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PETITION FOR LISTING UNDER THE ENDANGERED SPECIES ACT

LONGFIN SMELT &
SACRAMENTO SPLITTAIL

SUBMITTED TO: **THE U.S. FISH AND WILDLIFE SERVICE, Washington D.C. and Sacramento Field Office**
Informational copy to: National Marine Fisheries Service[1]

SUBMITTED BY: The Natural Heritage Institute, together with the following non-profit conservation organizations:

American Fisheries Society
Bay Institute of San Francisco
Planning and Conservation League
Save San Francisco Bay Association
Friends of the River
San Francisco Baykeeper
Sierra Club

The biological justification for listing presented in these petitions was prepared by Dr. Peter B. Moyle,[2] professor of fisheries in the Department of Wildlife and Fisheries Biology at the University of California, Davis. The data appeared initially in a report by Moyle and Yoshiyama to the California Policy Seminar at the University of California.[3] Dr. Moyle serves as a consultant to the Natural Heritage Institute.

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[1] In view of the anadromous nature of the longfin smelt.

[2] Dr. Moyle is the author or coauthor of over 100 publications, mostly on the ecology and conservation of California's freshwater and estuarine fishes. His books and monographs include: *Inland Fishes of California* (1976); *Distribution and Ecology of Stream Fishes of the Sacramento- San Joaquin Drainage System, California* (1982, with five co-authors); *Fish: an Introduction to Ichthyology* (2nd edition, 1988, with J. Cech); *Techniques for Fish Biology* (1990, with C. Schreck); *The Ecology of the Sacramento-San Joaquin Delta: a Community Profile* (1989, with B. Herbold). Dr. Moyle is one of three co-authors of the San Francisco Estuary Project's *Status and Trends Report on Aquatic Resources in the San Francisco Estuary* (Herbold et al. 1992), which is the most current and comprehensive study to date on the state of fish and invertebrate populations in the estuary.

[3] *Fishes, Aquatic Diversity Management Areas, and Endangered Species: A Plan to Protect California's Native Aquatic Biota* (with Ronald M. Yoshiyama, July 1992). That report documents the eligibility for listing under the Endangered Species Act of 28 freshwater fishes in California, including the two featured in these petitions.

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Preliminary Statement

This Statement describes the historical and ecological context pertinent to the evaluation of the accompanying petitions for listing of the longfin smelt and Sacramento splittail. These petitions are filed simultaneously because these species occupy overlapping habitats that are threatened by similar factors, and their conservation and recovery will entail related measures. The plight of these species and their ultimate fate is also closely tied to that of the estuarine ecosystem of which they are a part. The habitats of these species are contained within the critical habitat of the threatened winter-run chinook salmon, as proposed by the National Marine Fisheries Service. The habitats of both species also overlap with the proposed critical habitat identified by the U.S. Fish and Wildlife Service for the candidate species, delta smelt.

These, and at least two other jeopardized fish species, the spring run chinook salmon and the green sturgeon, depend for their survival on the integrity of the aquatic habitat at the convergence of California's two great Central Valley river systems, the Sacramento and the San Joaquin, at the Delta and the San Francisco estuary. It is not just this long and growing list of individual species but the estuarine ecosystem as a whole that is threatened with extinction as a result of severe alteration of the hydrodynamics of the estuary by humans. The problem is of such scale and extent that a species-by-species response must be supplemented by this multi-species approach to protect the ecosystem. In listing species one at a time, the agencies must be cognizant of how management decisions affect other jeopardized species and the estuarine ecosystem. These petitions are being presented as a multi-species package because protection and recovery of the species that are the subject of this petition, the already-listed species, other candidate species, and other jeopardized species, must be coordinated.[4]

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[4] The U.S. Fish and Wildlife Service, National Marine Fisheries Service and U.S. Environmental Protection Agency recommend just such an integrated, ecosystem approach for the protection of estuarine fish in their "Interagency Statement of Principles" to the California State Water Resources Control Board in the 1992 Water Right Phase of the Bay-Delta Estuary Proceedings (hearing exhibit WRINT-USFWS-10):

"The Board should adopt an integrated, ecosystem approach in managing the estuary. In the past, too much emphasis has been placed on addressing the impacts of just the State and Federal water

The extreme modifications of the structure, hydraulics, and hydrology of the estuary is the dominant reason behind the decline of all of these species.[5] Loss of spawning habitat, nursery habitat and the safety of migratory pathways are the primary factors causing the declines of most species of the upper San Francisco Bay Estuary. The most significant changes began in the 1850's and are continuing to this day. Early changes in the estuary were primarily caused by diking and filling of more than 90% of wetland habitats, sedimentation and other disruptions caused by hydraulic mining in the Sierras, and the introduction of exotic species. The first observed signs of the harm being done to the estuary were declining fisheries. By the 1880's the Dungeness crab fishery moved offshore. Next to be eliminated from the Bay were the commercial fisheries of large predatory fishes such as salmon and sturgeon. Today only herring and anchovies, small planktivorous species that move into the estuary from the ocean, are harvested commercially in the Bay.

Two factors, massive diversions of water from the southern delta to the Central Valley and southern California, and the consequent reductions in delta outflow to the Bay by more than 50% of historic levels in many months, continue to cause major disruptions in this ecosystem. The deleterious effects on the fishery are a function of the physical process of diverting the water and the resulting changes in flow and salinity patterns. The operation of water projects in a manner heedless of the consequences to aquatic resources was epitomized in 1989; despite being in the third year of a drought and in the face of plummeting fish populations, the Central Valley Project and State Water Project were allowed to divert more water from the Delta than in any other year in history. The disapproval of the State's salinity control plan for the estuary by the Environmental Protection Agency in September 1991 is further evidence of the inadequacy of current regulatory protection.

The two species petitioned for listing here are part of an ever-lengthening chain of estuarine species already extinct or in jeopardy:

- o Listing under the Endangered Species Act comes too late for two species, closely related to the Sacramento splittail. The only other species in the same genus as the

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projects on too few "target" species or particular life stages. Too little attention has been paid to the habitat needs of other species. Many estuarine species and their habitats have declined significantly, resulting in the listing of the winter-run chinook salmon, the proposed listing of the Delta smelt, and the likelihood of listing additional species such as the longfin smelt, Sacramento splittail, green sturgeon, and spring-run chinook salmon. Given the decline of these and other species, a comprehensive habitat protection approach is essential."

[5] Human activity in and around San Francisco Bay and the Sacramento-San Joaquin Delta estuary has so disrupted the ecosystem that the U.S. Fish and Wildlife Service and the U.S. Geological Survey consider it to be the most modified on any major estuary in the United States. R. Cross and D. Williams, Eds., *Proceedings of the National Symposium on Freshwater Inflow to Estuaries* (FWS/OBS-81/04, U.S. Fish and Wildlife Service Office of Biological Services, Washington, D.C., 1981) as cited in Frederic H. Nichols, et al., *The Modification of an Estuary*, Science, 231: 567, (Feb. 7, 1986).

Sacramento splittail was the Clear Lake splittail which was last captured in 1976, and is now extinct. Thus, this petition is for the last representative of a quite unusual genus which has already demonstrated the possibility of extinction. The thicktail chub was a similar large minnow that was abundant in the Central Valley in the previous century but which was completely exterminated by the mid 1950's. Sacramento splittail have shown a similar sensitivity to human disturbance by their restriction of range in recent years to a small fraction of their previous range.

- Sacramento perch were once one of the most abundant fish in the estuary and were harvested commercially in the nineteenth century. They gradually disappeared from their native habitats in the Central Valley and the estuary and are regarded as extinct in their natural range, except for a small population in Clear Lake and a few populations established temporarily in isolated ponds. They are abundant, however, in a few alkaline reservoirs outside their native range (which must be regarded as temporary habitats). In October, 1992, a single Sacramento perch was caught by an angler in the Delta (CDFG, Region 2). If this catch represents an established population, an endangered species petition for Sacramento perch may also be justified. It is currently regarded by CDFG as a species of special concern.

- The winter run chinook salmon has been declared to be threatened by federal and state agencies. NMFS has proposed reclassifying the status of the winter run chinook from threatened to endangered, a more protective classification. A critical habitat designation and conservation plan has been proposed.

- The delta smelt is a candidate species that may be listed in the near future.

- The longfin smelt was one of the most abundant species in San Francisco Bay as recently as 1983. Its decline parallels that of the candidate delta smelt because of their similar reliance on spawning, migration, and nursery conditions in the western Delta. While longfin smelt appear to be predominantly affected by reductions in outflow to the Bay, both smelts are subjected to changed hydraulics across their spawning habitats.

- The Sacramento splittail was once common throughout the Central Valley, but is now largely confined to the Delta. Like the non-native striped bass, it has shown a long-term decline in abundance in the estuary to the point where listing as a threatened species is justified. Because splittail reproductive success has a positive correlation with Delta outflows, the causes of its decline are probably similar to those of the much-studied striped bass, especially factors related to the operation of the major Delta diversions.

- Spring-run chinook salmon were once the most abundant race of chinook salmon in California and their continuing decline is well documented. The evidence that Sacramento spring-run chinook qualify for protection under state and federal endangered species acts is so compelling that we have prepared a petition for its listing.

At this time, NHI is withholding that petition to provide an opportunity for efforts now underway by commercial salmon fishermen to develop a strategic plan for the conservation and recovery of spring-run chinook. We believe that a private, voluntary initiative lead by those economic stake-holders has much to recommend it as an alternative to governmental intervention, if it is timely and sufficient. We expect to work closely with the fishermen in developing a workable course of action. (A cooperative venture to restore the spring run may become an early target of opportunity for NHI's habitat-oriented Aquatic Diversity Management Area Program, of which the listing agencies have been previously apprised.)

The reprieve is, however, conditional. NHI is prepared to file the petition for listing the spring run chinook if a plan is not forthcoming within a reasonable time, or if agreements for implementation of protective measures are inadequate to reverse the decline of this salmon.

- San Joaquin fall-run chinook salmon last fall numbered about 600 returning adults and there has been little evidence of successful reproduction in the past two years. These are the last salmon in the San Joaquin drainage, which once supported runs of over 500,000 fish. These fish have declined despite intensive efforts to manage their populations in the Stanislaus, Tuolumne, and Merced rivers. This indicates that the main causes of recent decline are outside the spawning and rearing areas and are most likely within the estuary. NHI has not yet developed a petition for listing this run, in part because of the intensified efforts to restore it in the spawning streams. If present trends continue, however, emergency listing by the National Marine Fisheries Service may be necessary in the next year or two.

- Green sturgeon are a species that show evidence of a decline throughout their range. Best evidence indicates that the Sacramento River and estuary contains one of only three remaining spawning populations. The collapse of the populations of this species may be imminent, in large part due to over-harvest, but also due to conditions in the rivers where they spawn and estuaries where they rear. NHI is monitoring this species with the intention of filing a petition if and when the evidence clearly warrants.

It must be kept in mind that these species represent the most conspicuous part of the declining native biota of the Sacramento-San Joaquin estuary. Other fish species are also in severe decline, such as Sacramento fall-run chinook, mainstay of the salmon fishery, and various introduced sportfish: striped bass, American shad, white catfish, etc. Not surprisingly, the algae and invertebrates that are part of the food webs leading to these species are also in decline.

The critical habitat designations recommended for Sacramento splittail and longfin smelt overlap to a significant degree with the proposed critical habitat designations that are pending for delta smelt and winter-run salmon. The common area of critical habitat for these four species includes the Sacramento River from the Delta Cross Channel Gates to Chipps Island, and all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzley Bay, Suisun Bay, and Carquinez Straight.[6]

All the declining species respond to flow and salinity. Therefore, it is clear that the estuary needs salinity and flow standards that will protect the entire ecosystem: all the species and their interactions.[7] In general, the physical and biological factors of the critical habitat proposed for each species are flows that will conduct smolt and larvae away from the influence of the export pumps. Adequate flows are also critical for Sacramento splittail, Delta and longfin smelt to ensure that salinity will be kept below critical levels in Suisun and San Pablo bays during spawning and early development.[8] Because the habitat conditions are similar to the Delta smelt and winter run, the incremental outflow requirements to conserve longfin smelt and Sacramento splittail are not likely to be substantial.[9]

We provide this context to urge the Fish and Wildlife Service to adopt a system-wide approach to species conservation in the estuary. We have not just an endangered species,

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[6] In addition to this common area, the delta smelt's proposed critical habitat includes all submerged lands below ordinary high water, but excludes waters west of the Carquinez Bridge (San Pablo and San Francisco Bays). The winter-run chinook salmon proposed critical habitat includes the Sacramento River below Keswick Dam, but excludes Suisun Marsh.

[7] Notably, the final report of the San Francisco Estuary Project's Technical Workshop on Salinity, Flows, and Living Resources of the San Francisco Estuary has recommended the placement of the 2 part per thousand salinity isohaline in the estuary as a control mechanism for comprehensive ecosystem management.

[8] The proposed listing for Delta smelt and the two petitions for longfin smelt and Sacramento splittail identify physical and biological factors that should be considered as part of those species' critical habitat, however, the proposed listing for winter-run chinook salmon does not include these factors in the proposed regulation. The winter-run chinook salmon notice does, however, identify physical and biological factors that are important to the species' critical habitat, stating that:

> The recommended temperature and flow criteria have not been included in the regulatory text describing the critical habitat; rather, this discussion is to alert the public to recommendations that NMFS may make on a case-by-case basis as part of the [governmental action mitigation measure] consultation process. 57 FR 36629.

[9] Longfin smelt begin spawning (as early as November) and reach their spawning peak (in March) somewhat earlier than Delta smelt (which being in early February and peak in mid-March through the end of April). Thus, longfin smelt may require increases in outflow relative to exports earlier than do the Delta smelt.

but an endangered ecosystem and threatened habitat problem associated with the massive extent to which water development has manipulated this water system. Petitioners propose an integrated approach to conservation of the species in this petition and their habitat that is cognizant of the requirements of all jeopardized species--those already listed, those en route to listing, the two species that are the subject of the instant petitions, the species for which we are on the verge of petitioning, and the entire suite of species that are known to be in serious decline in the estuary. The hearing record accumulated this summer by the State Water Resources Control Board in the interim water rights proceeding is replete with data and analyses on these species, their status and the causes of decline. We attach the NHI submittal by way of illustration.

To be clear, petitioners are not proposing to protect the longfin smelt and Sacramento splittail at the expense of other jeopardized species. Rather, we propose a cluster listing that leads to conservation and recovery strategies that are responsive to the needs of all. Nor do we favor delay in the listing of other candidate species or the development of recovery plans for any listed species in the estuary pending consideration of these instant petitions. Indeed, immediate listing of the delta smelt and prompt implementation of a recovery plan is essential not only to the existence of that species, but to the survival of the longfin smelt and Sacramento splittail, all of whose habitat needs are similar and compatible, and the health of the estuarine ecosystem as a whole. We are proposing that, beginning with this petition, all future decisions to protect each threatened species take into account the effects on the entire suite of jeopardized species. In sum, we are seeking an "endangered habitat" listing for the estuary. Existing authorities permit the agency to respond to this cluster petition by doing simultaneously and in an integrated, holistic fashion what it would otherwise do sequentially, namely evaluate abundance trends of jeopardized species, define critical habitat for the impaired ecosystem, and determine necessary conservation actions.

PETITION TO LIST AS ENDANGERED

Longfin Smelt	*Spirinchus thaleichthys* (Ayres)
Common Name	Scientific Name

1. EXECUTIVE SUMMARY

Longfin smelt have a wide distribution in estuaries along the Pacific coast but only three populations are known from California, the Sacramento-San Joaquin Estuary, Humboldt Bay, and the Klamath River Estuary. The population isolated in the Sacramento-San Joaquin Estuary is most likely a species or subspecies distinct from the other populations and certainly fits the definition of an Evolutionarily Significant Unit of the National Marine Fisheries Service. Longfin smelt are euryhaline but during larval, juvenile, and adult stages in the Sacramento-San Joaquin Estuary they are most abundant at salinities between 2 and 20 ppt, in San Pablo and Suisun bays. They move into the Delta and lower Suisun Bay in late summer in preparation for spawning. Spawning can take place at any time from November through June, but is concentrated in February through April. The eggs are deposited on gravel, rocks or aquatic plants in fresh water. Each female lays ca, 10,000 eggs and both sexes presumably die after spawning. The larvae move up into the surface waters and are washed downstream into brackish water nursery areas. Most growth in length takes place in the first nine to ten months of life, when they typically reach 6-7 cm SL. They spawn at two years of age although a few smelt, mostly females, will live yet another year, reaching lengths of 12-14 cm SL. The main food of longfin smelt is the opossum shrimp, *Neomysis mercedis,* although copepods and other crustaceans are important at times, especially to small fish.

There is a positive association between winter and spring river flow and longfin smelt abundance in following years and between freshwater inflow and juvenile survival in the Sacramento-San Joaquin estuary. The reason for this seems to be that high freshwater outflows increase the rate of transport into the rearing habitat in Suisun and San Pablo bays and reduce the probability of the larvae being retained in the Delta, where they are exposed to greater likelihood of entrainment. It is also likely that longfin smelt larvae have higher survival rates in brackish water.

In the Sacramento-San Joaquin estuary, longfin smelt were once one of the most abundant fish caught by various trawl surveys. Since 1983, their numbers have plummeted and have remained at record low numbers. The decline of longfin smelt in this estuary parallels that of other fishes in the estuary but has been even more precipitous. In Humboldt Bay, longfin smelt have become extremely rare since the 1960's.

Longfin smelt populations have been affected by pollution, by entrainment into irrigation diversions in the Delta, by entrainment into power plant cooling systems, by predation from introduced predators such as striped bass, by competition for zooplankton from introduced planktivorous fishes and invertebrates, and by droughts and floods, and other factors. However, most of these factors have been operating for a long time and the longfin smelt has managed to persist in large numbers despite them. The factor that is associated with their dramatic decline in recent years is the increase in the proportion of Delta inflows being diverted by the pumps of the State Water Project (SWP) and the federal Central Valley Project (CVP). These pumps not only pump more water than formerly but they pump water earlier in the year, when the smelt are spawning and larval fish are present. The pumping both entrains fish directly and drastically changes the hydraulics of the Delta, increasing the exposure of larval, juvenile, and adult smelt to within-Delta entrainment, predation, and other factors. The cause of the decline of Humboldt Bay longfin smelt has not been studied.

In the Sacramento-San Joaquin estuary, the longfin smelt will persist only if Delta outflows are substantially increased. Ideally, there should be no diversions by the CVP and SWP while the smelt are spawning, with mean minimum spring outflows set for dry and critical years at 12,000 to 14,000 cfs. Critical habitat in the estuary includes all of the Delta, Suisun Bay, San Pablo Bay, and San Francisco Bay, although these areas function as habitat for longfin smelt only if appropriate ecological conditions are present (which are largely determined by outflows). For Humboldt Bay and the Klamath Estuary, studies need to be conducted to determine the status of the smelt populations and their habitat requirements.

2. SPECIES DESCRIPTION AND BIOLOGY:

Description: Longfin smelt can be distinguished from other California smelts by their long pectoral fins (which reach or nearly reach the base of the pelvic fins), incomplete lateral line, weak or absent striations on the opercular bones, low number of scales in the lateral series (54-65), and long maxillary bones (which in adults extend just short of the posterior margin of the eye). The lower jaw projects forward of the upper when the mouth is closed. Small, fine teeth are present on both jaws, tongue, vomer and palatines. The number of dorsal rays is 8-10; anal rays, 15-22; pectoral rays, 10-12; gill rakers, 38-47; and pyloric caeca, 4-6. The orbit width goes into the head length 3.6-4.5 times, and the longest anal rays 1.4-2.2 times into the head length (McAllister 1963, Miller and Lea 1972, Morrow 1980). The lining of the gut cavity is silvery with a few scattered speckles. The sides of living fish appear translucent silver while the back has an olive to iridescent pinkish hue. Mature males are usually darker than females, with enlarged and stiffened dorsal and anal fins, a dilated lateral line region, and breeding tubercles on the paired fins and scales (McAllister 1963).

Taxonomic Relationships: The longfin smelt belongs to the true smelt family Osmeridae. Its closest relative in California is the night smelt, *Spirinchus starksi*. A third *Spirinchus* species, *S. lanceolatus*, occurs in northern Japanese waters and differs from *S. thaleichthys* in several morphological characters and in timing of spawning (McAllister 1963). The longfin smelt was at one time considered to be two species: the Sacramento smelt (*S. thaleichthys*) in the Sacramento-San Joaquin estuary, and the longfin smelt (*S. dilatus*), for the rest of the populations. McAllister (1963) merged the two species because he thought the meristic characters separating the Sacramento smelt from the other populations represented the southern end of a north-south cline in the characters, rather than a discrete set. However, the fact that the population in the Sacramento-San Joaquin estuary is isolated from the closest other population (in Humboldt Bay) by over 200 miles of coast makes it likely it is a distinct taxon. If a taxonomic reevaluation indicates that the Sacramento-San Joaquin population is a distinct taxon from the one in Humboldt Bay (and the Klamath River estuary), then there will be two threatened longfin smelt taxa in California, not just one. In any case, the isolation of the longfin smelt population in the Sacramento-San Joaquin estuary and the fact that this population is the southernmost of the species (as presently defined) clearly qualifies it for consideration for listing as a "species" under the federal Endangered Species Act. It is similar in this respect to a recognized run of chinook salmon (e.g., winter run chinook) and fits the definition of an Evolutionarily Significant Unit established by the National Marine Fisheries Service.[10]

Life History: Longfin smelt generally are euryhaline and anadromous. In the Sacramento-San Joaquin estuary adults and juveniles can be found in water ranging from nearly pure sea water to completely fresh water. However, they are most abundant in San Pablo and Suisun bays. Average summertime salinities in Suisun Bay normally were < 8 ppt even in dry years prior to the smelt decline. In San Pablo Bay salinities are typically < 25 ppt. The adults and juvenile smelt occupy mostly the middle or bottom of the water column, although larval smelt are concentrated in near-surface waters (R. Baxter, CDFG, pers. comm.)

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10 [A stock of fish] will be considered a distinct population, and hence a "species" under the ESA if it represents an evolutionarily significant unit (ESU) of the biological species. A stock of must satisfy two criteria to be considered an ESU:

> 1) It must be substantially reproductively isolated from other conspecific population units; and
> 2) It must represent an important component in the evolutionary legacy of the species.

The first criterion, reproductive isolation does not have to be absolute, but it must be strong enough to permit evolutionarily important differences to accrue in different population units. * * *

To be considered an ESU, the population must also represent an important component in the evolutionary legacy of the species. The evolutionary legacy of a species is the genetic variability that is a product of past evolutionary events and which represents the reservoir upon which future evolutionary potential depends. This second criterion would be met if the population contributed substantially to the ecological/genetic diversity of the species as a whole. In other words, if the population became extinct, would this event represent a significant loss to the ecological/genetic diversity of the species? In making this determination, the following questions are relevant:

> 1. Is the population genetically distinct from other conspecific populations?
>
> 2. Does the population occupy unusual or distinctive habitat?
>
> 3. Does the population show evidence of unusual or distinctive adaptation to its environment?

Policy on Applying the Definition of Species under the Endangered Species Act to Pacific Salmon, 56 FR 58612 (1991) at 58618.

The preference of larval smelt for the upper part of the water column is an adaptation that allows them to be swept quickly into food-rich nursery areas downstream, mainly Suisun and San Pablo bays. During years when periods of high outflow coincide with the presence of the larval smelt (e.g., 1980, 1982, 1983, 1984, 1986), the larvae are mostly transported to Suisun and San Pablo bay while in years of lower outflow, they are transported to the western Delta and Suisun Bay (R. Baxter, unpub. data). The distribution of young-of-year smelt largely coincides with that of the larvae. In the following winter, the yearling smelt become more widely distributed downstream, with some even colonizing South Bay, although they remain most abundant in San Pablo and Suisun bays.

In late summer (August, September), the distribution of yearling smelt gradually shifts upstream, a change which coincides with development of the gonads in preparation for spawning. They congregate for spawning at the upper end of Suisun Bay and in the lower and middle Delta, especially in the Sacramento River channel and adjacent sloughs. Larval longfin smelt are generally collected below Medford Island in the San Joaquin River and below Rio Vista on the Sacramento River (Wang 1991), indicating that spawning rarely occurs above these locations. The lower end of the spawning habitat seems to be upper Suisun Bay around Pittsburg and Montezuma Slough (Suisun Marsh) (Wang 1986).

The Sacramento longfin smelt has a rather protracted spawning period. Adult movements indicate that some spawning may take place as early as November (R. Baxter, unpubl. data) while larval surveys indicate spawning may occur into June (Wang 1986, 1991). Most spawning takes place from February through April, because larval smelt are most abundant in this period and large smelt become rare after this time. Wang (1986) indicates that older and larger smelt spawn later in the season than smaller ones. Males evidently precede the females in the spawning run upriver (Wydoski and Whitney 1979), and spawning occurs at night. The eggs are adhesive (Dryfoos 1965) and are deposited either on rocks or on aquatic plants in the freshwater sections of the Delta. Each female lays 5,000-24,000 eggs (Dryfoos 1965, Moyle 1976.). However, the mean number for ten females from Lake Washington was 18,104 (Dryfoos 1965), which is higher than recorded for California populations (mean = 9752, Moyle, unpublished data). The eggs hatch in 40 days at 7°C (Dryfoos 1965). Apparently, most longfin smelt die after spawning. A few smelt, mostly females, live another year, although it is not certain whether or not they have spawned previously.

Newly hatched larvae are 5-8 mm long (Wang 1991). They can spend considerable time in fresh water, as young fish up to 7.2 cm long have been caught in the Fraser River, British Columbia (Morrow 1980). Metamorphosis into the juvenile form probably begins 30-60 days after hatching, depending on temperature (Emmett et al. 1991). Growth in California populations is similar to that of more intensively studied Washington populations (Dryfoos 1965). Most growth in length takes place in the first nine to ten months of life, when they typically reach 6-7 cm SL. Growth rate levels off during the first winter, but there is another period of growth during the second summer and fall, when the smelt reach 9-11 cm SL. Weight gains may be considerable during this latter period as the gonads develop. The largest smelt are 12-14 cm SL, presumably females in their third year of life.

The life history pattern of Humboldt Bay longfin smelt is probably similar to that of the Sacramento-San Joaquin smelt because they have been recorded as spawning in fresh water and the adults and larvae are largely confined to the bay (Gotshall et al. 1980; Emmett et al. 1991).

The main food of longfin smelt is the opossum shrimp, *Neomysis mercedis*, although copepods and other crustaceans are important at times, especially to small fish (Moyle 1976). This is similar to their feeding habits in Lake Washington, Washington (Dryfoos 1965). Longfin smelt, in turn, are eaten by a variety of predatory fishes, birds and marine mammals. They are a major prey of harbor seals, *Phoca vitulina*, in the Columbia River (Emmett et al. 1991).

In the landlocked Lake Washington population in Washington, adult longfin smelt show daily vertical migrations, moving into deep water during the day and in the upper water column at night (Wydoski and Whitney 1979, Emmett et al. 1991). This may explain why juvenile and adult longfin smelt are usually captured in trawls in the lower half of the water column in the Sacramento-San Joaquin estuary (R. Baxter, unpubl. data), where most sampling takes place during the day.

Longfin smelt are caught and marketed incidentally with other smelt species (Wang 1986). They are of only minor commercial importance, evidently because the supply is sporadic and the amounts caught are relatively small. However, it is likely that they were an important component of the smelt fishery that existed in the estuary in the late 19th century.

3. HABITAT REQUIREMENTS

Spawning takes place in fresh water, over sandy-gravel substrates, rocks, and aquatic plants (Wang 1986; Emmett et al. 1991). Spawning in the Sacramento-San Joaquin estuary occurs at water temperatures of 7.0-14.5°C (Wang 1986), although spawning occurs at lower temperatures in other areas, such as Lake Washington (Emmett et al. 1991). There is a strong positive correlation between winter and spring Delta outflow and longfin smelt abundance the following year. There is also a strong correlation between juvenile survival in the Sacramento-San Joaquin estuary and Delta outflow (Stevens and Miller 1983). The reason for this seems to be that the flows increase the rate of transport into the rearing habitat in Suisun and San Pablo bays and reduce the probability of the larvae being retained in the Delta, where they are exposed to greater likelihood of entrainment. High freshwater outflows increase the volume of brackish water (2-18 ppt salinity) rearing habitat required by larval and juvenile smelt (R. Baxter, unpubl. data). Because the life history of longfin smelt is similar in many respects to that of striped bass, *Morone saxatilis*, it is likely that longfin smelt larvae, like striped bass larvae, have higher survival rates in brackish water (Hall 1991). Adults occur in the open waters of the estuary at salinities ranging from fresh water to full sea water. In most years, adults are found primarily in Suisun, San Pablo, and San Francisco bays. In low outflow years, they are concentrated in the Delta and Suisun Bay.

4. HISTORIC AND CURRENT DISTRIBUTION

In the Sacramento-San Joaquin estuary, longfin smelt are rarely found upstream of Rio Vista or Medford Island in the Delta. Adults occur seasonally as far downstream as South Bay but they are concentrated in Suisun, San Pablo, and North San Francisco bays. They are rarely collected outside the estuary.

The estuarine population is a separate ecological unit that is effectively isolated from other populations that are found north of San Francisco Bay as far as Prince William Sound, Alaska.[11] There is no genetic flow between the estuary's populations and those further north.

5. HISTORIC AND CURRENT ABUNDANCE

Sacramento-San Joaquin estuary. Longfin smelt were once one of the most abundant fish caught by various trawl surveys in the estuary, i.e., the CDFG fall midwater trawl survey of the upper estuary, the CDFG otter and midwater trawl Bay surveys, and the UCD Suisun Marsh surveys (Herbold et al. 1992). The numbers of longfin smelt fluctuated widely, reaching their lowest levels during drought years but quickly recovering when adequate winter and spring flows were once again present. Since 1983, longfin smelt numbers have plummeted and have remained at record low numbers (Herbold et al. 1992). For example, since 1986, the total catch of smelt in 27 stations consistently sampled by the CDFG fall midwater trawl survey has consistently been less than 300 fish and declining steadily to 67 fish in 1990. This decline in longfin smelt numbers parallels that of other fishes in the estuary, such as delta smelt, but has, if anything, been even more precipitous. It has declined in rank abundance from being first or second in most trawl surveys during the 1960's and 1970's to being 7th or 8th in abundance (B. Herbold, pers. comm.).

The California Department of Fish and Game analyzed abundance trends for longfin smelt in testimony presented during the summer of 1992 to the State Water Resources Control Board in the Interim Water Rights Proceedings for the Bay-Delta Estuary (Exhibit WRINT-DFG-6, "Estuary Dependent Species", at pp. 45-61), attached. That testimony is incorporated into this petition by reference. According to the CDFG analysis:

> "The Fall [Midwater Trawl] Survey longfin smelt abundance index showed that * * * in the past five drought years longfin smelt abundance has remained at very low levels ending in 1991 with the lowest index recorded" (p. 48).

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11 Emmett et al. (1991) considered longfin smelt to be common in Skagit Bay, Grays Harbor and Willapa Bay in Washington, highly abundant in the Columbia River, and common in Yaquina and Coos bays, Oregon. Landlocked populations occur in Lake Washington, Washington, and Harrison Lake, British Columbia. Historically, the largest population in California has occurred in Sacramento-San Joaquin estuary, with smaller populations in Humboldt Bay, the Eel River, and, probably, the Klamath River. Longfin smelt have been recorded from the Van Duzen River in the Eel River drainage, and a sample from there is in the museum collection at Humboldt State University. There are also recent records from the mouth of the Klamath River, but it is uncertain if a self-sustaining population exists there. The southernmost record of the species range is a single fish from Monterey Bay (Eschmeyer et al. 1983, Wang 1986), but probably only stray individuals occur that far south (W. Eschmeyer, pers. comm.).

6. NATURE AND DEGREE OF THREAT

The threats to a species' survival may be categorized, according to the Endangered Species Act, as: "(A) the present, or threatened, destruction, modification, or curtailment of its habitat or range, (B) over-utilization for commercial, recreational, or educational purposes, (C) disease or predation, (D) inadequacy of existing regulatory mechanisms, or (E) other natural or manmade factors affecting its continued existence." Longfin smelt are no longer harvested but all the other factors probably apply to its decline.

Modification of habitat. The Sacramento-San Joaquin estuary is one of the most modified estuaries in the world. Among the factors that can effect longfin smelt populations are domestic and agricultural pollution from many sources, increased water diversions through the export pumpts, entrainment in irrigation diversions in the Delta, entrainment in power plant cooling systems, and other systematic changes to the estuarine ecosystem.

Pollution is an insidious problem in the estuary because toxic compounds, especially pesticides, can come from many sources, may be episodic in nature (and therefore hard to detect), and may affect mainly early life history stages of fish, where mortality is hard to observe. For longfin smelt, there is no evidence that toxic compounds have affected their populations over the long term. This is not surprising because the smelt spawn early in the season when few agricultural chemicals are being applied and flows for dilution may be high. Also their short life span and plankton feeding habits (short food chain) reduce the probability of accumulation of toxic materials in tissues.

Water exports. To demonstrate the effects of the pumping plants on the smelt, a regression equation has been calculated relating smelt numbers to Delta outflow ($p < .01$, B. Herbold, USEPA, pers. comm.). This equation predicts that mean spring (March-May) outflows much less than 3400 cfs will result in reproductive failure of the smelt. Such flows for two or three years in a row would probably result in extinction of the longfin smelt in the estuary. Since 1986, outflows have been perilously close to that number, pushed there by the increase in diversions. This has resulted in abnormally low numbers of longfin smelt being produced (Figure 1). The strong correlation between average monthly outflow and the DFG longfin abundance index, and the mechanisms explaining that close relationship, are further documented in the attached testimony presented during the summer of 1992 to the State Water Resources Control Board in the Interim Water Rights Proceedings for the Bay-Delta Estuary (Exhibit WRINT-DFG-6, "Estuary Dependent Species", at pp. 50-61).

The tight relationship between spring outflow and longfin smelt abundance highlights the increasing impact of water exports on this species. Analysis of the decline over the last ten years shows that the increasing quantity of water exported during a time when the quantity of water in the state was low has resulted in a continuous decline in longfin smelt capture rates. In earlier, wetter years the quantity of exports was a small fraction of the total Delta inflow and outflow. In recent years the amount of water exported has exceeded the amount flowing into the Bay and capture rates of longfin smelt have declined largely due to the impacts of exports on total Delta outflow. This amplification of normal drought effects has been compounded by the ability of upstream reservoirs to retain more of the winter-spring runoff because the reservoirs have been below flood control limits. The later release of this water for export has exacerbated the normal drought year decline of this species even beyond the impacts of the annual totals shown in figure 1.

Entrainment of larvae in agricultural diversions in the estuary is largely unquantified. Presumably, entrainment in Delta agricultural diversion was a fairly constant source of mortality for 50-100 years, until flows across the Delta increased as the result of the changed hydraulics of the Delta. The changed flow patterns, which are associated with the dramatic decline of longfin smelt in recent years, are the result of the increase in the proportion of Delta inflows being diverted by the pumps of the State Water Project (SWP) and the federal Central Valley Project (CVP).[12] These pumps, located in the south Delta, not only pump more water than formerly but they pump water earlier in the year, when the smelt are spawning and larval fish are present. The pumping both entrains fish directly and drastically changes the hydraulics of the Delta, increasing the exposure of larval, juvenile, and adult smelt to in-Delta entrainment, predation, and other factors. Although large numbers of adult longfin smelt are "salvaged" at the pumping plants and trucked back to the estuary, it is unlikely many individuals of this delicate species survive the experience. If they do, they are probably consumed by piscine and avian predators attracted to the predictable commotion of trucks releasing fish.

Predation. The principal piscivore in the estuary is the striped bass. This species was introduced over 100 years ago, replacing native piscivores such as Sacramento perch and various salmonids. The longfin smelt remained abundant despite the explosion of striped bass numbers and in recent years the smelt decline has coincided with the decline of striped bass. Therefore, we do not believe that striped bass predation is responsible for the decline of the longfin smelt. It is possible that concentrated striped bass predation may be having a small effect on longfin smelt in the Clifton Court Forebay, into which smelt are drawn before being entrained in the SWP pumps. However, the smelt probably do not survive entrainment in any case, so whether they are eaten by bass or entrained by the pumps is a moot point.

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12 The U.S. Bureau of Reclamation has acknowledged the adverse effects of the delta export facilities on the estuarine fisheries in its testimony to the State Water Resources Control Board in the interim water rights proceeding for the Bay-Delta Estuary:

> ". . . Although there is evidence of other factors, such as toxics, fishing pressure, introduced species and major changes in the food chain, influencing the striped bass decline, the bulk of the evidence is that Delta exports and internal Delta diversions are adversely affecting striped bass and other fish populations.
>
> * * *
>
> ". . . Reclamation believes the negative impact of Delta diversions on the fisheries and food chain is largely a consequence of the flow patterns (hydrodynamics) resulting from Delta inflow and CVP/SWP exports. Consequently, any proposed solution must address this important issue if it is to be effective in the long-term." (WRINT-USBR-Exhibit Number 10, p. 8.)

Inadequacy of regulatory mechanisms. In 1978 the California State Water Resources Control Board adopted flow standards for the Sacramento-San Joaquin Delta and Suisun March in its water rights order D-1485. The water quality measures to protect fish and wildlife were limited to salinity standards, flow requirements and operational constraints for striped bass and salmon only. Additional salinity requirements were established for the Suisun Marsh. Whatever incidental benefit these measures may have afforded the longfin smelt was obviously inadequate, as demonstrated by their precipitous decline as since those measures were put into effect in 1978. More protective freshwater outflow standards were proposed in 1988. The plan was withdrawn and no new flow standards have been promulgated by the Board.

The Board issued a new water quality control plan for the estuary in 1991. This plan explicitly acknowledged that water diversions are jeopardizing the delta resident fish species, such as the longfin smelt, by direct entrainment in the export pumps; diversion of fish through the Delta Cross Channel into the interior Delta; reverse flows in various reaches of the San Joaquin River, Old River, Middle River; and, the lack of flows in some water years to either hold the entrapment zone in the proper location to provide a nursery area for young fish or to move (flush) the young into Suisun Bay and away from the entrapment zones. Because the State Board chose to limit this plan to control of salinity rather than regulating freshwater flows through the estuary or exports. The State Board deferred consideration of these critical factors. Because this limited approach failed to protect important estuarine habitat, this water quality plan was disapproved by the Environmental Protection Agency as inadequate under federal law.[13] In recognition of the ongoing deterioration of the estuarine fishery, the Board has been instructed by the Governor to issue an "interim" water rights order by the end of the year to "halt the decline and increase the protection of public trust resources where reasonable".[14]

These delayed, withdrawn and disapproved regulatory responses have frozen estuarine protection since the 1978 measures which the Board itself has acknowledged to be inadequate to protect flow-dependent species such as the longfin smelt. In default of meaningful state regulation, listing this species (and other Delta species) as threatened or endangered may be the only option available to protect the estuarine ecosystem. Unless the protections of the Endangered Species Act are afforded the longfin smelt, there is ample reason to fear that continued reductions in Delta outflow, especially in the spring, eventually may precipitate the further population collapse and extinction of this species.

Apart from the failure of the State Board to take effective action, the water projects themselves have not undertaken measures sufficient to protect the estuarine fish from the effects of their water diversions. The Fish and Wildlife Service noted during its testimony before the State Water Resources Control Board in the interim water rights proceeding that the measures that have been implemented in the Delta:

"have been largely structural or operational in nature and have not significantly increased

[13] Letter from Daniel W. McGovern, Regional Administrator, U.S.EPA, to W. Don Maughan, Chairman, California State Water Resources Control Board, September 3, 1991.

[14] Notice of Public Hearing, Consideration of Interim Water Rights Action, Water Right Phase of the Bay-Delta Estuary Proceedings, at p. 2 (May 8, 1992).

river flow or Delta inflow/outflow."[15]

The cause of the near-disappearance of longfin smelt from Humboldt Bay and the Eel River has not been studied. However, both estuaries have been severely altered and stream flows in the Mad River (which flows into Humboldt Bay) have been reduced. Adequate protection of the longfin smelt population in Humboldt Bay may be a function of better information on the causes of decline. The information that has been gathered to date is not sufficient. Because other species in that ecosystem are also suffering declines, broad-based studies are necessary to allow an ecosystem-level of protection that would both safeguard the longfin smelt population and the ecosystem upon which it depends.

Other factors. Two other factors may have contributed to longfin smelt decline in recent years: extreme climatic conditions and recently introduced species.

The past 10 years have seen some of the most extreme environmental conditions the estuary has experienced since the arrival of Europeans. The past eight years have been ones of continuous drought, broken only by the record outflows of February 1986. The 1986 flood occurred during the peak spawning season of longfin smelt and quite likely washed a high percentage of the spawning fish and/or their offspring far downstream, perhaps beyond the Golden Gate. This event was particularly unfortunate because the smelt were already showing signs of precipitous decline and the washout may have exacerbated the problem. The prolonged drought has had two major interacting effects: a natural decrease in outflow and an increase in the proportion of inflowing water being diverted. A natural decline in smelt numbers would be expected from the reduced outflow, because of the reduced availability of brackish water habitat for larvae and juveniles. However, the increase in diversions exacerbated the decline in smelt survival through a combination of further reduction in brackish water habitat and increased entrainment of larvae, juveniles, and adults. It is important to recognize that extreme floods and droughts have occurred in the past and smelt have managed to persist. Unlike today, the smelt historically did not experience the extreme conditions caused by increased diversion of water nor were their numbers depleted to the point where recovery from natural disasters becomes much more difficult.

Introduced species are a perpetual problem in the Sacramento-San Joaquin estuary, especially those that are introduced "accidentally" from the ballast water of ships. The most recent problem introductions have been several species of planktonic copepods and an Asiatic clam,

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[15] "Measures that have been implemented in the Delta include: 4-Pumps money for programs and plants of juvenile anadromous fish, winter-run salmon operations in the Delta, special operations in Suisun Marsh, substantial clean up of estuarine waters from point and non-point sources of contaminants, increased protection from harvest and illegal take, barriers for Delta fish protection, improved salvage operations at export pumps, and many others. Substantial upriver improvements include: seasonal raising of Red Bluff Diversion Dam Gates, pulse-flow operations for transport of Coleman Hatchery releases, power bypasses at Shasta, dilution flows for Spring Creed spills, gravel replenishment near Redding, effective screening of Red Bluff diversion intake, intensive Trinity Unit coordination with the Shasta Division, increased hatchery contribution to salmon, and winter-run operations up-river. These many measures have been successfully implemented but fish resources still declined greatly. . . . We note that the referenced measures U.S. Fish and Wildlife Service, "Expert Testimony of United States Fish and Wildlife Service on Recommendations for Interim Protection and Response to Hearing Notice Key Issues," July 6, 1992, WRINT-USFWS-8 p. 9.

Potamocorbula amurensis. The copepods are regarded as a problem because they seem to be replacing *Eurytemora affinis*, a native copepod that has been the favored food of larval fish. Although one of the introduced copepod species *(Sinocalanus doerri)* seems to be harder for larval fish to capture, it occurs mostly upstream of the concentrations of longfin smelt larvae. It may only be a problem if diversions keep the smelt larvae in upstream, freshwater conditions. Other introduced copepod species probably do not present the capture problems of *S. doerri* (e.g., Meng and Orsi 1991). The Asiatic clam, in contrast, may have a direct effect on smelt populations because it has become extremely abundant in San Pablo and Suisun bays, from which it appears to be filtering out most of the planktonic algae, the base of the food web on which smelt depend (Nichols et al. 1990).

The clam is not, however, a direct cause of the initial decline of longfin smelt because it did not invade until after February 1986, when the estuary's biota had been devastated by immense outflows (Nichols et al. 1990). Its present abundance may make the recovery of longfin smelt more difficult but it is quite likely that the Asiatic clam will become less abundant in response to (1) increased freshwater outflows, and (2) discovery of it as a food source by fishes such as sturgeon, by invertebrates such as the invading mitten crab, and by diving ducks. A typical pattern for invading species is to increase explosively in response to optimal conditions at the time of invasion (due to the absence of their predators, parasites, etc.) and then to decline as the local ecosystem adjusts to its presence.

7. CURRENT AND RECOMMENDED MANAGEMENT

The longfin smelt is currently an unmanaged species. In the Sacramento-San Joaquin estuary, the longfin smelt will persist only if adequate standards for Delta outflows are set. Ideally, there should be no diversions by the CVP and SWP while the smelt are spawning. At a minimum, spring outflows in dry and critical years should be 12,000 to 14,000 cfs from January through March before diversions are permitted.

For Humboldt Bay studies need to be conducted to determine if a longfin smelt population still exists there. If one does, conditions needed for survival of the species need to be determined. It is likely that adequate flows down the Mad and Klamath rivers in spring will have to be provided for its spawning. The nature and extent of the smelt population in the Klamath estuary needs to be determined, as well as factors that limit its abundance.

8. CRITICAL HABITAT

Long term survival of the longfin smelt in the Sacramento-San Joaquin estuary depends on protection of the habitat it needs to complete all stages of its life history. The geographic extent of this critical habitat includes all of the Delta (up to Sacramento on the Sacramento River, up to Mossdale on the San Joaquin River), Suisun Bay, including Suisun Marsh, San Pablo Bay, and San Francisco Bay. More important than geographic area, however, is the need to have appropriate ecological conditions in the estuary available to smelt, particularly adequate flows through the Delta while the smelt are spawning in February through April. Thus critical habitat should include the following components:[16]

1. Net positive flows down the Sacramento and San Joaquin rivers when adult smelt are moving up for spawning (November through February).

2. Net positive flows down the two rivers when larval smelt are present (mainly February through April).

3. Periodic flushing flows down the rivers when the smelt are spawning to assure rapid transport of larvae to Suisun and San Pablo bays.

4. Late spring (April-June) outflows of 12,000 to 14,000 cfs to keep juvenile and larval smelt out of the Delta, to prevent entrainment and exposure to toxic materials, and to maintain salinities below 2 ppt at Roe Island.

5. Salinities in San Pablo Bay at less than 25 ppt through September in most years.

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[16] In testimony before the California State Water Resources Control Board in the interim Bay-Delta proceedings on July 9, 1992, the National Marine Fisheries Service recommended similar measures to protect an array of jeopardized species, including the longfin smelt:

"To implement these interim, protective standards, the Board should rely on habitat protection measures that will reduce reverse flows, increase Delta outflow, reduce fish entrainment in diversions, and provide adequate reservoir carryover storage. In other words, the Board should focus primarily on changes to system management, such as changes to Delta export restrictions, Delta outflow requirements, cross-channel closures, reverse-flow limits, and carryover storage requirements. In addition, all diversions and export facilities should be managed to provide the best possible fish protections and minimal effects on natural migration pathways. These actions could provide immediate benefits to the ecosystem." Expert Witness Testimony of Roger S. C. Wolcott concerning Fishery Habitat Protection through Interim Water Rights Actions at p. 6.

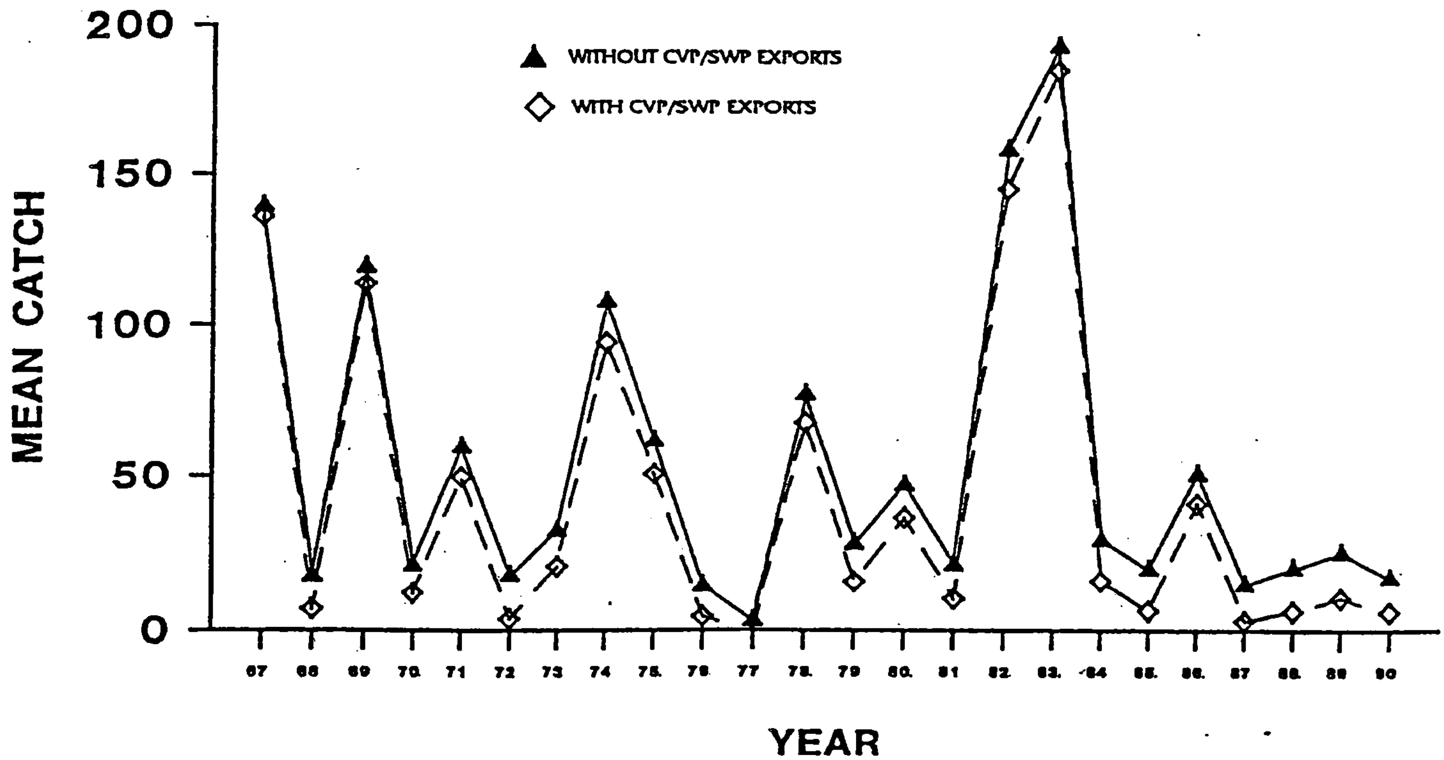

Figure 1. Mean catch of longfin smelt in trawls that caught smelt in the CDFG fall midwater trawl survey (solid line) and predicted mean catch if the pumps of the CVP and SWP had not been operating. Analysis by B. Herbold, USEPA.

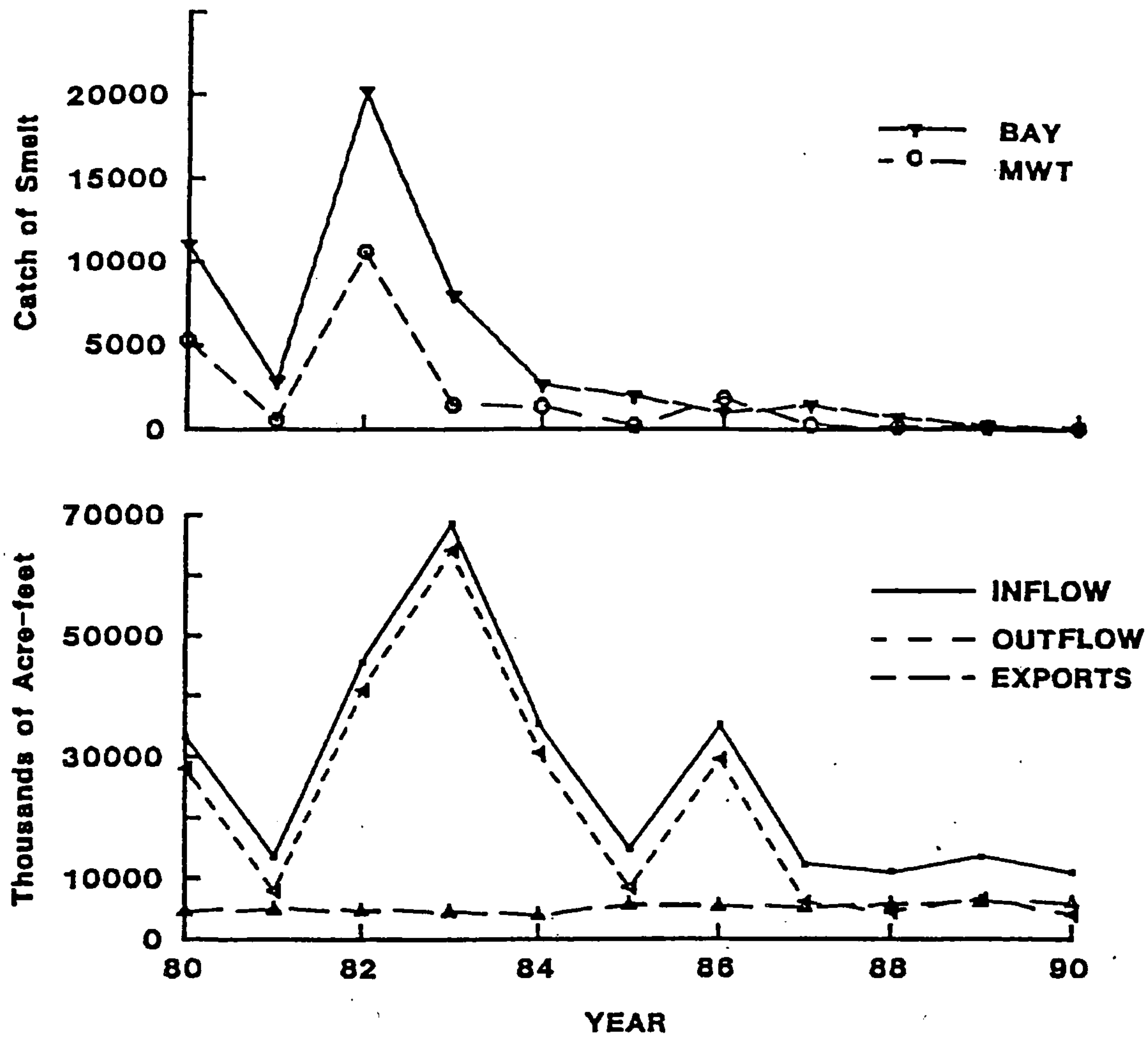

Figure 2, top. Catch of smelt from year-round sampling of Bay Study (BAY) and the September to December Sampling of the Fall Midwater Trawl (MWT). Data restricted to those stations in each sampling program that were sampled in all years (data provided by the California Department of Fish and Game).

Figure 2, bottom. Net Delta Outflow and Inflow compared to total exports. Note that exports have exceeded inflow in several recent years. (Data provided by California Department of Water Resources from DAYFLOW data set).

The tight relationship between spring outflow and longfin smelt abundance highlights the increasing impact of water exports on this species. Analysis of the decline over the last ten years shows that the increasing quantity of water exported during a time when the quantity of water in the state was low has resulted in a continuous decline in longfin smelt capture rates. In earlier, wetter years the quantity of exports was a small fraction of the total Delta inflow and outflow. In recent years the amount of water exported has exceeded the amount flowing into the Bay and capture rates of longfin smelt have declined largely due to the impacts of exports on total Delta outflow. This amplification of normal drought effects has been compounded by the ability of upstream reservoirs to retain more of the winter-spring runoff because the reservoirs have been below flood control limits. The later release of this water for export has exacerbated the normal drought year decline of this species even beyond the impacts of the annual totals shown in figure 1.

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PETITION TO LIST AS ENDANGERED OR THREATENED

Sacramento Splittail	*Pogonichthys macrolepidotus* (Ayres)
Common Name	Scientific Name

1. EXECUTIVE SUMMARY

The Sacramento splittail was once widely distributed throughout the California Central Valley, to which it is endemic. It is the only surviving member of its genus. The Sacramento splittail has disappeared from much of its native range because of loss or alteration of lowland habitats following dam construction, water diversion and agricultural development. This species is now largely confined to the Sacramento-San Joaquin estuary. Population levels have fluctuated widely in a general downward direction over the past two decades and have declined steadily since 1986, the last year with appreciable recruitment. Recruitment of young to the population is episodic and dependent upon sufficient flows in the lower reaches of rivers during spawning and subsequent high outflows through the Delta. Principal spawning areas and juvenile rearing habitat need to be identified and protected. Water management to maintain adequate flows through the Delta at appropriate times will be necessary to promote successful population recruitment and, hence, preservation of the species.

2. SPECIES DESCRIPTION AND BIOLOGY

Description: Splittail are large cyprinids, growing in excess of 300 mm SL, and are distinctive in having the upper lobe of the caudal fin larger than the lower lobe. The body shape is elongate with a blunt head. Small barbels may be present on either side of the subterminal mouth. They possess 14 to 18 gill rakers, and their pharyngeal teeth are hooked and have narrow grinding surfaces. Dorsal rays number from 9-10, pectoral rays 16-19, pelvic rays 8-9, and anal rays 7-9. The lateral line usually has 60-62 scales, but ranges from 57-64. The fish are silver on the sides and olive grey dorsally. Adults develop a nuchal hump. During the breeding season, the caudal, pectoral, and pelvic fins take on a red-orange hue and males develop small white nuptial tubercles in the head region.

Taxonomic Relationships: This species was first described in 1854 by W. O. Ayres as *Leuciscus macrolepidotus* and by S. F. Baird and C. Girard as *Pogonichthys inaeqilobus*. Ayres' species description is accepted as the official one but *Pogonichthys* was accepted as the genus name in recognition of its distinctive characteristics (Hopkirk 1973). The splittail is considered by some taxonomists to be allied to cyprinids of Asia (Howes 1984). The genus *Pogonichthys* comprises two species, *P. ciscoides* Hopkirk and *P. macrolepidotus* (Hopkirk 1973). The former species from Clear Lake, Lake County, became extinct in the early 1970's.

Life History: Splittail are relatively long-lived (about 5-7 yrs) and are highly fecund (over 100,000 eggs per female). Their populations fluctuate on an annual basis depending on spawning success and strength of the year class (Daniels and Moyle 1983). Both male and female splittail mature by the end of their second year (Daniels and Moyle 1983), although occasionally males may mature by the end of their first year and females by the end of their third year (Caywood 1974). Fish are about 180-200 mm SL when they attain sexual maturity (Daniels and Moyle 1983), and the sex ratio among mature individuals is 1:1 (Caywood 1974).

There is some variability in the reproductive period, with older fish reproducing first, followed by younger fish which tend to reproduce later in the season (Caywood 1974). Generally, gonadal development is initiated by fall, with a concomitant decrease in somatic growth (Daniels and Moyle 1983). By April, ovaries reach peak maturity and account for approximately 18% of the body weight. The onset of spawning seems to be associated with increasing water temperature and day length and occurs in late April and May in the marsh (Daniels and Moyle 1983) and between early March and May in the upper Delta (Caywood 1974). However, Wang (1986) found that in the tidal freshwater and euryhaline habitats of the Sacramento-San Joaquin estuary, spawning occurs by late January/early February and continues through July. Fish probably spawn on submerged vegetation in flooded areas, and spawning occurs in the lower reaches of rivers (Caywood, 1974), dead-end sloughs (Moyle 1976) and in the larger sloughs such as Montezuma Slough (Wang 1986). Larvae remain in the shallow, weedy areas inshore in close proximity to the spawning sites and move into the deeper offshore habitat as they mature (Wang 1986).

Splittail are benthic foragers that feed extensively on opossum shrimp (*Neomysis mercedis*), although detrital material typically makes up a high percentage of their stomach contents. They will feed opportunistically on earthworms, clams, insect larvae, and other invertebrates. They are preyed upon by striped bass and other predatory fishes. The preference for splittail by striped bass has long been recognized by anglers, who fish for splittail in order to use them for bait.

3. HABITAT REQUIREMENTS

Splittail are primarily freshwater fish, but are tolerant of moderate salinities and can live in water with salinities of 10-18 ppt (Moyle 1976, unpubl. obs.). In the 1950's, they were commonly caught by striped bass anglers in Suisun Bay during periods of fast tides (D. E. Stevens, pers. comm.). During the past 20 years, however, they were mostly found in slow-moving sections of rivers and sloughs, and in the Delta and Suisun Marsh they seemed to congregate in dead-end sloughs (Moyle 1976, Moyle et al. 1982, Daniels and Moyle 1983). They require flooded vegetation for spawning and as foraging areas for young, thus are found in habitat subject to periodic flooding (Caywood 1974). They are year around residents in Suisun Marsh, concentrating in the dead-end sloughs that typically have small streams feeding into them (Moyle et al. 1986). They tend to be most abundant where other native fishes, and striped bass, are abundant as well. In Suisun Marsh, trawl catches are highest in summer when salinities are 6-10 ppt and temperatures are 15-23 C (Moyle et al. 1986), reflecting an influx of young-of-year fish.

Daniels and Moyle (1983) found that year class success in splittail was positively correlated with Delta outflow, and Caywood (1974) found that a successful year class was associated with winter runoff sufficiently high to flood the peripheral areas of the Delta. These observations were confirmed by the analysis of the California Department of Fish and Game (CDFG 1992).

4. HISTORIC AND CURRENT DISTRIBUTION

The Sacramento splittail is a California Central Valley endemic that was once distributed in lakes and rivers throughout the Central Valley. They were found as far north as Redding by Rutter (1908) who collected them at the Battle Creek Fish Hatchery in Shasta County. Splittail are no longer found in this area and are limited by the Red Bluff Diversion Dam in Tehama County to the downstream reaches of the Sacramento River. They also enter the lower reaches of the Feather River on occasion, but records indicate that Rutter (1908) had collected them as far upstream as Oroville. Splittail are also known from the American River and have been collected at the Highway 160 bridge in Sacramento, although in the past Rutter (1908) collected them as far upstream as Folsom. He also collected them from the Merced River at Livingston and from the San Joaquin River at Fort Miller (where Friant Dam is today). Snyder (1905) reported catches of splittail from southern San Francisco Bay and at the mouth of Coyote Creek in Santa Clara County, but recent surveys indicate that splittail are no longer present in these locations (Leidy 1984).

Splittail are now largely confined to the Delta, Suisun Bay, Suisun Marsh, Napa Marsh, other parts of the Sacramento-San Joaquin estuary (Caywood 1974, Moyle 1976). In the Delta, they are most abundant in the north and west portions, although other areas may be used for spawning (CDFG 1987). This may reflect a shrinking of their Delta habitat because Turner (1966) found a more even distribution throughout the Delta. Recent surveys of the San Joaquin Valley streams found only a few individuals at one locality in the San Joaquin River below its confluence with the Merced River (Saiki 1984; Brown and Moyle, In Press). Successful spawning has been recorded in the lower Tuolumne River during wet years in the 1980's (T. Ford, pers. comm.). Occasionally, splittail are caught in San Luis Reservoir (Caywood 1974) which stores water pumped from the Delta. Splittail are largely absent from the Sacramento River as well, although large individuals are caught during spring in the lower river in large fyke traps set to catch striped bass migrating upstream to spawn (CDFG unpubl. data). Presumably the splittail are also on a spawning migration.

5. HISTORIC AND CURRENT ABUNDANCE

Splittail have disappeared from much of their native range because dams, diversions, and agricultural development have eliminated or drastically altered much of the lowland habitat these fish once occupied. Access to spawning areas or upstream habitats is now blocked by dams on the large rivers because splittail seem incapable of negotiating existing fishways. As a result they are restricted to water below Red Bluff Diversion Dam on the Sacramento River, below Nimbus Dam on the American River, and below Oroville Dam on the Feather River. They are rare, however, more than 10-20 km above the upstream boundaries of the Delta. Caywood (1974) found a consensus among splittail anglers that the fishery has declined since the completion of Folsom and Oroville Dams.

Today the principal habitat of splittail is the Sacramento-San Joaquin estuary, especially the Delta. Their abundance in this system is strongly tied to outflows, presumably because spawning occurs over flooded vegetation. Thus, when outflows are high, reproductive success is high, but when outflows are low, reproduction tends to fail (Daniels and Moyle 1983). The California Department of Fish and Game (CDFG) confirms this observation:

> "[S]uccessful reproduction is strongly associated with high outflows preceding, during and following spawning as demonstrated by high correlations between abundance of splittail in the fall midwater trawl survey and various monthly combinations of Delta outflow from the previous

winter through early summer." (CDFG 1992 at p. 2)

Even within their constricted range within the Delta, splittail populations are estimated to be only 35% to 60% as abundant as they were in 1940 (CDFG, 1992), and considered over their historic range, the percentage decline is much greater. Since 1980 splittail numbers in the Delta have declined steadily (Moyle et al. 1986), and they are now (1992) probably the lowest on record (P. Moyle and CDFG, unpubl. data). Population levels appear to fluctuate widely from year to year; CDFG midwater trawl data for 1967-1990 indicate a decline from the mid-1960's to mid-1970's, a resurgence (with fluctuations) through the mid-1980's, and a steady decline since 1986. Survey data for Suisun Marsh (Moyle, unpubl.) show a substantial decline in numbers during the period 1979-1991 (catch per trawl of 7 adults and 15 young-of-year in 1979; 2 adults and 1 young-of-year per trawl in 1991; mean catch in 1979-1983, ca. 188 fish/month, mean catch in 1987-1990, ca. 25 fish/mo., 1990-1991, 3-5 fish/month). Data from the CDFG Bay-Delta survey and fish salvage operations at the state and federal pumping plants in the south Delta indicate that splittail recruitment success is highly variable from year to year. Large pulses of young fish were observed in 1982, 1983 and 1986, but recruitment appeared virtually nonexistent in 1980, 1984, 1985 and 1987-1990. Since 1985, splittail have been rare in San Pablo Bay, reflecting a constriction of their distribution to the upper Bay-Delta areas. Proposed diversion of even more water from the Delta and estuary could cause a rapid decline of splittail populations by eliminating the frequency of successful spawning as well as suitable freshwater habitats. Channelization or riprapping projects that eliminate potential spawning areas in the upper Delta may also contribute to population declines.

6. NATURE AND DEGREE OF THREAT

The threats to a species' survival may be categorized, according to the Endangered Species Act, as follows: "(A) the present, or threatened, destruction, modification, or curtailment of its habitat or range, (B) over-utilization for commercial, recreational, or educational purposes, (C) disease or predation, (D) inadequacy of existing regulatory mechanisms, or (E) other natural or manmade factors affecting its continued existence."

Habitat modification. For Sacramento splittail, the preeminent factor in their decline appears to have been habitat constriction associated with the reduction of water flows and changed hydraulics in the Sacramento-San Joaquin Delta.[17] CDFG (1992) indicates that such changes are probably the largest

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[17] The U.S. Bureau of Reclamation has acknowledged the adverse effects of the delta export facilities on the estuarine fisheries in its testimony to the State Water Resources Control Board in the interim water rights proceeding for the Bay-Delta Estuary:

> ". . . Although there is evidence of other factors, such as toxics, fishing pressure, introduced species and major changes in the food chain, influencing the striped bass decline, the bulk of the evidence is that Delta exports and internal Delta diversions are adversely affecting striped bass and other fish populations.
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> * * *
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> ". . . Reclamation believes the negative impact of Delta diversions on the fisheries

factor contributing to the decline of splittail, but also indicates that "the loss of spawning and nursery habitat from reclamation activities" has been a major contributing factor.

Overexploitation. Although splittail have been harvested as food and bait by sport anglers, there is no evidence that this exploitation has contributed to their decline.

Disease or predation. Splittail are preyed upon by introduced striped bass but they have successfully coexisted with the bass since the introduction. It is possible that increased predation by bass and other predators on splittail drawn into Clifton Court Forebay by the changed hydraulics of the Delta may be a contributing factor in their decline. However, striped bass populations have been declining along with those of splittail.

Inadequacy of regulatory mechanisms. In 1978 the California State Water Resources Control Board adopted flow standards for the Sacramento-San Joaquin Delta and Suisun March in its water rights order D-1485. The water quality measures to protect fish and wildlife were limited to salinity standards, flow requirements and operational constraints for striped bass and salmon only. Additional salinity requirements were established for the Suisun Marsh. Whatever incidental benefit these measures may have afforded the Sacramento splittail was obviously inadequate. This is demonstrated by the precipitous decline in the numbers of several species, including Sacramento splittail and longfin smelt, as documented in this petition, since those measures were put into effect in 1978.

More protective freshwater outflow standards were proposed in 1988. The plan was withdrawn and no new flow standards have been promulgated by the Board.

The Board issued a new water quality control plan for the estuary in 1991. This plan explicitly acknowledged that water diversions are jeopardizing the delta resident fish species, such as the Sacramento splittail, by direct entrainment in the export pumps; diversion of fish through the Delta Cross Channel into the interior Delta; reverse flows in various reaches of the San Joaquin River, Old River and Middle River; and, the lack of flows in some water years to either hold the entrapment zone in the proper location to provide a nursery area for young fish or to move (flush) the young into Suisun Bay and away from the entrapment zones. Because the State Board chose to limit this plan to regulation of salinity rather than freshwater flows through the estuary or export limitations, the State Board deferred consideration of these threats to the fishery. Because this limited approach failed to protect important estuarine habitat, this water quality plan was disapproved by the Environmental Protection Agency as inadequate under federal law.[18]

In recognition of the ongoing deterioration of the estuarine fishery, the Board has been instructed by the Governor to issue an "interim" water rights order by the end of the year to "halt the decline and

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and food chain is largely a consequence of the flow patterns (hydrodynamics) resulting from Delta inflow and CVP/SWP exports. Consequently, any proposed solution must address this important issue if it is to be effective in the long-term." (WRINT-USBR-Exhibit Number 10, p. 8.)

[18] Letter from Daniel W. McGovern, Regional Administrator, U.S.EPA, to W. Don Maughan, Chairman, California State Water Resources Control Board, September 3, 1991.

increase the protection of public trust resources where reasonable".[19]

These delayed, withdrawn and disapproved regulatory responses have frozen estuarine protection since the 1978 measures which the Board itself has acknowledged to be inadequate to protect flow-dependent species such as the splittail. Listing this species (and other Delta species) as threatened or endangered may be the only option available to protect the estuarine ecosystem. Given the downward trends in their abundance and distribution in recent years, water management policies that continue to reduce water outflow through the system, especially in the spring, eventually may precipitate the further population collapse and extinction of Sacramento splittail.

Beyond State Board mandates, the changes in water project operations and other management measures have not proven sufficient to protect the estuarine fish from the effects of water diversions. The Fish and Wildlife Service noted during its testimony before the State Water Resources Control Board in the interim water rights proceeding that the measures that have been implemented in the Delta:

> have been largely structural or operational in nature and have not significantly increased river flow or Delta inflow/outflow."[20]

Other factors. Two other factors may have contributed to splittail decline in recent years: extreme climatic conditions and recently introduced species.

The past 10 years have seen some of the most extreme environmental conditions the estuary has experienced since the arrival of Europeans. The past eight years have been ones of continuous drought, broken only by the record outflows of February 1986. The 1986 flood occurred before the peak spawning season of splittail so it should not have affected reproduction. However, it may have washed large numbers of fish out of the estuary, reducing an already depleted population. The prolonged drought has had two major interacting effects: a natural decrease in outflow and an increase in the proportion of inflowing water being diverted. A natural decline in splittail numbers would be expected from the reduced outflow, presumably because of the reduced availability of spawning and larval rearing habitat. However, the increase in diversions has decreased the survival of splittail through a combination of

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19 Notice of Public Hearing, Consideration of Interim Water Rights Action, Water Right Phase of the Bay-Delta Estuary Proceedings, at p. 2 (May 8, 1992).

20 "Measures that have been implemented in the Delta include: 4-Pumps money for programs and plants of juvenile anadromous fish, winter-run salmon operations in the Delta, special operations in Suisun Marsh, substantial clean up of estuarine waters from point and non-point sources of contaminants, increased protection from harvest and illegal take, barriers for Delta fish protection, improved salvage operations at export pumps, and many others. Substantial upriver improvements include: seasonal raising of Red Bluff Diversion Dam Gates, pulse-flow operations for transport of Coleman Hatchery releases, power bypasses at Shasta, dilution flows for Spring Creed spills, gravel replenishment near Redding, effective screening of Red Bluff diversion intake, intensive Trinity Unit coordination with the Shasta Division, increased hatchery contribution to salmon, and winter-run operations up-river. These many measures have been successfully implemented but fish resources still declined greatly. . . . We note that the referenced measures U.S. Fish and Wildlife Service, "Expert Testimony of United States Fish and Wildlife Service on Recommendations for Interim Protection and Response to Hearing Notice Key Issues," July 6, 1992 (WRINT-USFWS-8). WRINT-USFWS-8 p. 9.

further reduction in habitat, especially in the lower Delta and Suisun Marsh, and increased entrainment of larvae, juveniles, and adults. It is important to recognize that extreme floods and droughts have occurred in the past and splittail have managed to persist through them. However, the splittail historically did not experience the extreme conditions caused by increased diversion of water nor did they have the reduced populations that make recovery from natural disasters much more difficult.

Introduced species are a perpetual problem in the Sacramento-San Joaquin estuary, especially those that are introduced "accidentally" from the ballast water of ships. The most recent problem introductions have been several species of planktonic copepods and an Asiatic clam, *Potamocorbula amurensis*. The copepods are regarded as a problem because they seem to be replacing *Eurytemora affinis*, a native copepod that has been the favored food of larval fish and of opossum shrimp, the favored prey of splittail. Although one of the introduced copepod species *(Sinocalanus doerri)* seems to be harder for larval fish (and perhaps opossum shrimp, L. Meng, unpubl. data) to capture, other introduced copepod species probably do not present the capture problems of *S. doerri* (e.g., Meng and Orsi 1991). The Asiatic clam, in contrast, may have a direct effect on splittail populations because it has become extremely abundant in Suisun Bay, from which it appears to be filtering out most of the planktonic algae, the base of the food web that leads to splittail through opossum shrimp (Nichols et al. 1990). The clam, however, is not a direct cause of the initial decline of splittail because it did not invade until after February 1986, when the estuary's biota had been devastated by immense outflows (Nichols et al. 1990). Also, the splittail occurs in many areas where the clam is not abundant. The clam present abundance may make the recovery of splittail more difficult but it is quite likely that the Asiatic clam will become less abundant in response to (1) increased freshwater outflows, and (2) discovery of it as a food source by fishes such as sturgeon, by invertebrates such as the invading mitten crab, and by diving ducks. A typical pattern for invading species is to have a population explosion in response to optimal conditions at the time of invasion (due to the absence of their predators, parasites, etc.) and then a decline to lower levels as the local ecosystem adjusts to their presence.

7. CURRENT AND RECOMMENDED MANAGEMENT

Principal spawning areas of splittail need to be identified so they can be protected. Habitat requirements of young-of-year splittail, especially for the first month of life, need to be identified to determine special protective measures. The status of splittail populations should be reported annually, based on CDFG fish surveys.

Because successful reproduction is strongly associated with high Delta outflows preceding, during and following spawning (CDFG 1992 at p. 2), additional measures are necessary to limit diversion of water from the Delta and to assure adequate inflow from the lower reaches of the rivers during the spring months.

8. CRITICAL HABITAT

Survival of the Sacramento splittail is dependent on protection of the habitat it needs in all stages of its life. The geographic extent of this critical habitat includes all of the Delta including the Sacramento River up to and including the lower mile of the American River, and the San Joaquin River as far as Modesto and including the lower mile of the Tuolumne River; Suisun Bay, including Suisun Marsh; Napa

Marsh; and all areas fed by Petaluma Creek. As is the case with several other fish species that share this geographical habitat, the physical and biological conditions that are related to adequate Delta outflows are critical. Thus critical habitat for the Sacramento splittail should include the following factors:

1. Adequate fresh water (< 1 ppt) and flooded vegetation in spawning areas during March and April to ensure successful spawning.

2. Periodic flushing flows down the rivers when the splittail are spawning to assure rapid transport of larvae to Suisun and San Pablo Bays.

3. Late spring (April-June)outflows of 12,000 to 14,000 cfs to keep juvenile and larval splittail out of the Delta, to prevent entrainment and exposure to toxic materials.

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