Western Delta Brackish Desalination Study: An Assessment of the Potential Risk to Delta Smelt & Other Sensitive Fish Species Inhabiting the Sacramento-San Joaquin Bay-Delta Estuary to Water Diversions & Discharges Associated with a Potential Western Delta Desalination Facility to Provide New Water Supplies

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Summary of Findings

This assessment is intended to be a broad-based overview of potential biological risk of constructing a desalination plant in the brackish waters of the San Joaquin River near Pittsburg/Antioch, east of Suisun Bay. Installation of a state-of-the-art positive barrier fish screen, as part of the proposed desalination project, would be required as an avoidance and minimization action designed to reduce potential adverse environmental impacts associated with entrainment mortality. The potential adverse effects associated with exposure of aquatic resources to elevated salinity concentrations as part of a brine stream can be avoided and minimized through proper siting and design of the discharge structure. Due to higher salinities occurring within the estuary further downstream in the vicinity of Pittsburg, it would be expected that the size of the discharge for a desalination project would be smaller, based on a lower requirement for mixing and dilution flows prior to discharge, than a discharge located further upstream in the vicinity of Antioch. Additional studies and a detailed engineering assessment would be needed to further investigate a detailed facility siting and design, although preliminary research indicates that the adverse effects on municipal water supplies of potential future conditions within the Delta could be reduced by the flexible operations, largely independent of salinity conditions that could be accommodated by supplemental reliable water supplies provided by a local desalination facility.

Project Need

Municipal, industrial, and agricultural water supplies available within the San Francisco Bay area and other regions of California have been adversely impacted in recent years by regulatory and legal constraints on water diversion operations. These constraints have directly resulted in a reduction in water supply availability as well as the reliability of water supplies from one year to the next. Changes in water quality, including changes in salinity and the costs associated with water supply treatment and disinfection, have also been major concerns in recent years for urban water users. The Sacramento-San Joaquin rivers and Bay-Delta estuary (Figure 1) serves as the major water supply source through direct water diversions for much of California including Contra Costa County as well as diversions from the State Water Project (SWP) and Central Valley Project (CVP) that provide water supplies for both agricultural and municipal usage in areas located south of the Bay-Delta estuary. As a direct result of increasing environmental concerns regarding the overall health and condition of fishery populations inhabiting the Bay-Delta estuary, State Water Resources Control Board water right decisions, increased levels of protection for fish species listed for protection under the California and/or federal Endangered Species Acts (ESA), and increasing constraints and limitations on water diversion operations resulting from state and federal litigation, the availability of water supplies to meet service area demands has declined and the level of uncertainty regarding future water supplies has increased.

Limitations imposed by groundwater quantity and quality, particularly within Contra Costa County and many of the South Bay urban areas, have reduced water supplies and/or reliability. Many water providers such as the Contra Costa Water District, East Bay Municipal Utility District, Alameda County Zone Seven, Alameda County Water District, and Santa Clara Valley Water District rely on surface water diversions, in large part, for both reservoir storage and groundwater recharge. High costs and growing environmental concerns have reduced opportunities for the design and construction of additional surface water storage reservoirs to meet water supply, reliability, and water quality demands.

Given the current and anticipated future constraints on available and reliable water suppliers, there has been renewed interest in recent years in investigating the feasibility of using desalination technology to provide a cost-effective, reliable water supply that could be used to offset and augment declines in surface water diversions, reservoir storage, and groundwater supplies.

A Feasibility Study completed in July 2007 by the Bay Area Regional Desalination Project ranked a generalized East Contra Costa site as the highest among several siting scenarios considered. The San Francisco Bay-Delta estuary (Figure 1) is strategically located in an area having high urban densities and increasing constraints on the ability of surface water diversions to meet local demand. In the past, surface water diversions from the Bay-Delta estuary were limited geographically to upstream freshwater areas to meet urban drinking water quality, however increasing sensitivity regarding the health and condition of the aquatic community inhabiting the freshwater regions of the estuary have made it difficult to develop additional freshwater diversions and exports, as well as increased constraints and limitations on currently existing water diversions. Opportunities exist, however to develop desalination facilities that would utilize brackish estuarine water supplies (e.g., low to moderate salinities ranging from approximately 1 to 15 ppt) as a water supply source for municipal drinking water. Among the key elements in siting a potential brackish water diversion for desalination within the Bay-Delta estuary are considerations of (1) suitable water quality and salinity regimes, (2) proximity to electrical power (3) water rights (4) proximity to existing water conveyance facilities, (5) proximity to urban service areas having a need for increased water supplies, increased water supply reliability, or improved water quality, and (6) located within an area of the estuary where fishery and aquatic related environmental impacts could be avoided or minimized to less than significant levels. Potential locations for a surface water diversion from the Bay-Delta estuary that could support a desalination facility exist along the industrial shoreline of Contra Costa County within the reach of the lower San Joaquin River and Suisun Bay extending from approximately Pittsburg to Antioch (Figure 2).

Fish Populations

The Bay-Delta estuary supports a diverse assemblage of resident and migratory fish and macroinvertebrates (Baxter *et al*., 1999) including species that support commercial and/or recreational fisheries such as striped bass, American shad, white sturgeon, catfish, largemouth bass, and Chinook salmon. The Bay-Delta estuary also supports several fish species which have been identified for protection under the California and/or federal Endangered Species Acts as threatened or endangered species, including winter-run and spring-run Chinook salmon, Central Valley steelhead, green sturgeon, and delta smelt. Other fish species including Sacramento splittail, fall-run/late fall-run Chinook salmon, and longfin smelt have either been proposed or are currently candidate species for ESA protection. In recent years, many of the fish and macroinvertebrate species inhabiting the Bay-Delta estuary have experienced a significant decline in population abundance, including several pelagic fish species such as delta smelt and longfin smelt (commonly referred to as the pelagic organism decline, or POD) that have reached record low levels of abundance. A number of factors have been identified that are thought to affect the abundance and population dynamics of these species including, but not limited to, changes in hydrologic conditions within the estuary as a result of reservoirs and water diversions, entrainment into surface water diversions from the Delta (e.g., SWP, CVP, local agricultural diversions, etc.), exposure to contaminants and toxic substances, and the effects of introduced non-native species on available food supplies and predation mortality for native fish inhabiting the estuary.

Project Impacts

Assessing the potential feasibility for the design, construction, and operation of a brackish water desalination facility located within the Bay-Delta estuary requires consideration of the potential for adverse impacts of the proposed project on the aquatic ecosystem, with specific emphasis on sensitive species such as delta smelt. Project feasibility, costs, and environmental effects also depend on integration of specific project features and operational conditions designed to minimize and avoid adverse environmental impacts to the Bay-Delta aquatic ecosystem. Consideration of potential adverse impacts of desalination facility operations on the aquatic ecosystem includes (1) surface water diversions from the estuary that would potentially result in the entrainment of various fish and macroinvertebrate species; and (2) discharge of a concentrated brine solution generated through the desalination process, which is subsequently discharged to receiving waters within the Bay-Delta estuary.

The Delta Diablo Sanitation District is currently investigating the feasibility of designing and operating a desalination facility that would use a brackish water supply diverted from the estuary. To investigate the feasibility and potential environmental issues associated with a proposed desalination facility on aquatic resources information was compiled to address the following questions:

- Are delta smelt and other sensitive fish species present within the lower San Joaquin River and Suisun Bay between Pittsburg and Antioch that would potentially be susceptible to entrainment resulting from diversion of brackish waters?

- Are sensitive species and life-history stages of the key species, such as those listed for protection under the California and/or federal ESA, present in the vicinity of a proposed surface water intake during only specific seasonal periods or are they present?

- Is there a preferred location within the lower San Joaquin River or Suisun Bay between Pittsburg and Antioch where a surface water intake could be located to reduce or avoid the potential risk of entrainment of sensitive life-history stages of protected species?

- Are there structural components of a proposed surface water diversion, such as a state-of-the-art positive barrier fish screen, that could be used to avoid and minimize the potential vulnerability of various fish species to entrainment?

- Are there operational opportunities to seasonally reduce or curtail diversion operations to avoid or minimize the vulnerability of sensitive fish species to entrainment?

- Are there design and preferred locations for a brine discharge into Bay-Delta estuary receiving waters that would avoid or minimize potential exposure of sensitive fish species to the discharged effluent?

To address these feasibility-level environmental issues, information was compiled on the species composition, seasonal and geographic distribution of a wide variety of fish species and lifestages collected from the Bay-Delta estuary in routine fishery surveys conducted by the California Department of Fish and Game (CDFG). CDFG has conducted extensive fishery monitoring programs within the Bay-Delta estuary, surveying year-round using a variety of sampling techniques, at locations throughout the estuary (Figure 2). Data from these fishery surveys, a number of which extend over a period of several decades, is available for sampling sites in the immediate vicinity of the lower San Joaquin River and Suisun Bay between Pittsburg and Antioch (Figure 3) including data from the CDFG Bay-Delta studies, CDFG 20 mm delta smelt surveys, CDFG summer townet survey, CDFG fall midwater trawl survey, and CDFG Kodiak trawl survey. Specific information available from sampling in the vicinity of Stations 508 and 520 near Pittsburg, and Stations 804 and Station 802 near Antioch, including information on both salinity at these various sampling sites (Appendix B) as well as the species composition and seasonal distribution of various fish species, are particularly relevant as technical foundation for the feasibility study.

Are Fish Present?

Results of the CDFG fishery monitoring surveys were studied to determine species composition, abundance, and distribution throughout the geographic area where the proposed project could be located. Between CDFG 20 mm stations 508, 520, 804, and 802 (Table 1), larval species present are roughly the same, with a varying composition of each species. The lower San Joaquin River and northern reach of Suisun Bay provide habitat for a diverse assemblage of estuarine fish species including delta smelt, longfin smelt, Chinook salmon, steelhead, green and white sturgeon, splittail, striped bass, and a variety of other species. Examining CDFG Bay Study data showed that the species composition observed further downstream in the vicinity of Bay Study Station 535 near Pittsburg (Figure 7; Table 3) included a greater abundance of marine species such as Pacific herring, northern anchovy, and starry flounder, which would be expected based on their higher salinity tolerances, when compared to the lower salinity stations located adjacent to Antioch (Figure 7; Table 3). Similarly, species with lower salinity tolerance such as threadfin shad and largemouth bass were typically more abundant at the freshwater and low salinity stations adjacent to Antioch. The salinity regime, and correspondingly the composition of the fish community, varied substantially within the reach between Pittsburg and Antioch in response to annual and seasonal variation in freshwater inflow to the Delta from the Sacramento and San Joaquin river watersheds and the resultant salinity gradient within the western portion of the Delta. In those years when hydrologic conditions result in low freshwater inflow to the Delta the higher salinity regime generally intruded further to the east resulting in a greater occurrence of species with higher salinity tolerance in the area of Antioch when compared to those periods of high hydrology when Delta inflows are high, lower salinities extend further to the west, and a greater frequency of fish species having lower salinity tolerance are observed further downstream in the vicinity of Pittsburg. For many of the fish species that migrate through the estuary, such as Chinook salmon, steelhead, green and white sturgeon, striped bass, American shad, the area of the lower San Joaquin River and Suisun Bay serves as a migratory corridor for both juvenile migration as well as adult migration and hence these species are present seasonally throughout the reach. Given the distribution of various sensitive resident and migratory fish throughout the reach of the estuary extending from Pittsburg to Antioch no specific location was identified that would avoid the occurrence of sensitive fish species.

Diversion Location

Delta smelt and longfin smelt are two of the resident and pelagic fish species, both of which have experienced substantial declines in population abundance in recent years that inhabit the proposed area between Pittsburg and Antioch. Both of these fish species utilize the Bay-Delta estuary for spawning and juvenile rearing and have planktonic early life-history stages, although longfin smelt tend to prefer high salinity waters. Planktonic larvae passively drift with water currents and therefore would be vulnerable to being diverted into a surface water diversion located in the general area between Pittsburg and Antioch. Because of the small size of these planktonic larvae (< 15mm) they would not be expected to be effectively excluded from entrainment by a state-of-the-art positive barrier fish screen (Weisberg *et al.*, 1987). To examine the geographic distribution of larval delta smelt and longfin smelt, data were compiled from the CDFG 20 mm delta smelt surveys which is conducted during the spring months (Table 4). Results of these analyses show that during dry water years (low Delta inflows) delta smelt larvae tend to occur in higher concentrations (densities) in the general vicinity of Antioch, while longfin smelt larvae tend to occur in higher densities further downstream in the vicinity of Pittsburg (Figure 4). Under higher flow years, both larvae of longfin smelt and delta smelt tend to occur in highest densities further downstream in the vicinity of Pittsburg (Figure 5). Longfin smelt, in particular, tend to prefer higher salinity waters as shown in fishery collections conducted throughout both the San Francisco Bay and Sacramento-San Joaquin Delta, and tend to appear in the eastern-most Delta during the months of February and March, and sometimes as late as April depending on hydrology (Figure 7; see also Table 3, showing higher collections of longfin smelt downstream towards Pittsburg). As part of the in State Water Resources Control Board 1995 Water Quality Control Plan, inflows to the Delta are managed in such a way as to preferentially locate the zone of low salinity (referred to as $X_{2,}$ or the location of the 2 ppt salinity isohaline) further downstream in the vicinity of Chipps Island in Suisun Bay. Many of the early life-history stages of estuarine fish (e.g., Chinook salmon, smelt, splittail, and others) are known to preferentially rear within the low salinity region of the estuary, and densities of many of these fish eggs and larvae tend to be higher further downstream in the vicinity of Pittsburg when compared to results of surveys conducted further upstream near Antioch. Based upon these results, locating a surface water diversion further upstream in the vicinity of Antioch would be expected to contribute to a reduction and minimization in the vulnerability of many of the estuarine fish species to entrainment losses as a result diversion operations under the current WQCP. Locating a surface water diversion in the vicinity of Antioch as part of a desalination project would also provide operational benefits since salinity in the source water in the vicinity of Antioch is typically lower than corresponding salinities further downstream in the vicinity of Pittsburg (Figure 6).

Annual Variability & Vulnerability to Entrainment

Examination of results from the CDFG fishery surveys show that sensitive fish species may inhabit the area of the lower San Joaquin River and Suisun Bay year-round. Many of the anadromous migratory fish, such as Chinook salmon and steelhead, migrate downstream through the estuary as juveniles during the winter and spring months (January through May). Many of the resident fish inhabiting the estuary, including delta smelt, longfin smelt, and striped bass spawn during the late winter and early spring and their planktonic larvae and early juveniles are present within the estuary typically during spring months (March - May). Many of the resident fish species, such as striped bass, which have larger juvenile and subadult lifestages (40 mm in length and above) inhabit the estuary throughout the summer and fall months. Installation of a state-of-the-art positive barrier fish screen as part of a proposed desalination project would be required as an avoidance and minimization action designed to reduce potential adverse environmental impacts associated with entrainment mortality. For a surface water diversion located in the lower San Joaquin River or Suisun Bay the state-of-the-art positive barrier fish screen would be designed to achieve an approach velocity of 0.2 ft/sec or less typically using a flat wedge-wire-type screen design having a screen mesh opening of 1.75 mm or less (see Appendix A for additional intake screen design information). The fish screen would require active continuous mechanical cleaning (e.g., brushes or airburst/water back flushing) to maintain a clean screen surface and uniformity of approach velocities. The intake would be located within a tidally influenced region of the estuary and therefore would need to accommodate both upstream and downstream tidal flows that would not meet conventional sweeping flow criteria.

Although detailed engineering design or cost estimates have not been developed for a positive barrier fish screen for a full-sized desalination facility, a general order-of-magnitude cost estimate is approximately $25,000 per cfs of water diverted. Based on this general rule-of-thumb estimate, the cost of a fish screen for a project designed to divert 250 cfs (161 mgd) would be approximately $6.25 million and a fish screen designed for a diversion rate of 700 cfs (452 mgd) would be approximately $17.5 million. The actual cost of an intake structure and fish screen would vary based on features of the site, infrastructure, and other factors.

Information developed through monitoring of various types of fish screen facilities within the Delta and elsewhere, as well is results of experimental laboratory studies, have demonstrated that a state-of-the-art positive barrier fish screen is an effective method for reducing and avoiding entrainment of larger juvenile, subadult, and adult fish species that may occur in the vicinity of the intake, such as juvenile Chinook salmon, juvenile steelhead, green and white sturgeon, juvenile and adult delta smelt and longfin smelt. Because of the small size and planktonic nature of fish eggs and larvae these early life-history stages would be vulnerable to entrainment through the positive barrier fish screen mesh. Results of laboratory studies (Weisberg *et al.* 1984) have shown that a fish screen having 1 mm mesh opening is expected to be approximately 99.9% effective in excluding fish greater than 15 mm in length, while a fish screen having a 2 mm screen mesh opening is expected to be approximately 99.5% effective in excluding fish greater than 15 mm. Based upon the 1.75 mm screen mesh opening assumed to be used in a positive barrier fish screen located in the Bay-Delta estuary in the vicinity of either Pittsburg or Antioch, it is estimated that the positive fish screen would be effective in excluding the larval stages of species such as delta smelt and longfin smelt greater than approximately 15 mm in length. Larval fish less than 15 mm in length would continue to be vulnerable to potential entrainment at the surface water diversion. As part of a proposed desalination project pilot study, it is likely that fishery monitoring would be required to document the effectiveness of the fish screen in excluding sensitive fish from entrainment.

Inter-Annual Variability

The value and benefits of the reliability of a desalination facility water supply would be greatest during dry and critically dry water years when naturally occurring water supplies from conventional reservoirs and water diversions are reduced. Under these dry hydrologic conditions, salinity intrusion into Suisun Bay and the western Delta is greater than under wetter hydrologic conditions and the geographic distribution of many of the fish species is typically located near the confluence between the Sacramento and San Joaquin rivers. Under these hydrologic conditions, and assuming a state-of-the-art-positive barrier fish screen and comparable diversion operations, there would be little or no expected difference to fishery resources between a diversion located in the vicinity of Antioch or a diversion located further downstream near Pittsburg. Migratory fish such as juvenile salmon, steelhead, and sturgeon, would pass in the vicinity of a diversion located at either Antioch or Pittsburg during their upstream and downstream migrations and would be protected at either location by the positive barrier fish screen. Seasonal reductions in diversion operations to reduce and avoid the risk of entrainment of larval lifestage of species such as delta smelt would be expected to be comparable for an intake sited in the vicinity of either Antioch or Pittsburg based on their relatively close proximity, interannual variation in salinity distributions and the distribution of sensitive fish species, and the effects of tidal movement within the area.

One of the advantages of a desalination facility located within the Delta would be the ability to accommodate flexible operations independent of the range of salinity conditions occurring within the source waters. Given this operating flexibility it would be possible to design a facility that would allow reductions in diversion operations during a seasonal period to reduce and avoid entrainment of larval fish (e.g., reduce diversions during the spring months of April and May by 50%) while subsequently increasing water diversion rates later in the summer and fall (e.g., increase diversions during July and August by 50%) when fish are less vulnerable to diversion effects. A sampling program at the pilot desalination plant, much like efforts that have been undertaken by other municipal desalination facilities, as well as new screened water intake diversions, would be able to further provide information on the facility’s screen efficiency. Through flexible desalination facility operations, in combination with conjunctive operations with reservoirs and other facilities within a municipal water districts service area or upstream storage and delivery facilities, the project could provide environmental protection while also achieving a substantially greater level of water supply reliability, independent of water-year type and seasonal hydrologic and salinity conditions.

Given the current declines in many of the fishery resources within the Delta, and the increasing constraints on diversions and upstream reservoir operations to protect an increasing number of fish species listed for protection under the California and/or federal Endangered Species Act, the capacity and reliability of water supplies from the Delta to support municipal service areas within the Bay Area (e.g., Alameda County Zone 7, Alameda County Water District, Contra Costa Water District, East Bay Municipal Utility District) as well as increasing environmental concerns and constraints on water supplies from other sources such as Alameda Creek, the Tuolumne River, and others to increase habitat and the level of protection for fishery resources and their habitat will continue to constrain and reduce municipal water supplies from these and other sources. These environmental constraints (and an anticipated increasing level of concern and constraint in the future) on water supplies and reliability are greatest during dry and critically dry water years. Furthermore, water quality conditions within the Delta are also an increasing constraint on local water supplies, particularly in dry and critically dry years, when supplemental supplies from a desalination facility would be of greatest benefit. In response to the observed declines in many of the Delta fishery resources, there is also increasing interest in modifying salinity management within the estuary to achieve a greater level of seasonal and interannual variation in salinity and to reduce the effects of increased diversion operations from the SWP and CVP and other diversions during the fall months. The adverse effects on municipal water supplies of these potential future conditions within the Delta could be reduced by the flexible operations, largely independent of salinity conditions that could be accommodated by supplemental reliable water supplies provided by a local desalination facility.

Expected Screen Requirement

Typically a small pilot-scale on-site test facility would be constructed and the mechanical systems and processes for desalination would be tested over the period of approximately one year prior to a decision to design and construct a full-scale production facility. The pilot-scale test facility may divert and process estuarine water supplies at a rate of approximately 5 to 10 million gallons per day (MGD; 7.75 to 15.5 cfs). During pilot-scale testing of a desalination facility for the Marin Municipal Water District located in Richardson Bay near the Richmond-San Rafael Bridge, state and federal resource agencies requested that sampling be conducted to determine the efficiency of a positive barrier fish screen in excluding fish and macroinvertebrates from being entrained into the desalination plant. Given the biological sensitivity of water diversions from the Bay-Delta estuary in the vicinity of Antioch, similar entrainment monitoring and validation of the performance of a fish screen in reducing and avoiding adverse impacts to fishery resources would be expected if a pilot-scale test facility were to be tested.

Based on the experience in designing and operating larger water diversions located within the Delta (e.g., Contra Costa Water District Old River intake, Contra Costa Water District Alternative Intake Project (AIP), Freeport diversion, and others) expanding the size of a positive barrier fish screen design to a full-scale desalination facility with a diversion capacity in the range of 150 to 450 mgd (233 to 698 cfs) is within the range of diversion capacities currently in operation in the Delta (CCWD Old River and AIP diversions) or within the range of diversion capacities currently under investigation for other municipal water supplies. The design and operation of the full-scale diversion facility would need to meet the fish screen performance criteria (e.g., 0.2 ft/sec approach velocity, and other criteria) established to protect sensitive fish species such as delta and longfin smelt, juvenile salmon and steelhead, and other resident and migratory fish species. Current experience with water diversions located primarily on the Sacramento River (e.g., RD 108 Wilkins Slough fish screen, City of Sacramento diversion, Freeport diversion, Old River diversion) have demonstrated the feasibility of designing, constructing, and operating large-scale water diversions equipped with positive barrier fish screens that would be directly applicable to a full-scale desalination facility located within the Delta.

As a result of their small size and planktonic nature (low swimming ability) it is assumed that early life-history stages ($\leq$ 15 mm) of fish species having planktonic larvae, such as both delta smelt and longfin smelt, would continue to be vulnerable to entrainment into the surface water diversion from the estuary during the seasonal period that they occur in the vicinity of the diversion. Examination of results from the CDFG 20 mm delta smelt survey show that larval stages of both longfin smelt and delta smelt occur in the estuary during the late winter and early spring months (March - mid-May: Figures 4 and 5) with their distribution located further downstream in Suisun Bay in those years when spring Delta inflows are high and with fish located further upstream in those years when spring Delta inflows are low. Using this information on seasonal and geographic distribution of sensitive fish larvae, operational strategies can be developed for a surface water diversion located within the estuary that would be operated to avoid and minimize the potential vulnerability of larval longfin and delta smelt to entrainment losses. The primary component of the avoidance and minimization strategy is to reduce and/or curtail diversion operations during the seasonal period when planktonic larvae would be in the immediate vicinity of the diversion location. Reduction or curtailment of diversion operations, therefore, may occur during the spring months when the early life-history stages of longfin and delta smelt are present within the estuary. In those years when Delta inflow is high, and evidence from CDFG surveys demonstrates that the distribution of larval fish is located further downstream in Suisun Bay, diversion operations may be relaxed, reflecting the lower vulnerability to entrainment of larval lifestages under these circumstances.

Conclusion for Screen Requirements

The combination of a positive barrier fish screen designed and operated to protect delta smelt and other fish, and seasonal diversion operations, is expected to be effective in reducing and avoiding diversion related losses of delta smelt and longfin smelt, and other resident and migratory fish inhabiting the estuary.

Brine Impacts

Potential adverse effects associated with exposure of aquatic resources to elevated salinity concentrations as part of a brine stream can be avoided and minimize through proper sitting and design of the discharge structure. The Bay-Delta estuary between Pittsburg and Antioch includes a strong salinity gradient that can be used to help site a brine discharge. The brine discharge should be located near the channel bottom, away from obstructions, in an area of the channel influenced by both ebb and flood tidal currents that promote plume dispersal. The discharge may also need to be designed to include subsurface multi-port diffusers and an ambient water Venturi injection located within the discharge pipe upstream of the point of discharge. Through proper discharge siting, diffuser design, and matching salinities within the discharge with general seasonal salinity patterns within the estuary, the salinity of the discharge can approximate ambient receiving water conditions within a small zone of initial dilution.

Assuming that a desalination facility removed 50% of the freshwater and thereby doubled the salinity within the discharge, a full-scale discharge of 150 to 350 cfs could be designed that would promote rapid mixing within the receiving waters, particularly given the strong tidal currents and mixing within Suisun Bay, that could avoid significant adverse impacts on water quality and fishery habitat conditions within the estuary. In addition, the water discharged from a full-scale desalination facility would be returned to the estuary and would continue to provide Delta outflows and flows downstream into the estuary that support habitat for a variety of estuarine fish and macroinvertebrate species. Given the higher salinities that occur within the estuary further downstream in the vicinity of Pittsburg, it would be expected that the size of the discharge for a desalination project would be smaller, based on a lower requirement for mixing and dilution flows prior to discharge, than a discharge located further upstream in the vicinity of Antioch, however, details of facility siting, engineering design, and cost have not been developed. Potential species effects and/or benefits have also not been thoroughly evaluated, and a more detailed biological assessment would be needed to make those determinations. Siting of the discharge would depend, in part, on availability of pipeline corridors and conveyance facilities, existing discharge facilities, and the anticipated seasonal volume and concentration of the discharge relative to ambient receiving water salinity conditions.

Through these design considerations potential adverse effects of the brine discharge on water quality conditions and fish and macroinvertebrate species inhabiting the estuary are expected to be reduced to less than significant levels.

Figures and Tables

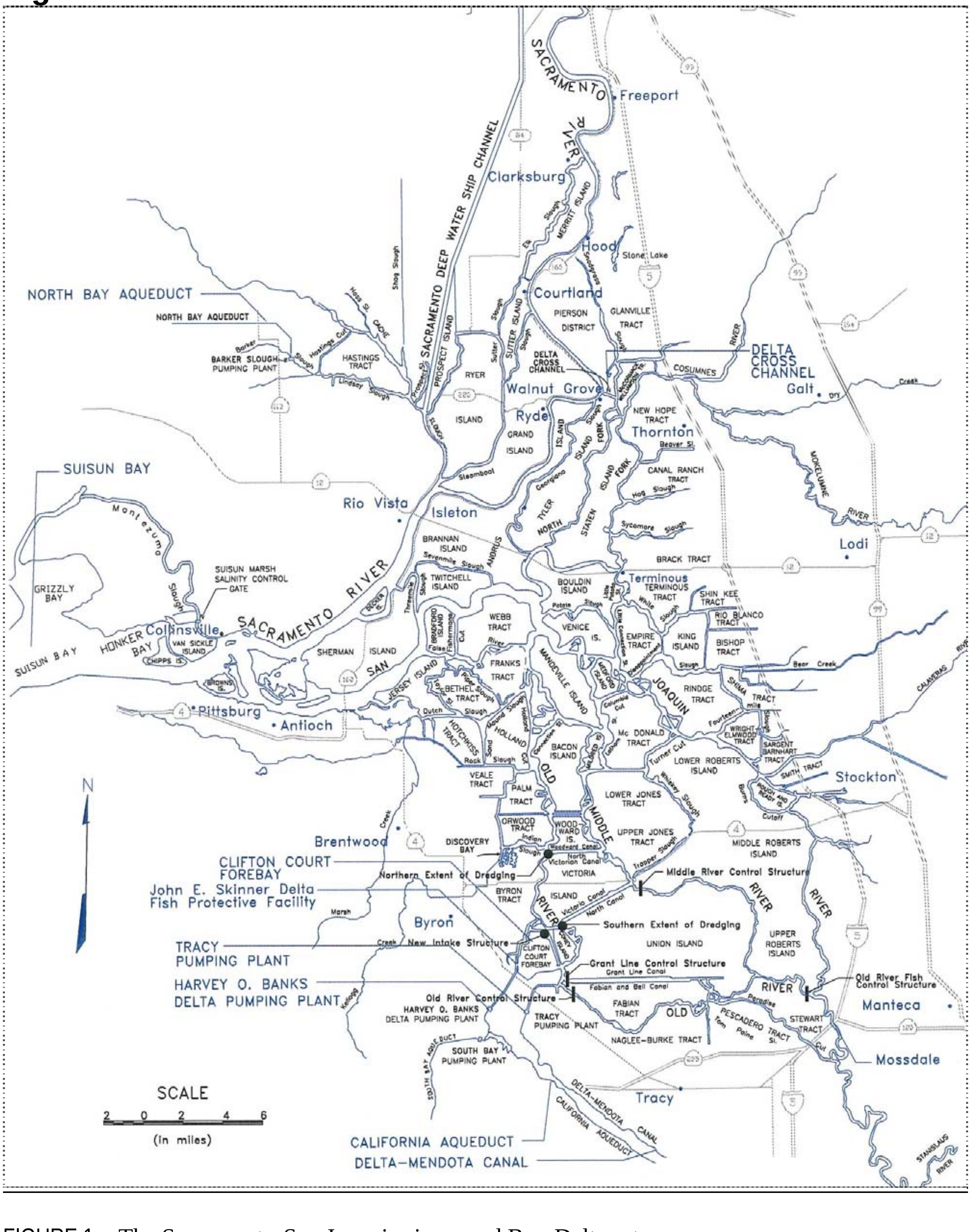


FIGURE 1. The Sacramento-San Joaquin rivers and Bay-Delta estuary.

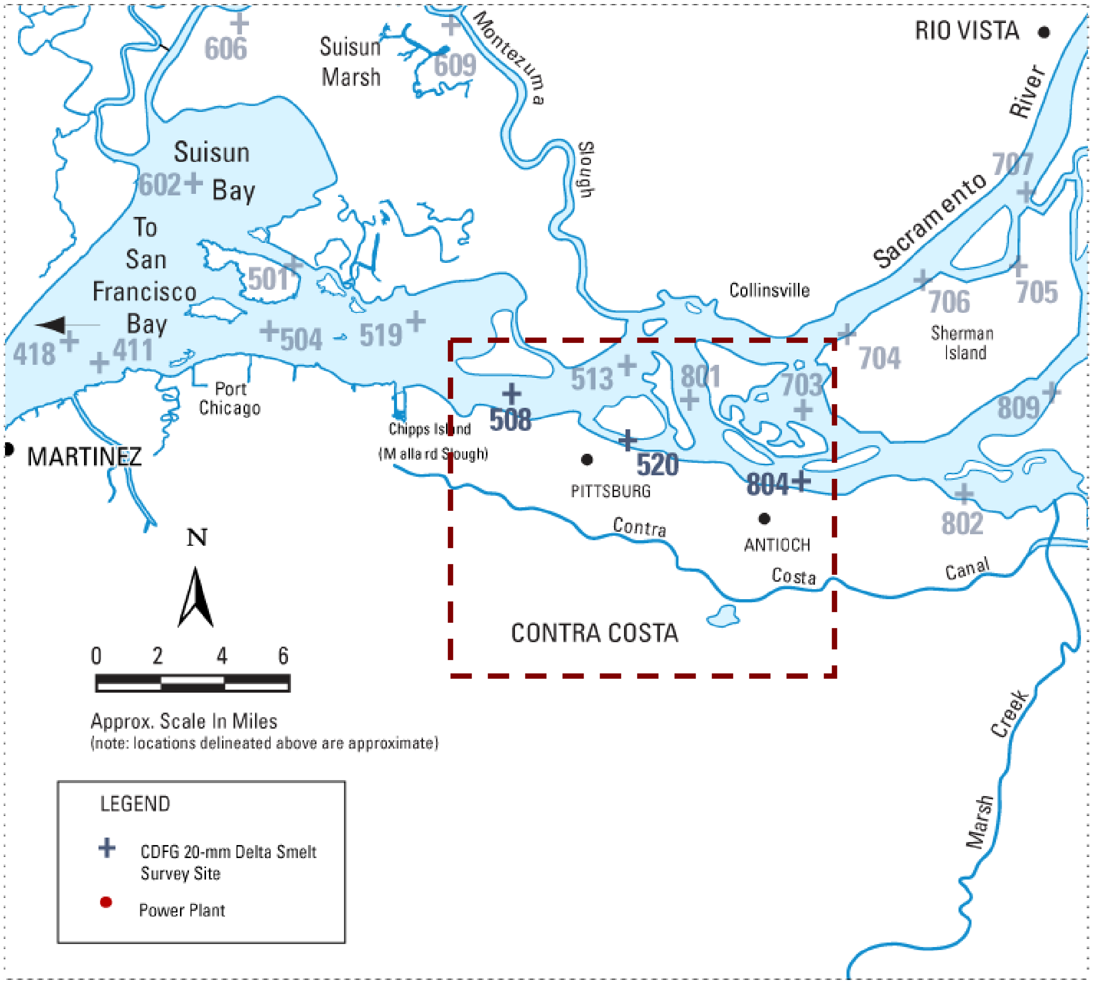


FIGURE 2. Area of potential locations for a surface water diversion from the Bay-Delta estuary that could support a desalinization facility exist along the industrial shoreline of Contra Costa County within the reach of the lower San Joaquin River and Suisun Bay extending from approximately Pittsburg to Antioch.

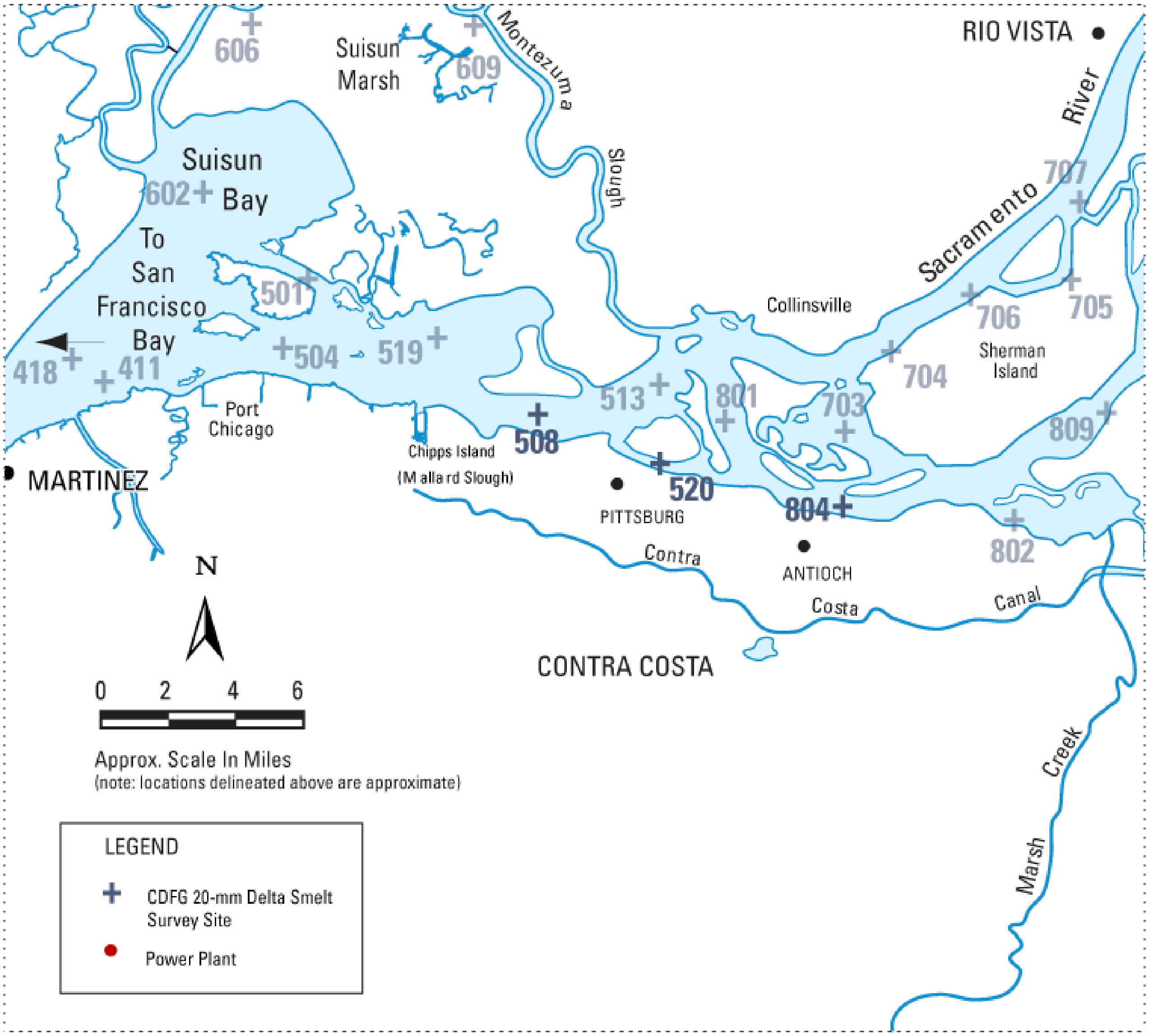


FIGURE 3. CDFG has conducted extensive fishery monitoring programs within the Bay-Delta estuary, surveying year-round using a variety of sampling techniques, at locations throughout the estuary.

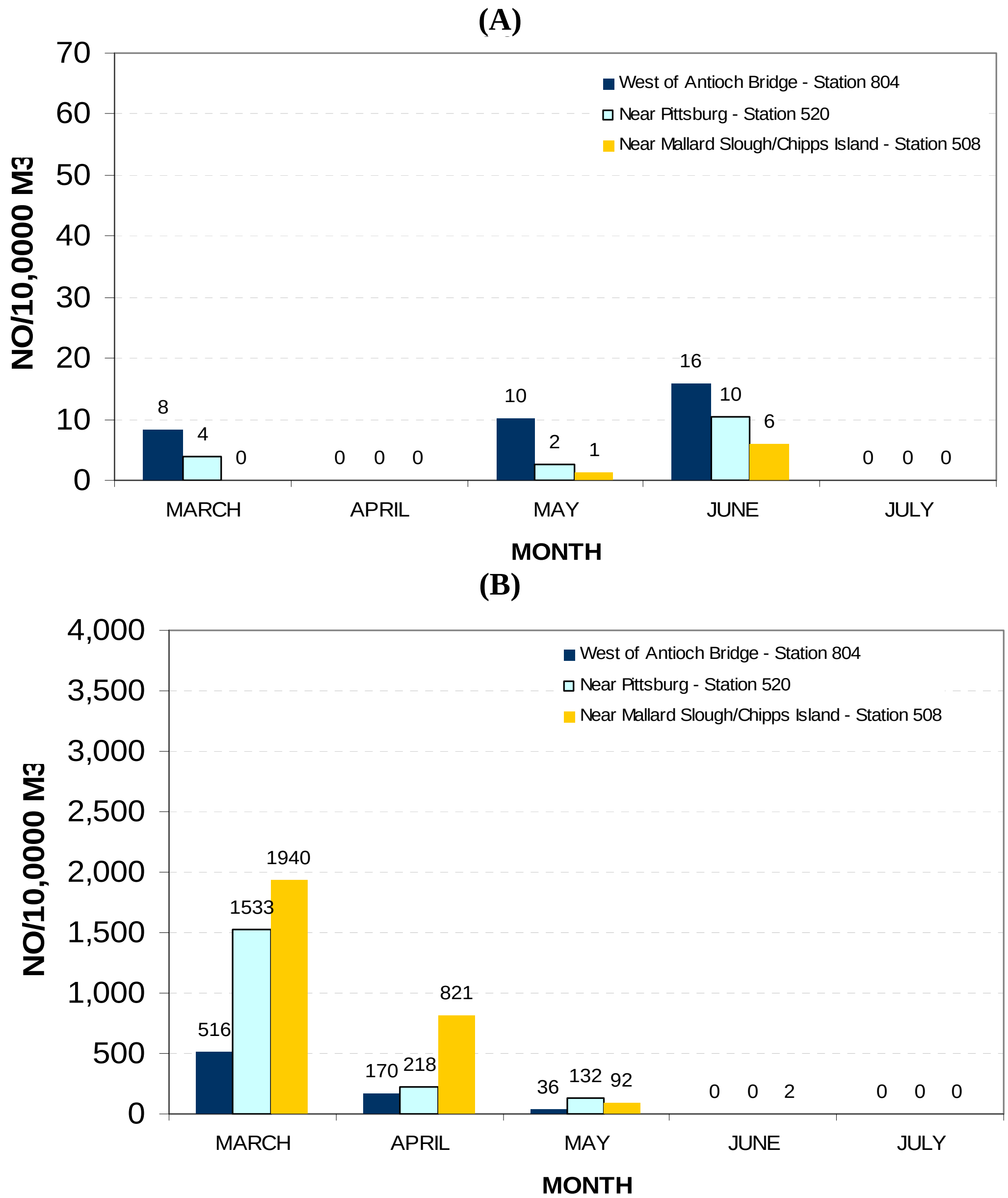
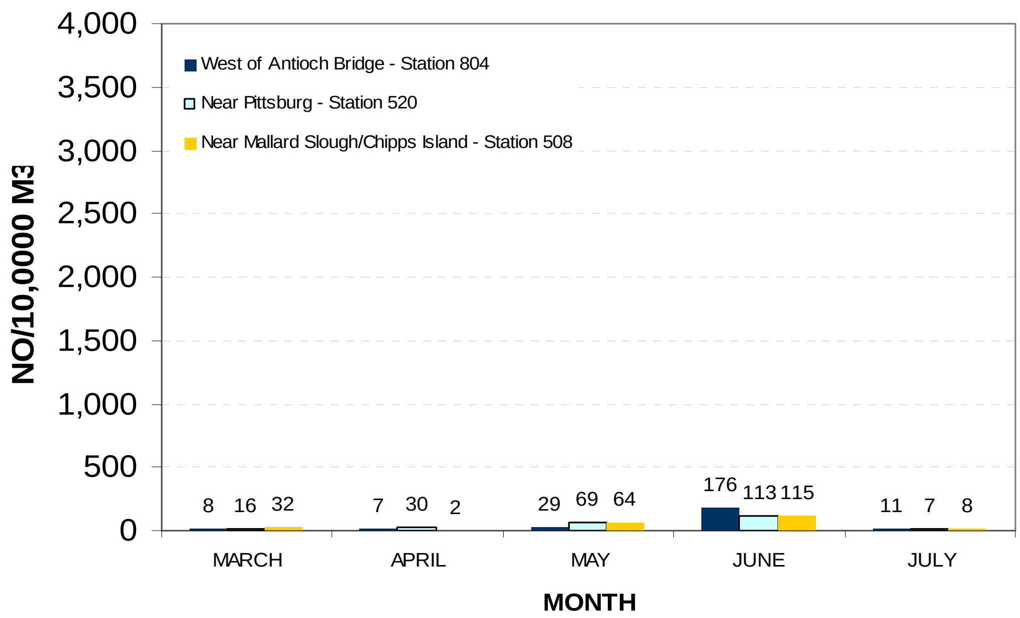


FIGURE 4. During dry water years (low Delta inflows) (e.g., 2001) delta smelt larvae (A) tend to occur in higher concentrations (densities) in the general vicinity of Antioch, while longfin smelt (B) larvae tend to occur in higher densities further downstream in the vicinity of Pittsburg (source: CDFG 2008a).

(A)



(B)

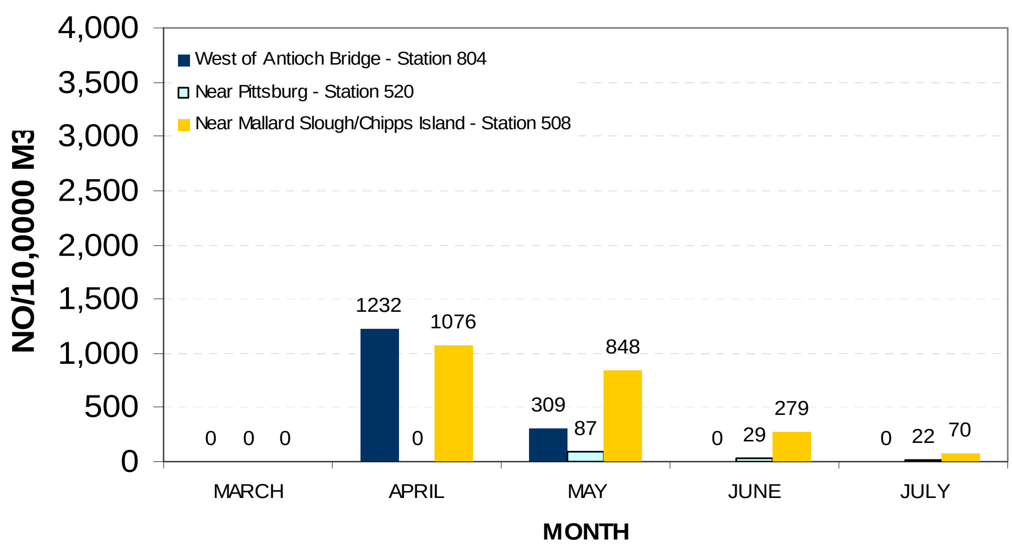


FIGURE 5. Under higher flow years (high Delta inflows) (e.g., 2000), both larvae of delta smelt (A) and longfin smelt (B) tend to occur in highest densities further downstream in the vicinity of Pittsburg (source: CDFG 2008a).

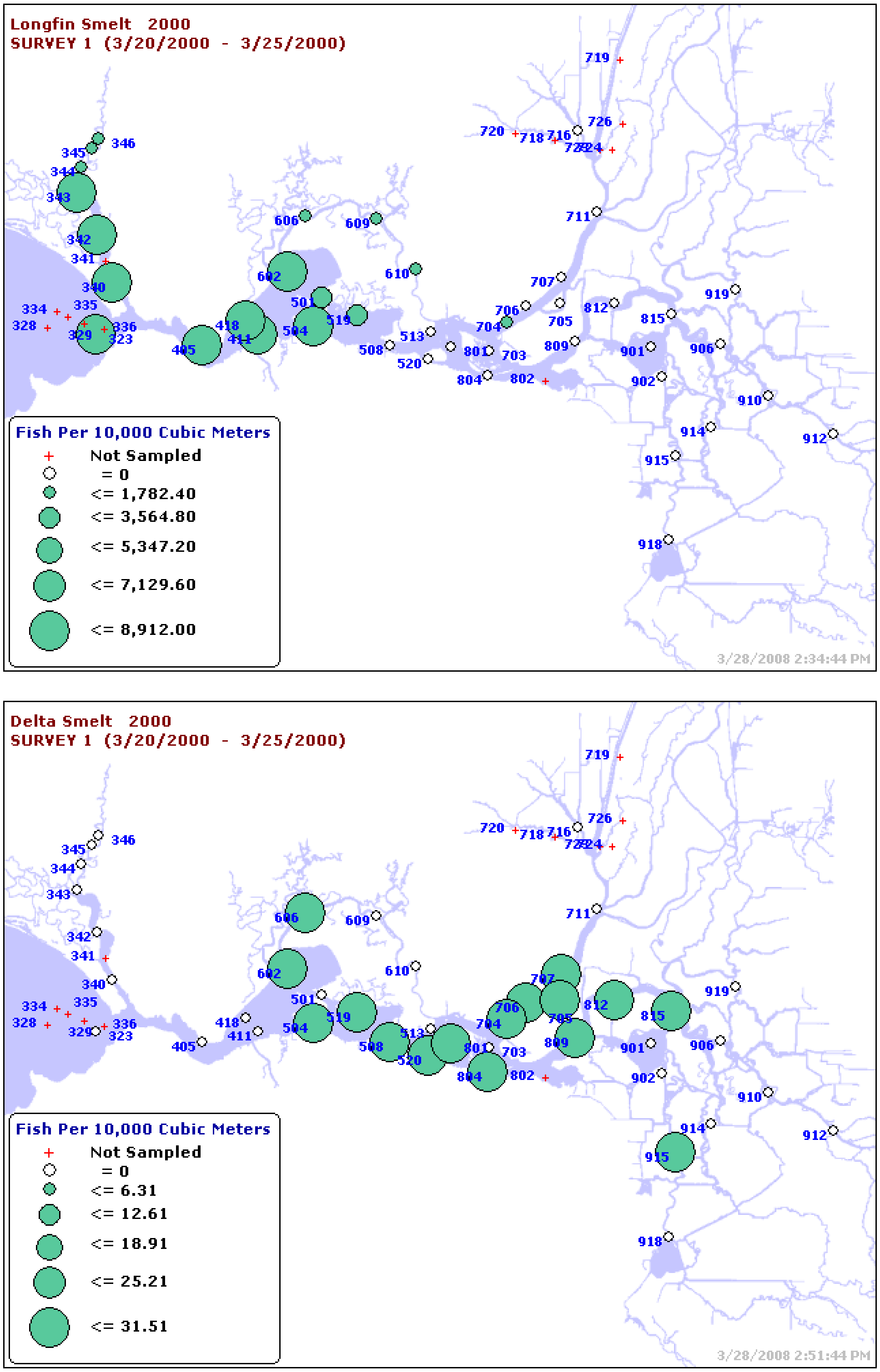
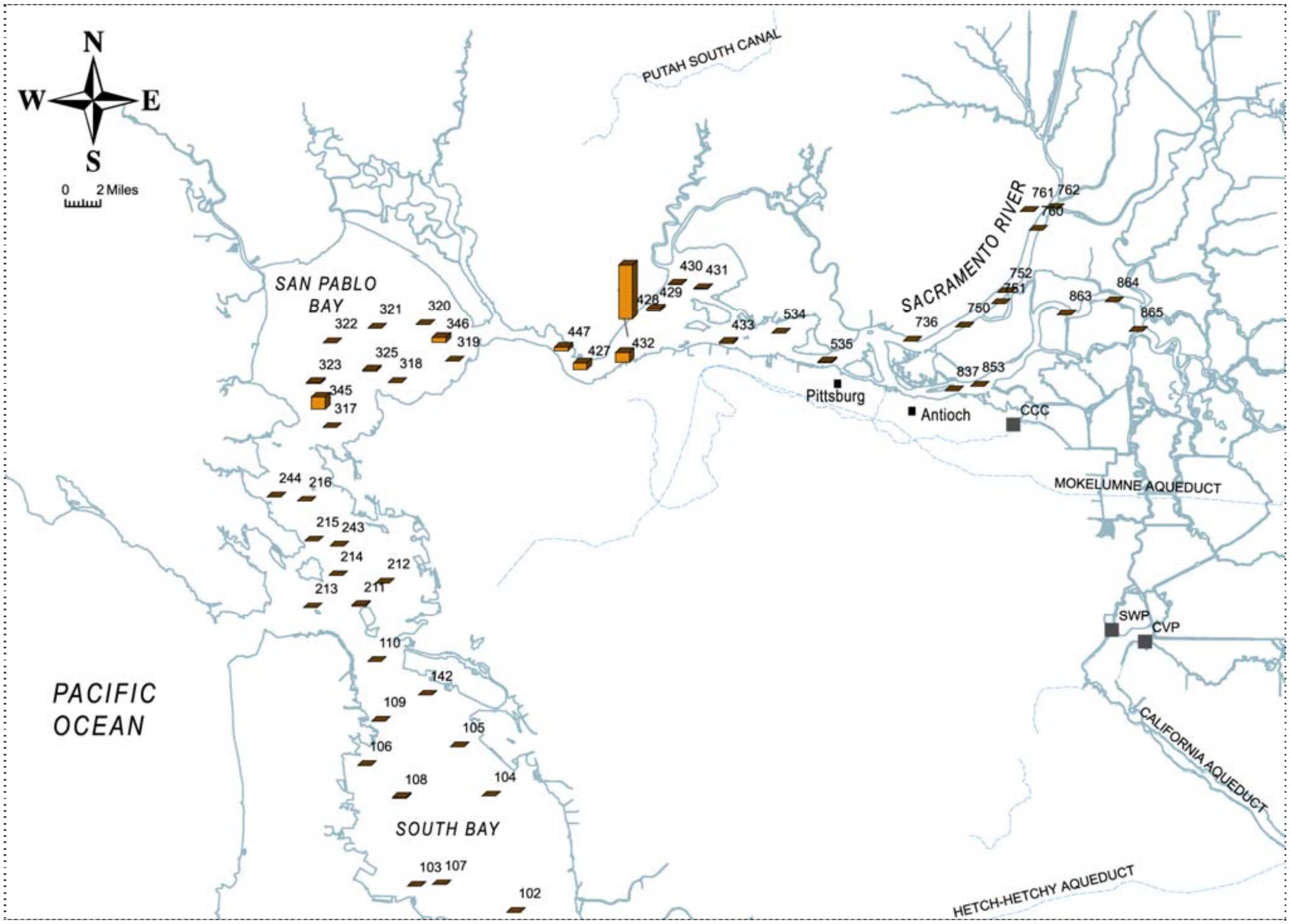


FIGURE 6. Under higher flow years (e.g., 2000), both larvae of delta smelt (A) and longfin smelt (B) tend to occur in highest densities further downstream in the vicinity of Pittsburg (source: CDFG 2008b).

(A) FEBRUARY



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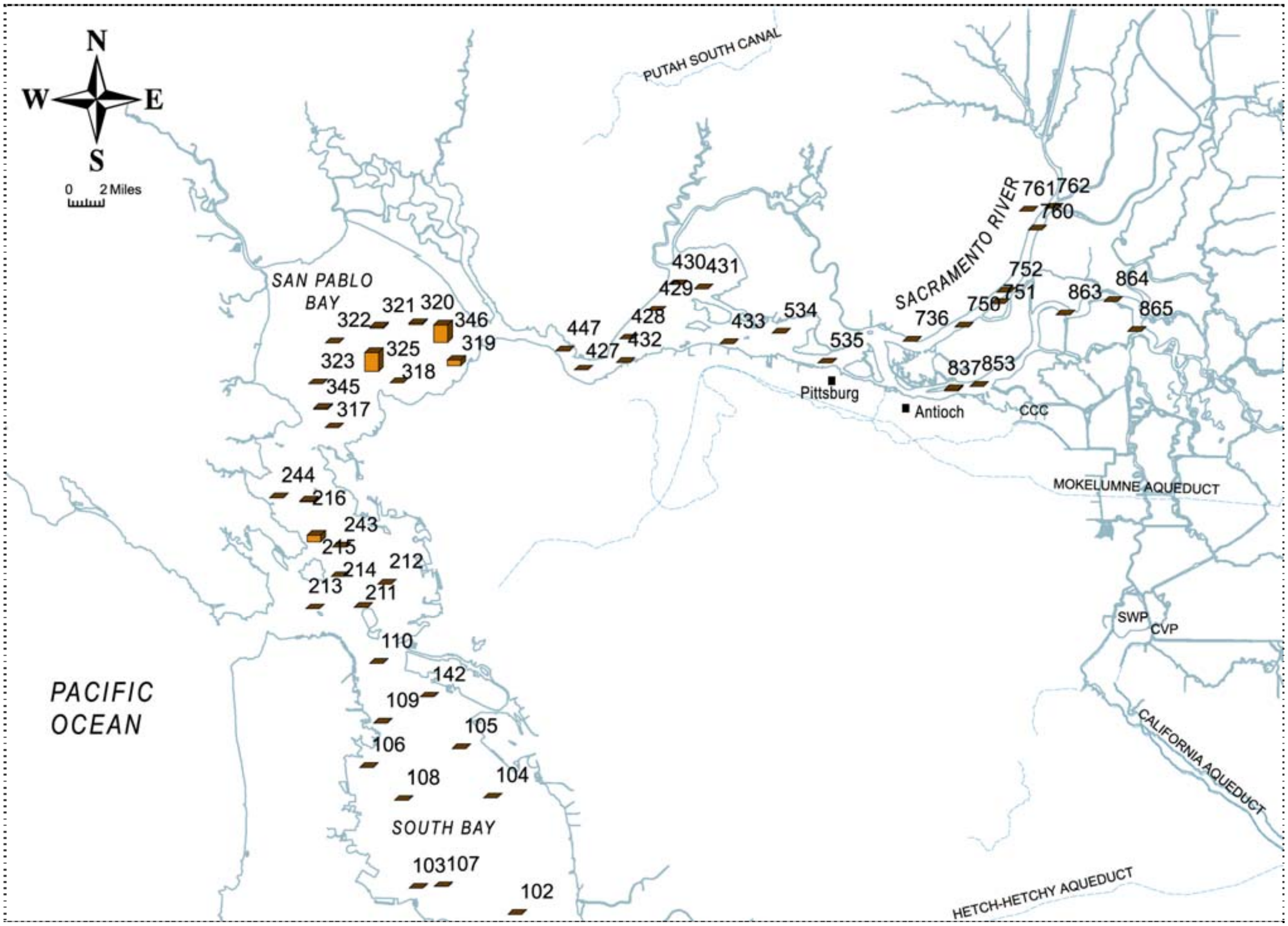
0 2 Miles
PUTAH SOUTH CANAL
SAN PABLO BAY
SACRAMENTO RIVER
Pittsburg
Antioch
CCC
MOKELUMNE AQUEDUCT
SWP
CVP
CALIFORNIA AQUEDUCT
HETCH-HETCHY AQUEDUCT
PACIFIC OCEAN
SOUTH BAY

(B) MARCH


N
W
E
S
0 2 Miles
PUTAH SOUTH CANAL
SAN PABLO BAY
SACRAMENTO RIVER
761
762
760
430
431
429
428
432
427
447
433
534
535
736
752
751
750
863
864
865
837
853
Pittsburg
Antioch
CCC
322
321
320
346
325
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SOUTH BAY
PACIFIC OCEAN
MOKELUMNE AQUEDUCT
SWP
CVP
CALIFORNIA AQUEDUCT
HETCH-HETCHY AQUEDUCT

(C) APRIL

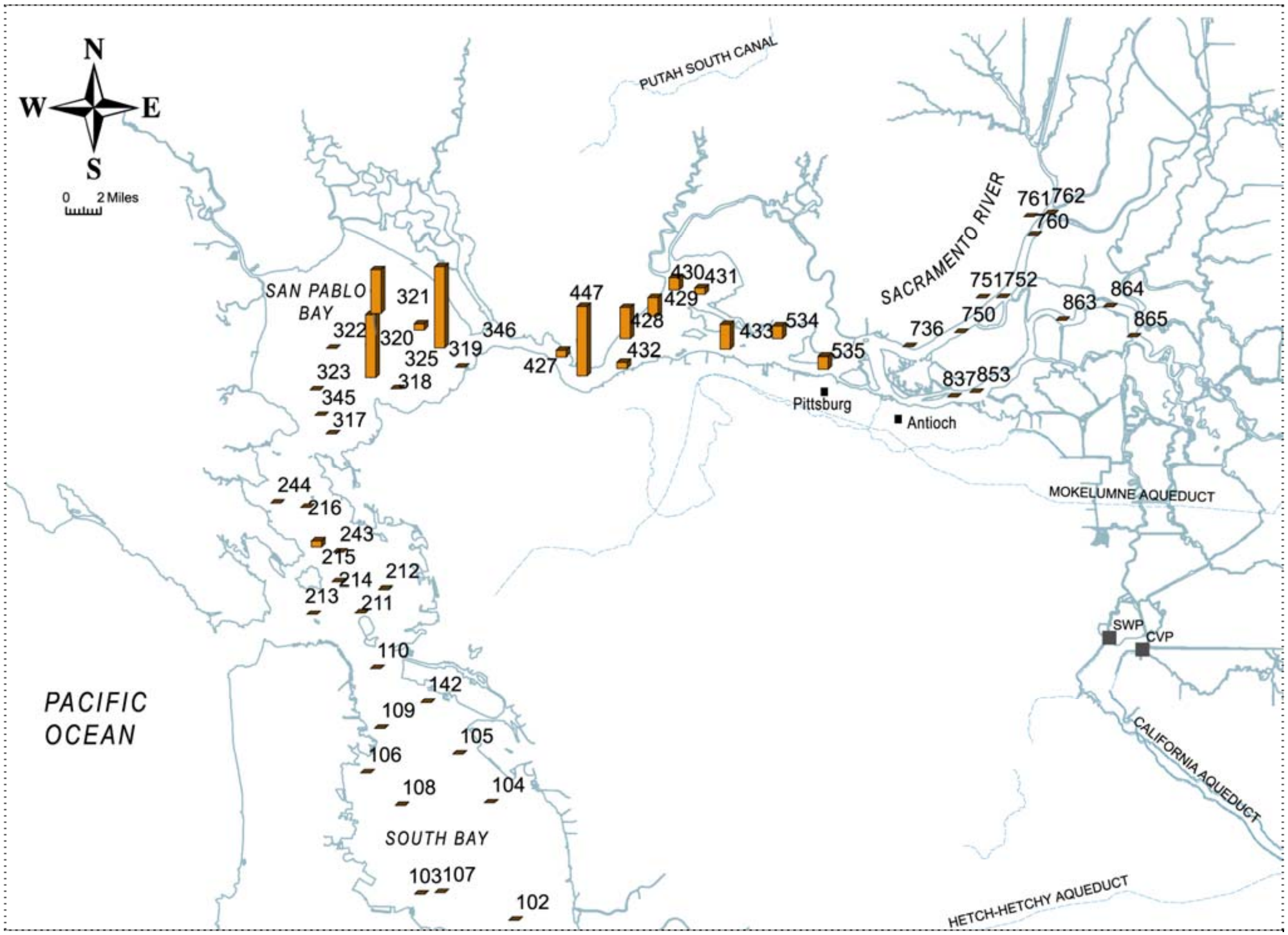


FIGURE 7. Distribution and abundance of total longfin smelt collected at CDFG Bay Study midwater trawl sampling sites, which survey the central and western Delta, and San Francisco Bay, during (A) March (B) April (C) April 1980-2005 (note: flat bar graphs indicate sites where sampling occurred but no longfin smelt were caught) (souce: CDFG 2005).

TABLE 1. Species composition of CDFG 20 mm survey during March and April 2000 (source: CDFG 2008a) (note: limited data was from collected at Station 802 in 1995-1996, and thus, comparable catch is not reported in this table).

MARCH						
	Station 508		Station 520		Station 804	
SPECIES	% of total	catch	% of total	catch	% of total	catch
Prickly Sculpin	62.5%	15	89.6%	43	86.4%	19
Delta Smelt	33.3%	8	8.3%	4	9.1%	2
Splittail	4.2%	1	0.0%	0	0.0%	0
Channel Catfish	0.0%	0	2.1%	1	0.0%	0
Pacific Staghorn Sculpin	0.0%	0	0.0%	0	4.5%	1
TOTAL		24		48		22

APRIL						
SPECIES	Station 508		Station 520		Station 804	
	% of total	catch	% of total	catch	% of total	catch
Longfin Smelt	94.9%	540	87.2%	598	96.6%	688
Prickly Sculpin	1.8%	10	6.9%	47	1.5%	11
Striped Bass	1.8%	10	2.8%	19	0.6%	4
Wakasagi	0.9%	5	0.1%	1	0.3%	2
Yellowfin Goby	0.4%	2	0.4%	3	0.1%	1
Delta Smelt	0.2%	1	2.3%	16	0.6%	4
Three Spine Stickleback	0.2%	1	0.0%	0	0.0%	0
Sacramento Sucker	0.0%	0	0.1%	1	0.0%	0
Centrachids	0.0%	0	0.1%	1	0.0%	0
Bay Goby	0.0%	0	0.0%	0	0.1%	1
White Catfish	0.0%	0	0.0%	0	0.1%	1
TOTAL		**569**		**686**		**712**

TABLE 2. Species composition of CDFG Bay Study survey otter trawl (a bottom trawling survey) and midwater trawl during March, 1980-2005, near Antioch (Station 837) (source: CDFG 2005).

OTTER TRAWL		
SPECIES	% OF TOTAL CATCH	TOTAL CATCH (1980-2005)
Striped Bass	60.7%	133
Channel Catfish	16.0%	35
Bigscale Logperch	5.5%	12
Tule Perch	5.0%	11
White Catfish	3.7%	8
Starry Flounder	3.2%	7
Shimofuri Goby	2.3%	5
Splittail	1.8%	4
Chinook Salmon	1.4%	3
Delta Smelt	0.5%	1
TOTAL		219

MIDWATER TRAWL		
SPECIES	% OF TOTAL CATCH	TOTAL CATCH (1980-2005)
Delta Smelt	29.2%	14
Striped Bass	29.2%	14
American Shad	10.4%	5
Chinook Salmon	10.4%	5
Longfin Smelt	10.4%	5
Threadin shad	4.2%	2
Steelhead	2.1%	1
Shimofuri Goby	2.1%	1
Splittail	2.1%	1
TOTAL		48

TABLE 3. Species composition of CDFG Bay Study survey otter trawl (a bottom trawling survey) and midwater trawl during March, 1980-2005, near Pittsburg (Station 535) (source: CDFG 2005).

OTTER TRAWL		
SPECIES	% OF TOTAL CATCH	TOTAL CATCH (1980-2005)
Chinook Salmon	26.7%	28
Striped Bass	23.8%	25
Longfin Smelt	22.9%	24
Northern Anchovy	7.6%	8
Splittail	4.8%	5
Pacific Herring	3.8%	4
Delta Smelt	3.8%	4
Shimofuri Goby	1.9%	2
Steelhead	1.0%	1
River Lamprey	1.0%	1
Starry Flounder	1.0%	1
Pacific Staghorn Sculpin	1.0%	1
White Sturgeon	1.0%	1
TOTAL		105

MIDWATER TRAWL		
SPECIES	% OF TOTAL CATCH	TOTAL CATCH (1980-2005)
Longfin Smelt	66.1%	78
Striped Bass	21.2%	25
Shimofuri Goby	3.4%	4
Delta Smelt	3.4%	4
Chinook Salmon	2.5%	3
Green Sturgeon	0.8%	1
Steelhead	0.8%	1
White Sturgeon	0.8%	1
Channel Catfish	0.8%	1
TOTAL		118

TABLE 4. Delta smelt lifestages represented by various agency survey data.

<table>
<tr><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sept</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td colspan="5"></td><td colspan="4">JUVENILES [Townet survey]</td><td colspan="3"></td></tr>
<tr><td colspan="2"></td><td colspan="6">LARVAE to EARLY JUVENILES [20 mm survey]</td><td colspan="4"></td></tr>
<tr><td colspan="4">ADULTS [fall midwater trawl survey]</td><td colspan="3"></td><td colspan="4">JUVENILES [fall midwater trawl survey]</td><td>ADULTS [fall midwater trawl survey]</td></tr>
</table>

TABLE 5. Longfin smelt lifestages represented by various agency survey data.

<table>
<tr><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sept</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td colspan="5"></td><td colspan="4">JUVENILES [Townet survey]</td><td colspan="3"></td></tr>
<tr><td colspan="2"></td><td colspan="6">LARVAE to EARLY JUVENILES [20 mm survey]</td><td colspan="4"></td></tr>
<tr><td colspan="4">ADULTS [fall midwater trawl survey]</td><td colspan="3"></td><td colspan="4">JUVENILES [fall midwater trawl survey]</td><td>ADULTS [fall midwater trawl survey]</td></tr>
</table>

References

Baxter, R,K. Hieb, S. DeLeon, K. Fleming, and J. Orsi. 1999 (November). Report on the 1980–1995 Fish, Shrimp, and Crab Sampling in the San Francisco Estuary, California. The Interagency Ecological Program for the Sacramento-San Joaquin Estuary. Technical Report 63.

California Department of Fish and Game (CDFG). 2008a. 20 mm Survey Data. ftp://ftp.delta.dfg.ca.gov/Delta%20Smelt/

California Department of Fish and Game (CDFG). 2008b. 20 mm Delta Smelt: Fish Distribution Map. http://delta.dfg.ca.gov/data/20mm/CPUE_map.asp

California Department of Fish and Game (CDFG). 2005. Bay Study Otter Trawl and Midwater Trawl Data.

Intake Screens, Inc. 2007. ISI Brushed Cylinder Intake/Fish Screens. <http://www.intakescreensinc.com/Cylinder-Screens.aspx>

Weisberg, S.B., W.H. Burton, F. Jacobs, and E.A. Ross. 1987. Reductions in Ichthyoplankton Entrainment Using Fine Mesh Wedge-Wire Screens. North American Journal of Fisheries Management 7:386-393.

Weisberg, S.B., W.H. Burton, E.A., Ross, and F. Jacobs. 1984. The Effects of Screen Slot Size, Screen Diameter, and Through-Slot Velocity on Entrainment of Estuarine Ichthyoplankton Through Wedge-Wire Screens. Martin Marrietta Environmental Studies, Columbia, MD. August 1984.

APPENDIX A
ISI Brushed Cylinder Intake / Fish Screens

Use ISI's Brushed Cylinder Intake Screens to:

- Protect / screen fish from entrainment and impingement
- Protect pumps from clogging
- Protect downstream filtration and irrigation equipment

Key Features of ISI's Brushed Cylinder Intake / Fish Screens

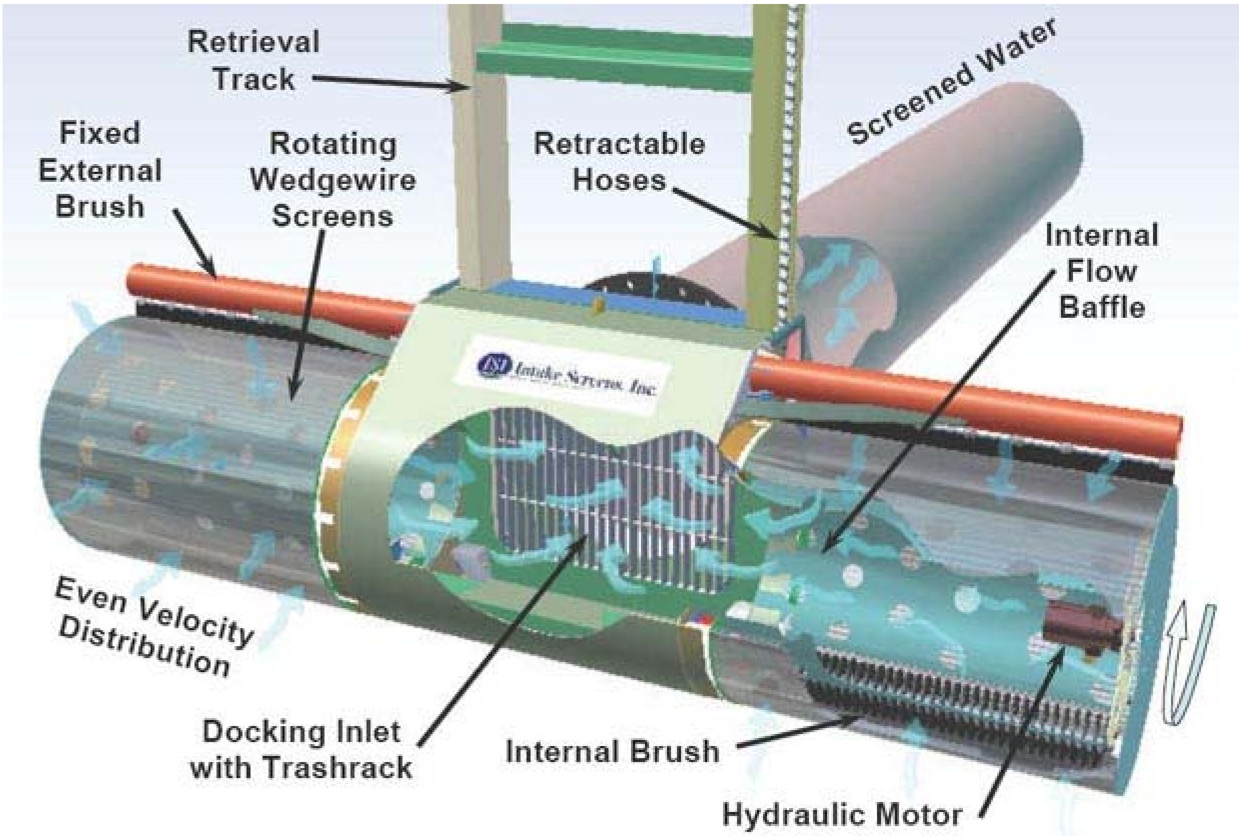
- Cylinders concentrate a large amount of surface into a small area
- Strong stainless steel construction with wedgewire cylinders provide durability
- Powerful and thorough brushing inside and out keep the screens clean and free of debris
- Even flows distributed along the screen surface provide better fish protection
- Easily retrievable with winch and track system allowing for easy access for maintenance
- Cathodically protected minimizing corrosion from ionic electrical action

Control & Power Features

- Marine-duty hydraulic drive motor rotates cleaning brushes
- Control panel allows user defined cleaning cycles
- Solar power option
- Interfaces with customers SCADA controls
- Remote monitoring and control available

Customization

- Wedgewire slot width options
- Screen design and construction for extreme design loads
- Custom control panels to match customer's equipment if necessary
- Screen lengths and diameters meet application needs



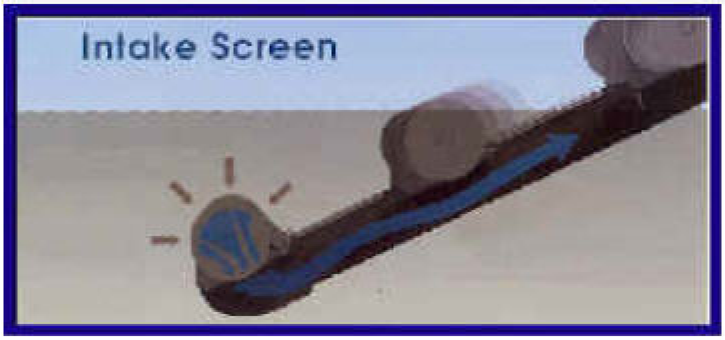
How the Self-Cleaning Cylinder Screens & Retrieval Systems Work

The intake / fish screen unit is made up of a rolling center manifold constructed of stainless steel with two stainless steel wedgewire cylinders on either end. This screen unit is easily raised and lowered on tracks with a winch.

When the screen is in place for pumping, the manifold seals against the *docking inlet* and all incoming water passes through the screen. The screen will periodically run through a cleaning cycle.

A programmable computer controller runs the cleaning cycle and checks the system operation. The screen cylinders are mechanically cleaned by rotating them using a high torque, low speed, marine duty oil hydraulic motor.

The cylinders typically rotate at 4 RPM for one minute in each direction. The exterior of screen cylinder is cleaned by rotating its surface against a stationary brush bar. The interior of the cylinder is also brush cleaned. The internal manifold distributes and promotes even flows along the surface of the screen cylinders.



Screen rolls down the track to *docking inlet* at bottom. Water flows through the screen & up the pump column to the pump discharge

Screen shown just below the surface at low water level

Cylinder screen can be adapted for vertical pump applications. Note the docking inlet with trash rack at bottom of wet well pipe.

A track allows the screen to be pulled up for inspection or non-use periods.

When the screens are raised from the docking inlet, the pump intake is still protected.

Screens can be manifolded to meet additional flow requirements. 72-inch

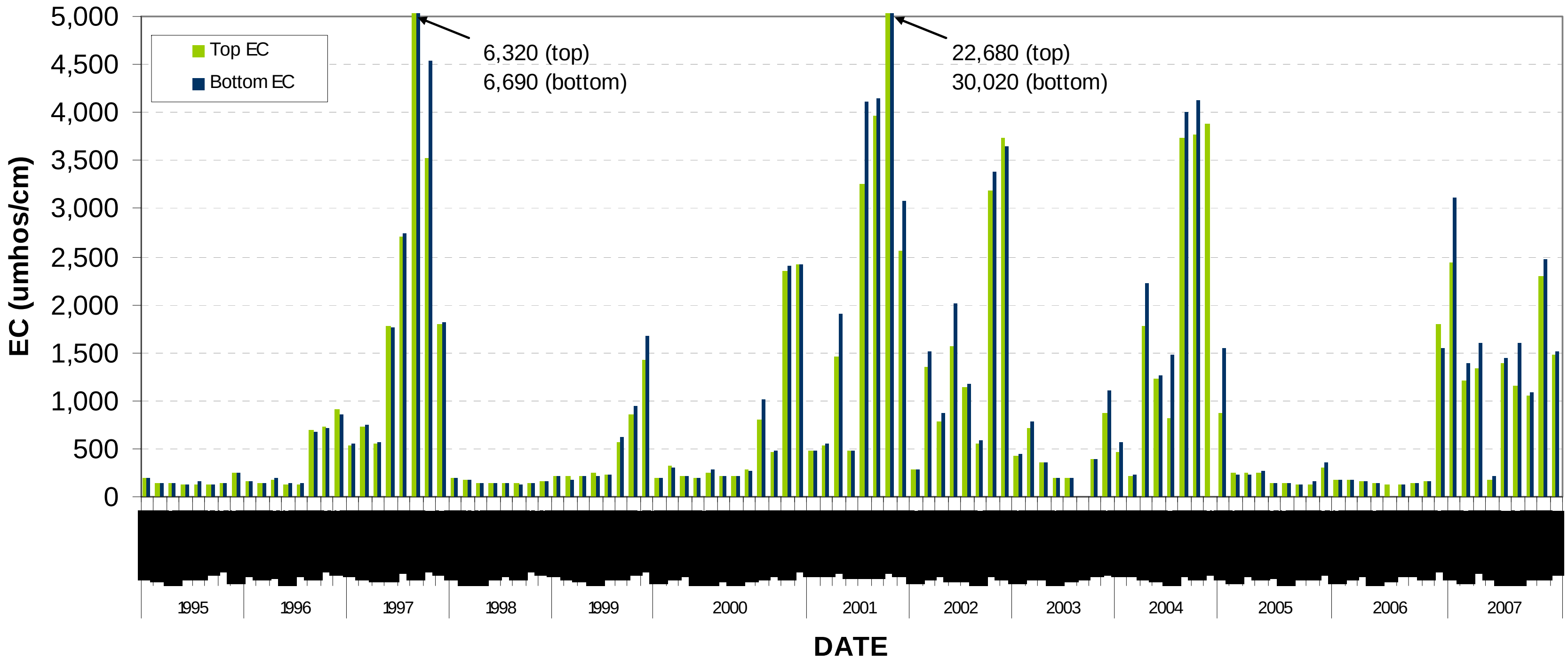
(source: Intake Screens 2007).

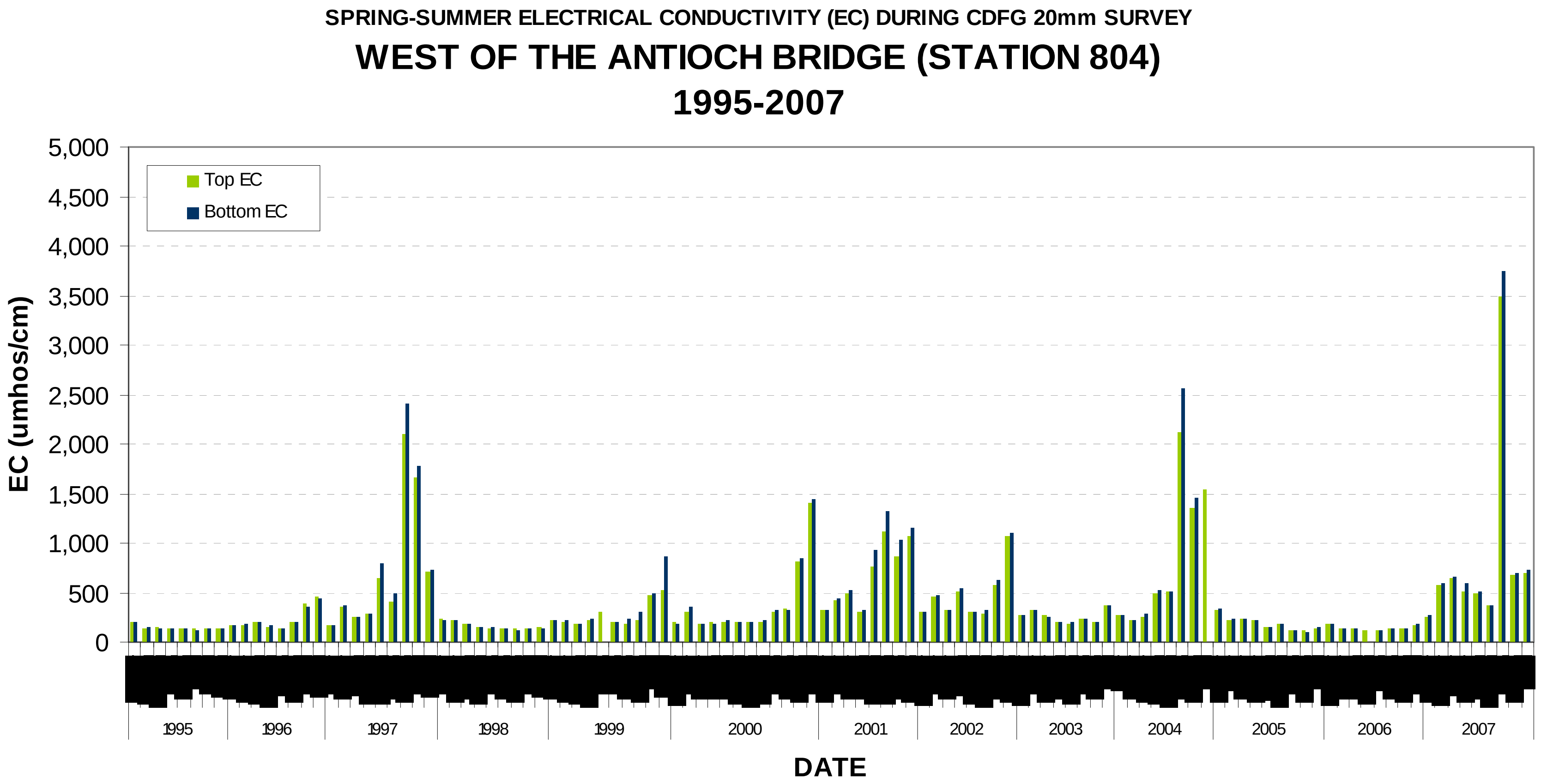
APPENDIX B

Electrical Conductivity During CDFG 20mm Surveys

SPRING-SUMMER ELECTRICAL CONDUCTIVITY (EC) DURING CDFG 20mm SURVEY

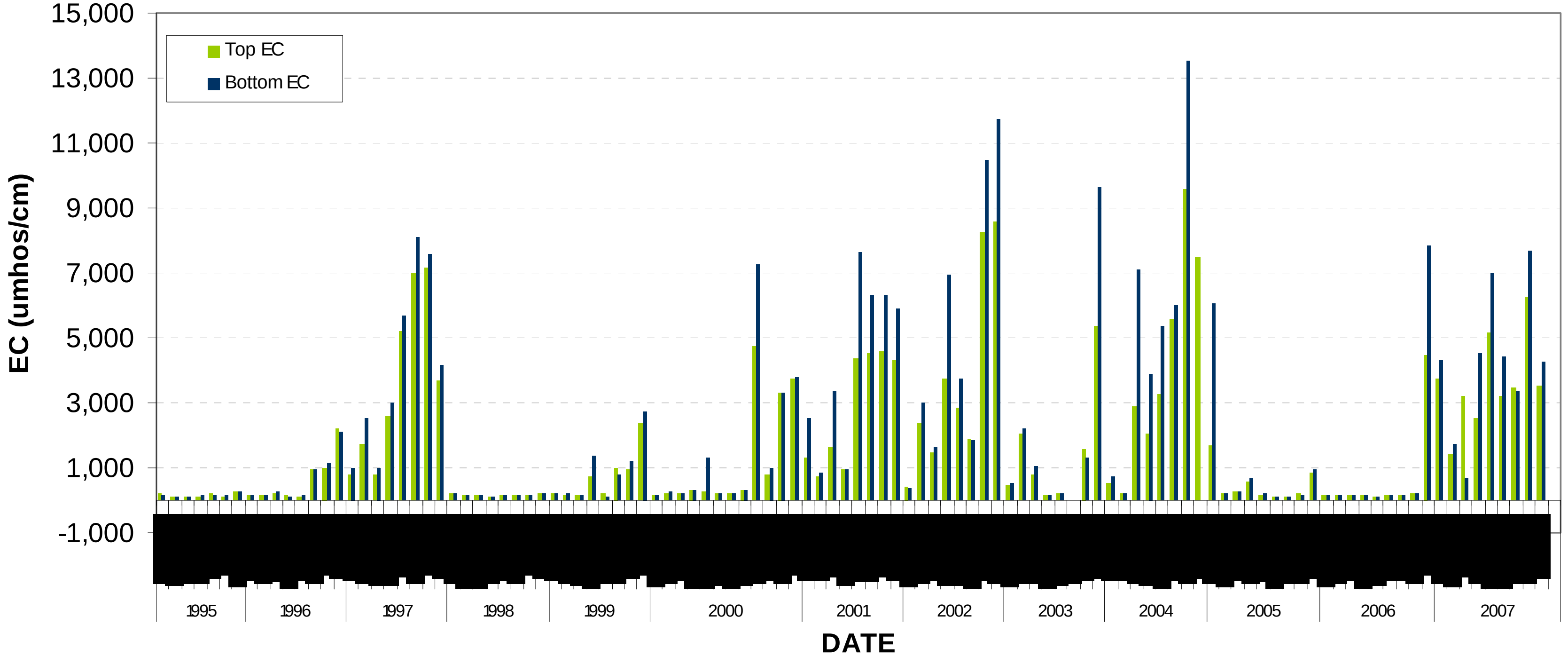
NEAR PITTSBURG (STATION 520)
1995-2007




SPRING-SUMMER ELECTRICAL CONDUCTIVITY (EC) DURING CDFG 20mm SURVEY
WEST OF THE ANTIOCH BRIDGE (STATION 804)
1995-2007
EC (umhos/cm)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Top EC
Bottom EC
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
DATE

SPRING-SUMMER ELECTRICAL CONDUCTIVITY (EC) DURING CDFG 20mm SURVEY

NEAR MALLARD SLOUGH/CHIPPS ISLAND (STATION 508)
1995-2007



Note scale change from previous graphs – maximum salinity is 15,000 umhos/cm.