Chapter E3: Evaluation of I&E Data

Summary: Combined Impacts of Pittsburg and Contra Costa EPA evaluated impacts to aquatic organisms resulting from the CWIS of the Pittsburg and Contra Costa facilities using the assessment methods described in Chapter A5 of this document. EPA's analysis focused on impacts to threatened and endangered (T&E) fish species. The combination of decreasing freshwater flows and the entrainment of early life stages in both government water project intakes and power plant intakes has contributed to a dramatic decline in the abundance of fishes in the Bay-Delta estuary and the subsequent listing of several fish species as threatened or endangered. Section E3-1 of this chapter lists all fish species that are known to be impinged or entrained at Pittsburg and Contra Costa, Section E3-2 summarizes life histories of species evaluated by EPA, and Section E3-3 outlines the facilities' I&E monitoring methods. Section E3-4 presents annual impingement estimates, Section E3-5 presents annual entrainment estimates, and Section E3-6 summarizes results for the two facilities combined.

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E3-1 Aquatic Species Vulnerable to I&E at the Pittsburg and Contra Costa Power Plants

Table E3-1 lists species that, because of their life histories, are vulnerable to I&E at the Pittsburg and Contra Costa facilities, as well as their designations as recreational, commercial, or forage species, or their special status classifications. EPA's analysis focused on losses of striped bass and special status species. However, EPA noted that other species are also impinged or entrained at Pittsburg and Contra Costa.

Table E3-1: Aquatic Species Vulnerable to I&E at the Pittsburg and Contra Costa Power Plants

Scientific Name	Common Name	Commercial	Recreational	Forage	Special Status
Alosa sapidissima	American shad		X		
Percina macrolepida	Bigscale logperch			X	
Siluriformes	Catfish			X	
Oncorhynchus mykiss	Central Valley ESU steelhead				X (FT)
Oncorhynchus tshawytscha	Central Valley fall/late fall-run ESU chinook salmon				X (FCT)
Oncorhynchus tshawytscha	Central Valley spring-run ESU chinook salmon				X (FT, ST)
Hypomesus transpacificus	Delta smelt				X (FT, ST)
Gobiidae	Gobies			X	
Acipenser medirostris	Green sturgeon				X (SOC)
Lavinia exilicauda	Hitch			X	
Spirinchus thaleichthys	Longfin smelt			X	X (SOC)
Cyprinidae	Minnows or carps			X	
Engraulis mordax	Northern anchovy	X	X		
Clupea pallasii	Pacific herring	X	X		
Cottus asper	Prickly sculpin			X	
Oncorhynchus tshawytscha	Sacramento River winter-run ESU chinook salmon				X (FE, SE)
Pogonichthys macrolepidotus	Sacramento splittail				X (FT)
Platichthys stellatus	Starry flounder	X	X		
Morone saxatilis	Striped bass		X		
Centrarchidae	Sunfish family			X	
Dorosoma petenense	Threadfin shad			X	
Ictalurus catus	White catfish			X	
Acanthogobius flavimanus	Yellowfin goby			X	

FT = federally listed as threatened.
ST = state listed as threatened.
FE = federally listed as endangered.
SE = state listed as endangered.
FCT = federal candidate listing as threatened
SOC = species of concern.
Sources: Ecological Analysts Inc., 1981a, 1981c; Southern Energy Delta LLC, 2000.

E3-2 Life Histories of Species Impinged and Entrained at the Pittsburg and Contra Costa Plants

Chinook salmon (*Oncorhynchus tshawytscha*)

Chinook salmon are anadromous members of the salmon and trout family (Salmonidae) (Moyle, 1976; Emmett et al., 1991; Boydstun et al., 1992). The San Francisco Bay-Delta is an important nursery area and migration route for chinook salmon (Kennish, 2000). Eggs, alevins (larvae), and young juveniles (fry and parr) use freshwater streams and rivers upstream of the delta, and juveniles migrate through the delta and use it as a nursery area (Emmett et al., 1991). Juveniles eventually migrate downstream to the Pacific Ocean as they transform into smolts, the ocean-dwelling stage. Chinook salmon spend from 1-8 years in the ocean before returning to their natal stream to spawn.

Four races of chinook salmon use the Sacramento-San Joaquin River system (Moyle, 1976; Yoshiyama et al., 2000). These include the fall run, late fall run, winter run, and spring run chinook salmon. In the Sacramento River, the winter run spawns from April to July, and the other runs spawn from July to December (Moyle, 1976). Spawning once occurred into the upper reaches of both the Sacramento and San Joaquin rivers, but dams have limited spawning to the lower reaches of these rivers and their tributaries (Moyle, 1976; Yoshiyama et al., 2000). The Central Valley late fall run was recently evaluated as a part of a proposed listing of the fall run under the federal Endangered Species Act (ESA). Although it was decided that the combined Central Valley fall/late-fall run currently does not qualify for formal protection, both runs remain under consideration as candidate species (Yoshiyama et al., 2000). The Sacramento River winter run is listed as endangered under both the state and federal ESA. The Central Valley spring run is listed as threatened under both statutes.

The four Central Valley runs of chinook salmon are vulnerable to I&E at the Pittsburg and Contra Costa power plants. Adults have been observed near the plants in October, and larvae (alevins) have been collected from inshore, shallow areas of Suisun Bay in January and February (Wang, 1986a). Parr have been observed throughout the estuary in spring, with peak migration occurring in May and June (Wang, 1986a).

CHINOOK SALMON
(Oncorhynchus tshawytscha)

Family: Salmonidae (salmon and trout).

Common names: Blackmouth, king salmon, quinnat salmon, spring, tyee.[a]

Similar species: Steelhead.

Geographic range: Arctic and Pacific from Point Hope, Alaska to Ventura River, California.[a]

Habitat: Oceans, streams and lakes.[a] Prefers gravel substrates for spawning.[b]

Lifespan: Can live up to 9 years.[a]

Fecundity: 2,000 to 14,000 eggs.[b]

Food sources:
- In streams, food is mainly terrestrial insects and small crustaceans.[a]
- In oceans, chinook salmon consume fish, crustaceans, and other invertebrates.[a]

Prey for:
- Striped bass, American shad, sculpins, Sacramento squawfish, sea gulls, mergansers, kingfishers.[a,b]

Life stage information:

Eggs: demersal
- Eggs range from 6.0 to 8.5 mm (0.24 to 0.33 in).[b]
- Deposited and buried in gravel, and are bright orange-red in color.[b]

Larvae: demersal for 2-3 weeks, then free-swimming.[b]
- Approximately 20 mm (0.79 in) at hatching.

Juveniles:
- Found in shallow and open waters of the Sacramento - San Joaquin Estuary.[b]
- Remain in freshwater for 1-2 years.[b]
- Drift feeders.[b]

***Adults*:**
- Return to natal streams from the sea for spawning.[a]
- Reach up to 147 cm (58 in).[a]

[a] Froese and Pauly, 2001.
[b] Wang, 1986a.
Fish graphic from NEFSC, 2001.

Delta smelt (Hypomesus transpacificus)

The delta smelt is a pelagic member of the smelt family (Osmeridae). It is a small, short-lived species that is found only in the bay-delta estuary, in areas with low salinities (Moyle, 1976; Moyle et al., 1992; U.S. Fish and Wildlife Service, 1996b). It is the only smelt species endemic to California and the only true native estuarine species found in the delta (Moyle et al., 1992).

The spawning period of delta smelt is relatively long, and adults may spawn from December to May, although most spawning occurs in February and March (Moyle, 1976). Before spawning in the fall, delta smelt congregate in upper Suisun Bay and the lower reaches of the delta (Moyle, 1976). Spawning takes place in freshwater along river margins and adjoining dead-end sloughs of the western delta. Fecundity is low, ranging from only 1,247 to 2,590 eggs per female (Moyle, 1976). Adults apparently die shortly after spawning, at the end of their 1-year life span (Moyle et al., 1992).

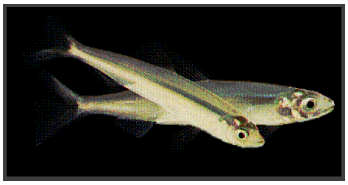
Eggs are demersal and adhesive, sticking to aquatic plants and gravel, and are therefore unlikely to be drawn into cooling water intakes, although the larvae are vulnerable (Bruce Herbold, EPA Region 9, personal communication, September 1, 2000). After hatching, the buoyant larvae are carried downstream to the entrapment zone, the highly productive areas where freshwater and salt water mix. This zone is located in Suisun Bay in years of high freshwater inflow. Juveniles move downstream to San Pablo Bay and Carquinez Strait before turning back to Suisun Bay for spawning.

The delta smelt was once one of the most common fish species in the bay-delta estuary, but the species has declined nearly 90 percent over the last 20 years. A number of physical and biological factors have contributed to declines in recent years, including increased water exports, competition and predation from the accidentally introduced inland silverside (*Menidia beryllina*), drought conditions in the late 1980s and early 1990s, and changes in food availability (CDWR, 1994; U.S. Fish and Wildlife Service, 1996b). Another major factor is the seasonal location of the entrapment zone. The location of the entrapment zone is a function of the timing and magnitude of delta outflow. There is a significant positive relationship between delta smelt abundance and the number of days that the entrapment zone is located within Suisun Bay from February through June (Moyle et al., 1992). Habitat and prey availability for delta smelt are greater when the entrapment zone is in this area because Suisun Bay is broad and shallow, and therefore light penetrates most of its waters, promoting algal growth (U.S. Fish and Wildlife Service, 1996b). Algal growth under these conditions provides an abundant food supply for zooplankton, which in turn provide food for plankton-eating fish like delta smelt.

Altered flow patterns caused primarily by agricultural water diversions during spawning also appear to contribute to delta smelt population losses by increasing the likelihood of entrainment of spawning adults and newly hatched larvae in diversion pumps (Moyle et al., 1992). In dry years, delta smelt are concentrated in upstream areas, whereas in wet years overall habitat conditions are more favorable and delta smelt are more widely distributed. When favorable conditions result in wider distribution, more delta smelt are affected by water diversion pumps (CDWR, 1994). The California Department of Water Resources (CDWR) estimated that entrainment losses of delta smelt at delta diversions reached 1.2 million in 1992 (CDWR, 1994).

Losses of delta smelt related to other water uses equal or exceed those at government water project pumps (CDWR, 1994). For example, because of their schooling behavior and preference for the region around Suisun Bay, delta smelt are highly vulnerable to the intakes of the Pittsburg and Contra Costa power plants. Monitoring of this species has not been required of the power plants, and the only estimates of I&E are based on incidental collection in striped bass monitoring samples in the late 1970's (Ecological Analysts, 1981a, 1981c). Nonetheless, the data indicate that in the late 1970's delta smelt were one of the most common fish species in the vicinity of the plants and experienced I&E in the millions each year.

Delta smelt is currently listed as a threatened species by both the USFWS and California. Historically, the delta smelt occurred from Suisun Bay upstream to the city of Sacramento on the Sacramento River and upstream to Mossdale on the San Joaquin River (Moyle et al., 1992). The size of the current population is uncertain, but in the early 1990's the population was estimated to be about 280,000 (Southern Energy Delta, LLC, 2000). Even at this population size, the delta smelt is considered highly vulnerable to environmental stressors because of its 1-year life cycle and low fecundity. Low fecundity and a short life span mean that even as few as 2 successive years of low reproductive success could decimate the population (Moyle, 1976).



DELTA SMELT
(Hypomesus transpacificus)

Family: Osmeridae (smelt).

Common names: none.

Similar species: Longfin smelt.

Geographic range: Sacramento - San Joaquin Delta.[a]

Habitat: Deadend sloughs, inshore areas of the delta and lower reaches of the Sacramento and San Joaquin rivers.[b]

Lifespan: Only live for one year.[c]

Fecundity: Fecundity is low, ranging from only 1,247 to 2,590 eggs per female.[d] Delta smelt die shortly after spawning.[c]

Food sources:
- Juveniles eat planktonic crustaceans, small insect larvae, and mysid shrimp.[b]

Prey for:

Life stage information:

Eggs: demersal
- Eggs are adhesive and stick to aquatic plants and gravel.[e]
- Approximately 1mm (0.04 in) in diameter.[b]

Larvae: pelagic
- Larvae are approximately 5.5 to 6.0 mm (0.22 to 0.24 in) at hatching.[b]
- Found near surface of water column.[b]

Juveniles: pelagic
- Juveniles are concentrated in the Suisun Bay and the delta and in the lower reaches of the Sacramento and San Joaquin rivers.[b]

***Adults*:**
- Reach 12 cm (4.7 in).[a]

[a] Froese and Pauly, 2001.
[b] Wang, 1986a.
[c] Moyle et al., 1992.
[d] Moyle, 1976.
[e] Bruce Herbold, EPA Region 9, personal communication, September 1, 2000.
Fish graphic from California Department of Fish and Game, 2002c.

Green sturgeon (*Acipenser medirostris*)

The green sturgeon is a member of the sturgeon family Acipenseridae (Emmett et al., 1991; Southern Energy Delta, LLC, 2000). It is an anadromous species that is closely related to the white sturgeon (*A. transmontanus*), though it shows a greater preference for marine waters, spending little time in freshwater. It is not abundant in any Pacific Coast estuary, and therefore life history characteristics are poorly known (Emmett et al., 1991). Along the North America coast it is found from Mexico north to the Bering Sea (Southern Energy Delta, LLC, 2000).

Although not abundant in the bay-delta, in the Columbia River green sturgeon is caught commercially with the white sturgeon, but it is considered inferior eating and therefore less valuable (Emmett et al., 1991). Green sturgeon is also incidentally captured in the white sturgeon recreational fishery.

Females mature at 15 to 20 years of age (Southern Energy Delta, LLC, 2000). Spawning occurs in California in spring and early summer in deep, fast water in the lower reaches of the Sacramento and Klamath Rivers (Emmett et al., 1991; Southern Energy Delta, LLC, 2000). The green sturgeon is a broadcast spawner, with fecundity ranging from 60,000 to 140,000 eggs per female (Emmett et al., 1991). Juveniles are found in freshwater areas of the San Joaquin Delta in summer (Emmett et al., 1991). By age 2, juveniles move to the ocean. Adults move back into estuaries in spring and early summer to feed and spawn. Adults can reach up to 2.1 m (6.9 ft) in length and live up to 60 years (Emmett et al., 1991).

Green sturgeon are found near the Pittsburg and Contra Costa power plants as adults migrating to freshwater rivers to spawn in spring and as juveniles moving to the ocean (Southern Energy Delta, LLC, 2000). Green sturgeon has been identified as a species of concern in this area (Southern Energy Delta, LLC, 2000).

GREEN STURGEON
(Acipenser medirostris)

Family: Acipenseridae (sturgeon).

Common names: none.

Similar species: White sturgeon.

Geographic range: North America from the Aleutian Islands and the Gulf of Alaska to Ensenada, Mexico.[a]

Habitat: Spawn in freshwater rivers, found in estuaries in spring, and in oceans.[b,c]

Lifespan: Live up to 60 years.[c]

Fecundity: Females mature at 15 to 20 years.[b] Females produce 60,000 to 140,000 eggs.[c]

Food sources:
- Juveniles consume amphopods and mysid shrimp.[d]

Prey for:
-

Life stage information:

Eggs:
- Little known, difficult to differentiate from white sturgeon.[d]

Larvae:
- Little known, difficult to differentiate from white sturgeon.[d]

Juveniles:
- Found in freshwater areas of the San Joaquin Delta in summer.[c]

***Adults*:** anadramous
- Prefer marine environments.[c]

[a] Froese and Pauly, 2001.
[b] Southern Energy Delta, LLC, 2000.
[c] Emmett et al., 1991.
[d] Wang, 1986a.
Fish graphic from California Department of Fish and Game, 2002b.

Longfin smelt (*Spirinchus thaleichthys*)

Longfin smelt is a member of the smelt family (Osmeridae) (Moyle, 1976). Longfin smelt is a native planktivore with a reproductive biology that is similar to delta smelt (Moyle, 1976; Wang, 1986a; Herbold and Moyle, 1989; Emmett et al., 1991). It is an anadromous species that is abundant in many Pacific Coast estuaries from Monterey Bay, California, as far north as Prince William Sound, Alaska (Emmett et al., 1991). Longfin smelt have been sold seasonally in bay-delta fish markets (Wang, 1986a). They also provide food for numerous predatory fishes, birds, and marine mammals (Emmett et al., 1991).

Adult longfin smelt are found in conditions ranging from seawater to freshwater during their upstream spawning migrations (Moyle, 1976; Wang, 1986a; Herbold and Moyle, 1989; Emmett et al., 1991). Adults also show vertical migrations within the water column, concentrating in bottom waters during the day and surface waters at night. Spawning occurs in winter and spring in rivers (Kennish, 2000).

In California, longfin smelt are concentrated around San Pablo Bay, but the population also shows distinct seasonal movements (Moyle, 1976). Early summer is spent in San Francisco and San Pablo bays. In August, longfin smelt move into Suisun Bay, and in winter they congregate for spawning in upper Suisun Bay and the lower delta. In April and May, large schools of juveniles move back downstream, and concentrate in the Carquinez Strait, San Pablo Bay, and San Francisco Bay throughout spring and summer.

Most longfin smelt reach maturity at age 2 (Moyle, 1976; Wang, 1986a; Herbold and Moyle, 1989; Emmett et al., 1991). Spawning takes place in freshwater at night from December to June, and is known to occur near both the Pittsburg and Contra Costa plants (Wang, 1986a). The majority of adults die after spawning, but some females apparently live to spawn a second time (Moyle, 1976). The average female produces 18,000 to 24,000 eggs (Emmett et al., 1991). Eggs are demersal and adhesive and are deposited singly over rocks and submerged vegetation. Larvae are pelagic, and are found in surface waters from the Carquinez Strait to the lower reaches of the Sacramento and San Joaquin rivers. Schools of larvae often also include

delta smelt (Wang, 1986a), and it can be difficult to distinguish the two species in I&E samples. Juveniles range from 22 to 88 mm (0.9 to 3.5 in) in length, while adults average 100 mm (3.9 in) (Emmett et al., 1991). In the bay-delta estuary, abundance is positively correlated with the amount of freshwater inflow from February to September (Herbold and Moyle, 1989). Longfin smelt has been identified as a species of concern (Southern Energy Delta, LLC, 2000).

LONGFIN SMELT
(Spirinchus thaleichthys)

Family: Osmeridae (smelt).

Common names: Pacific smelt, Sacramento smelt.[a]

Similar species: Delta smelt.

Geographic range: Northern Pacific from Prince William Sound, Alaska to Monterey Bay, California.[a]

Habitat: Close to shore, in bays and estuaries.[a] Prefers rocky, hard or sandy substrates and aquatic vegetation for cover.[b]

Lifespan: Live up to 3 years.[a]

Fecundity: Females mature at 2 years and usually spawn only once, producing 18,000 to 24,000 eggs.[c]

Food sources:
- Diaphanosoma, Diaptomus, Epischura, mysid shrimp, and other small crustaceans.[b]

Prey for:
- Predatory fish, birds, and marine mammals.[b]

Life stage information:

Eggs: demersal
- Eggs are approximately 1.2mm (0.04 in).[b]
- Eggs are deposited singly.[b]

Larvae: pelagic
- Larvae are 6.9 to 8 mm (0.27 to 0.31 in) at hatching.[b]
- Larvae are found mostly on the surface of the water.[b]

Juveniles:
- Range from 22 to 28 mm (0.9 to 3.5 in) in length.[c]
- Juveniles are found in the middle to bottom of the water column.[b]

***Adults*:**
- Adults average 100 mm (3.9 in).[c]

[a] Froese and Pauly, 2001.
[b] Wang, 1986a.
[c] Emmett et al., 1991.
Fish graphic from California Department of Fish and Game, 2002c.

Sacramento splittail (*Pogonichthys macrolepidotus*)

Sacramento splittail is a member of the minnow family (Cyprinidae) and a freshwater native of California's Central Valley (Moyle, 1976; Daniels and Moyle, 1983; Wang, 1986a). Splittail are bottom foragers that can reach up to 40.6 cm (16 in) in length. Juveniles provide forage for squawfish and striped bass.

Historically, splittail were abundant in the lakes and rivers of the Central Valley, including upstream reaches of the Sacramento and San Joaquin rivers and their tributaries. However, dams and diversions have restricted upstream access, and splittail are now limited in their distribution to freshwater and brackish conditions in the lower reaches of the Sacramento River, the delta, Suisun Marsh, San Pablo Bay, and Napa Marsh. Over the past 15 years, the species has declined by over 60 percent, primarily as a result of increasing water exports and the loss of shallow-water habitat (Meng and Moyle, 1995). Sacramento splittail was listed as threatened under the Federal Endangered Species Act by the USFWS effective March 1999.

Splittail spawn in the delta in spring over flooded vegetation in tidal freshwater and oligohaline areas (Wang, 1986a; Kennish, 2000). The spawning season can extend from late January to July, but most spawning occurs from March through May as water levels and temperatures increase. Females mature at 1-2 years and produce up to 250,000 eggs (Daniels and Moyle, 1983). Eggs are demersal and adhesive and therefore unlikely to be entrained, but larvae and small juveniles are vulnerable. The delta and Suisun Bay are important nursery areas (Kennish, 2000). Larvae are known to concentrate near the Pittsburg plant at New York Slough (Wang, 1986a). Juveniles are particularly abundant in Suisun Marsh and the Montezuma Slough of Suisun Bay (Meng and Moyle, 1995). Most splittail complete their life cycle in 5 years.

SACRAMENTO SPLITTAIL
(Pogonichthys macrolepidotus)

Family: Cyprinidae (minnow).

Common names: Splittail.[a]

Similar species:

Geographic range: Formerly throughout the Sacramento-San Joaquin River drainage, now restricted to the San Francisco Bay Delta and lower Sacramento River.[a]

Habitat: Backwaters and pools of rivers and lakes.[a]

Lifespan: Live for 5 years.[b]

Fecundity: Females mature at 1-2 years and produce up to 250,000 eggs.[c]

Food sources:
- Bottom foragers.[d]
- Juveniles prey on algae, pelecypods, and amphipods.[e]

Prey for:
- Juveniles are prey for squawfish and striped bass.[d]

Life stage information:

Eggs: demersal
- Eggs are adhesive, and unlikely to be entrained.[f]
- Mature eggs are 1.3 to 1.6 mm (0.05 to 0.06 in).[e]

Larvae: planktonic
- Hatch at less than 6.5 mm (0.26 in).[e]

Juveniles:
- Found in shallow and open water from the delta to San Pablo Bay.[e]

***Adults*:**
- Spawn in the delta in spring over flooded vegetation in tidal freshwater and oligohaline areas.[e,f]
- May reach 40.6 cm (16 in) in length.[d]

[a] Froese and Pauly, 2001.
[b] Meng and Moyle, 1995.
[c] Daniels and Moyle, 1983.
[d] Moyle, 1976.
[e] Wang, 1986a.
[f] Kennish, 2000.
Fish graphic from California Department of Fish and Game, 2002c.

Steelhead (*Oncorhynchus mykiss*)

Steelhead is an anadromous form of rainbow trout and is part of the salmon and trout family (Salmonidae) (Moyle, 1976; Herbold and Moyle, 1989; Emmett et al., 1991). It is ecologically similar to chinook salmon.

There are at least two subspecies or races of steelhead in California, defined by when adult fish enter freshwater to spawn (Emmett et al., 1991). The winter run of steelhead that uses the Central Valley migrates upstream during fall, winter, and early spring and spawns from December to June, while the summer run migrates during spring, summer, and early fall and spawn the following spring.

Construction of Shasta Dam blocked access to half of the suitable spawning habitat for steelhead in the Sacramento River drainage, contributing to serious population declines (Herbold and Moyle, 1989). Other causes of decline include dewatered streams resulting from excessive water diversions, rapid flow fluctuations from water conveyance, high water temperatures in summer below reservoirs, and entrainment of juveniles into government water project pumps (McEwan, 1992). In March 1998, the winter run was listed as threatened by the NMFS. Much of the production of steelhead now occurs in hatcheries. Hatchery steelhead have lower survival and reproductive rates than wild steelhead and can reduce the genetic diversity of wild stocks by interbreeding (Emmett et al., 1991).

Steelhead eggs, larvae (alevins), and young juveniles (fry and parr) are riverine life stages that normally remain in freshwater for 1-4 years (Emmett et al., 1991). Alevins range from 14 mm (0.55 in.) at hatching to about 28 mm (1.1 in.). Eggs and alevins are benthic and infaunal. Fry and parr are found in areas with cover and move to deeper water as they grown. Parr transform into smolts as they move through rivers and estuaries on their migration to the ocean, where they remain for 1-5 years before returning to their natal river as adults to spawn. The average female produces 1,500 to 5,000 eggs (Emmett et al., 1991).

Juveniles are found in all habitats of the delta, but it is unknown how long the delta is used as a nursery area (Herbold and Moyle, 1989). Food sources in freshwater and estuarine areas include gammarid amphipods, crustaceans, and small fish (Moyle, 1976). Juveniles range from 28 mm (1.1 in.) to 400 mm (15.7 in.) (Emmett et al., 1991).

STEELHEAD
(Oncorhynchus mykiss)

Family: Salmonidae (salmon and trout).

Common names: Coast range trout, hardhead, rainbow trout, salmon trout.[a]

Similar species: Chinook salmon.

Geographic range: Eastern Pacific from Alaska to Baja California, Mexico.[a]

Habitat:

Lifespan: Adults may reach 11 years.[a]

Fecundity: Females produce from 1,500 to 5,000 eggs.[b]

Food sources:
- Gammarid amphipods, crustaceans, small fish.[c]

Prey for:

Life stage information:

Eggs: benthic
- Spawned in riverine fresh water.

Larvae: benthic
- Larvae range from 14 to 28 mm (0.55 to 1.1 in).[b]

Juveniles:
- Juveniles range from 28 to 400 mm (1.1 to 15.7 in).[b]
- Found in all habitats of the delta.[d]

***Adults*:** Anadromous
- Two subspecies or races of steelhead are defined by the timing of spawning (winter run & summer run).[b]
- May grow as large as 120 cm (47 in).[a]

[a] Froese and Pauly, 2001.
[b] Emmett et al., 1991.
[c] Moyle, 1976.
[d] Herbold and Moyle, 1989.
Fish graphic from Mason, 2002.

Striped bass (*Morone saxatilis*)

Striped bass was intentionally introduced to the Sacramento-San Joaquin River system during the 1870's (Moyle, 1976; Emmett et al., 1991; Stevens, 1992). Unlike some East Coast populations that make extensive coastal migrations, Sacramento-San Joaquin River populations appear to spend most of their lives in bays and estuaries. Adults move into bays (some into the delta) in the fall, overwinter in the bay and delta, and then after spawning in spring, move back to the ocean (Moyle, 1976).

Commercial fishing for striped bass in the San Francisco Bay system has been prohibited since 1935 because of demands by sport anglers (Stevens, 1992). The San Francisco striped bass recreational fishery is one of the most important recreational fisheries on the Pacific Coast. In 1985, it was valued at over $45 million annually (Stevens, 1992). However, the Sacramento-San Joaquin population has declined since the early 1960's. Poor recruitment of young striped bass is thought to be the primary reason for the decline in the adult stock (Stevens, 1992).

Striped bass spawn in schools at night (Stevens, 1992). Spawning occurs in freshwater, beginning in April in California and peaking in May and early June. Females mature at age 5, producing an average of 250,000 eggs per year. Striped bass can live up to 20 years, and exceed 22.7 kg (50 lb) in weight, thus showing high reproductive potential.

Larval striped bass feed on opossum shrimp in the delta and Suisun Bay, reaching about 3.8 cm (1.5 in) in length by late summer (Stevens, 1992). Large numbers of eggs and larvae are killed by the intakes of the Pittsburg and Contra Costa plants and government water projects, contributing to poor recruitment (Stevens, 1992; Southern Energy Delta, LLC, 2000). A number of restoration and management actions are in place to improve recruitment. However, striped bass are voracious predators on small fish, including several delta T&E species or species of concern such as delta smelt, longfin smelt, and Sacramento splittail, complicating management efforts.

STRIPED BASS
(Morone saxatilis)

Family: Moronidae (temperate basses).

Common names: Striper, rockfish, linesider, and sea bass.[a]

Similar species: White perch.

Geographic range: St. Lawrence River in Canada to the St. Johns River in Florida, and from the Suwannee River in western Florida to Lake Pontchartrain, Louisiana.[b] Intentionally introduced to Sacramento-San Joaquin River system.[c]

Habitat: Sacramento-San Joaquin River populations spend most of their lives in bays and estuaries.[c] Juveniles prefer shallow rocky to sandy areas. Adults in inshore areas use a variety of substrates, including rock, boulder, gravel, sand, detritus, grass, moss, and mussel beds.[b]

Lifespan: Adults may reach 30 years.[d]

Fecundity: Females mature at age 5 and produce an average of 250,000 eggs per year.[e]

Food sources:
- Larvae feed primarily on mobile planktonic invertebrates (beetle larvae, copepodids *Daphnia* spp.).[b]
- Juveniles eat larger aquatic invertebrates and small fishes.[b]
- Adults are piscivorous. Clupeid fish are the dominant prey and adults prefer soft-rayed fishes.[b]

Prey for: Any sympatric piscivorous fish.[b]

Life stage information:

Eggs: *pelagic*
- Eggs and newly hatched larvae require sufficient turbulence to remain suspended in the water column; otherwise, they can settle to the bottom and be smothered.[f]

Larvae: *pelagic*
- Larvae range from 5 to 30 mm (0.2 to 1.2 in).[b]

Juveniles:
- Most striped bass enter the juvenile stage at 30 mm (1.2 in) total length.[f]
- Juveniles school in larger groups after 2 years of age.[f]

Adults**:** Anadromous
- Adults move into bays in the fall, overwinter in the bay and delta, and after spawning in the spring,, return to the ocean.[c]
- May grow as large as 200 cm (79 in).[a]

[a] Froese and Pauly, 2001.
[b] Hill et al., 1989.
[c] Moyle, 1976.
[d] Atlantic States Marine Fisheries Commission, 2000d.
[e] Stevens, 1992.
[f] Bigelow and Schroeder, 1953.
Fish graphic from California Department of Fish and Game, 2002b.

E3-3 Facility Methods for Estimating I&E

Results of facility I&E studies are summarized in Appendix B of the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000) and presented below. Data are for the 1-year monitoring period in 1978-1979 and the average for 1987-1090 (for impingement) and the average for 1986-1980 (for entrainment).

E3-3.1 Impingement Monitoring

Impingement sampling was conducted about once a month from March 1978 to April 1979, as well as from August to February for 1987 to 1990 (Southern Energy Delta, LLC, 2000). Impingement samples represent the total volume of circulating water during sampling and therefore reflect all fish impinged during the sampling period. Mortality of impinged organisms was assumed to be 100 percent.

E3-3.2 Entrainment Monitoring

Entrainment sampling was conducted in a relatively small volume of circulating water during one 24-hour sampling period each week from April 1978 to April 1979, as well as from May to mid-July for 1986 to 1992 (Southern Energy Delta, LLC, 2000). Numbers of entrained individuals collected were converted to a density estimate (number per m^3) and combined with cooling water flow (m^3 during each week) to estimate the total number entrained per year. Mortality of entrained organisms was assumed to be 100 percent.

E3-4 ANNUAL IMPINGEMENT

EPA evaluated annual impingement at Pittsburg and Contra Costa using the methods described in Chapter A2 of Part A of this document. The species-specific life history values used by EPA for its analyses are presented in Appendix E1. Table E3-2 displays facility estimates of annual impingement (numbers of organisms) at the Pittsburg facility for striped bass and special status species. Table E3-3 displays impingement losses of striped bass and special status species expressed as age 1 equivalents, Table E3-4 displays impingement expressed as lost recreational fishery yield (for striped bass only), and Table E3-5 displays impingement expressed as production foregone. Tables E3-6 through E3-9 display the same information for the Contra Costa facility.

Table E3-2: Facility Estimates of Annual Impingement (numbers of organisms) at the Pittsburg facility

Monitoring Period	Chinook Salmon	Delta Smelt	Longfin Smelt	Sacramento Splittail	Steelhead	Striped Bass
1978-1979	808	14,107	137,261	8,732	0	111,299
Avg. 1987-1990	106	283	12,677	212	0	NA
Mean	457	7,195	74,969	4,472	0	—
Minimum	106	283	12,677	212	0	—
Maximum	808	14,107	137,261	8,732	0	—
SD	496	9,775	88,094	6,025	0	—
Total	914	14,390	149,938	8,944	0	—

0=Sampled, but none collected.
MonJan2112:00:43MST2002Raw.losses.IMPINGEMENT;Plant:pittsburg;
PATHNAME:P:/Intake/Calif/Calif_Science/scodes/pittsburgh/tables.output/raw.losses.imp.pittsburg.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

Table E3-3: Annual Impingement at the Pittsburg Facility Expressed as Age 1 Equivalents

Monitoring Period	Chinook Salmon	Delta Smelt	Longfin Smelt	Sacramento Splittail	Striped Bass
1978-1979	873	22,076	181,597	10,329	128,956
Avg. 1987-1990	114	443	16,772	251	NA
Mean	493	11,259	99,184	5,290	—
Minimum	114	443	16,772	251	—
Maximum	873	22,076	181,597	10,329	—
SD	536	15,297	116,549	7,127	—
Total	987	22,519	198,369	10,580	—

NA=Not sampled.
Note: Impingement losses expressed as age 1 equivalents are larger than raw losses (the actual number of organisms impinged). This is because the ages of impinged individuals are assumed to be distributed across the interval between the start of year 1 and the start of year 2, and then the losses are normalized back to the start of year 1 by accounting for mortality during this interval (for details, see description of S*j in Chapter A2, Equation 4 and Equation 5). This type of adjustment is applied to all raw loss records, but the effect is not readily apparent among entrainment losses because the majority of entrained fish are younger than age 1.
Mon Jan 21 12:03:45 MST 2002; Results; I Plant: pittsburg; Units: equivalent.sums Pathname:
P:/Intake/Calif/Calif_Science/scodes/pittsburgh/tables.output/I.equivalent.sums.pittsburg.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

Table E3-4: Annual Impingement of Striped Bass at the Pittsburg Facility Expressed as Yield Lost to the Recreational Fishery (in pounds)

Year	Striped Bass
1978-1979	46,991

Mon Jan 21 12:03:51 MST 2002; Results; I Plant: pittsburg; Units: yield Pathname: P:/Intake/Calif/Calif_Science/scodes/pittsburgh/tables.output/I.yield.pittsburg.csv

Table E3-5: Annual Impingement at the Pittsburg Facility Expressed as Production Foregone (in pounds)

Monitoring Period	Chinook Salmon	Delta Smelt	Longfin Smelt	Sacramento Splittail	Striped Bass
1978-1979	2,735	30	1,174	1,055	16,674
Avg. 1987-1990	359	1	108	26	NA
Mean	1,547	16	641	540	—
Minimum	359	1	108	26	—
Maximum	2,735	30	1,174	1,055	—
SD	1,680	21	754	728	—
Total	3,094	31	1,282	1,080	—

NA=Not sampled.
MonJan2112:03:47MST2002;Results;IPlant:pittsburg;Units:annual.prod.forgPathname: P:/Intake/Calif/Calif_Science/scodes/pittsburgh/tables.output/I.annual.prod.forg.pittsburg.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

Table E3-6: Facility Estimates of Annual Impingement (numbers of organisms) at the Contra Costa Facility

Monitoring Period	Chinook Salmon	Delta Smelt	Longfin Smelt	Sacramento Splittail	Steelhead	Striped Bass
1978-1979	1,083	8,253	19,475	12,455	38	136,149
Avg. 1987-1990	0	942	336	889	0	NA
Mean	542	4,598	9,906	6,672	19	—
Minimum	0	942	336	889	0	—
Maximum	1,083	8,253	19,475	12,455	38	—
SD	766	5,170	13,533	8,178	27	—
Total	1,083	9,195	19,811	13,344	38	—

NA=Not sampled.
0=Sampled, but none collected.
Mon Jan 21 11:20:56 MST 2002 Raw.losses. IMPINGEMENT; Plant:contracosta; PATHNAME:P:/Intake/Calif/Calif_Science/scodes/contracosta/tables.output/raw.losses.imp.contracosta.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

Table E3-7: Annual Impingement at the Contra Costa Facility Expressed as Age 1 Equivalents

Monitoring Period	Chinook Salmon	Delta Smelt	Longfin Smelt	Sacramento Splittail	Striped Bass
1978-1979	1,169	12,915	25,766	14,733	157,749
Avg. 1987-1990	0	1,474	445	1,052	NA
Mean	585	7,195	13,105	7,892	—
Minimum	0	1,474	445	1,052	—
Maximum	1,169	12,915	25,766	14,733	—
SD	827	8,090	17,905	9,674	—
Total	1,169	14,389	26,210	15,785	—

NA=Not sampled.
0=Sampled, but none collected.
Note: Impingement losses expressed as age 1 equivalents are larger than raw losses (the actual number of organisms impinged). This is because the ages of impinged individuals are assumed to be distributed across the interval between the start of year 1 and the start of year 2, and then the losses are normalized back to the start of year 1 by accounting for mortality during this interval (for details, see description of S*j in Chapter A2, Equation 4 and Equation 5). This type of adjustment is applied to all raw loss records, but the effect is not readily apparent among entrainment losses because the majority of entrained fish are younger than age 1.
Mon Jan 21 11:24:23 MST 2002; Results; I Plant: contracosta; Units: equivalent.sums Pathname: P:/Intake/Calif/Calif_Science/scodes/contracosta/tables.output/I.equivalent.sums.contracosta.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

Table E3-8: Annual Impingement of Striped Bass at the Contra Costa Facility Expressed as Yield Lost to the Recreational Fishery (in pounds)

Year	Striped Bass
1978-1979	57,482

Mon Jan 21 11:24:28 MST 2002; Results; I Plant: contracosta; Units: yield Pathname: P:/Intake/Calif/Calif_Science/scodes/contracosta/tables.output/I.yield.contracosta.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

Table E3-9: Annual Impingement at the Contra Costa Facility Expressed as Production Foregone (in pounds)

Monitoring Period	Chinook Salmon	Delta Smelt	Longfin Smelt	Sacramento Splittail	Striped Bass
1978-1979	3,666	18	167	1,504	20,396
Avg. 1987-1990	0	2	3	107	NA
Mean	1,833	10	85	806	—
Minimum	0	2	3	107	—
Maximum	3,666	18	167	1,504	—
SD	2,592	11	116	988	—
Total	3,666	20	169	1,612	—

NA=Not sampled.
0=Sampled, but none collected.
Mon Jan 21 11:24:26 MST 2002; Results; I Plant: contracosta; Units: annual.prod.forg Pathname: P:/Intake/Calif/Calif_Science/scodes/contracosta/tables.output/I.annual.prod.forg.contracosta.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

E3-5 ANNUAL ENTRAINMENT

EPA evaluated annual entrainment at Pittsburg and Contra Costa using the methods described in Chapter A2 of Part A of this document. The species-specific life history values used by EPA for its analyses are presented in Appendix E1. Table E3-10 displays facility estimates of annual entrainment (numbers of organisms) at the Pittsburg facility for all species collected. Table E3-11 displays impingement losses of striped bass and special status species expressed as age 1 equivalents, Table E3-12 displays impingement expressed as lost recreational fishery yield (for striped bass only), and Table E3-13 displays impingement expressed as production foregone. Tables E3-14 through E3-17 display the same information for the Contra Costa facility.

Table E3-10: Facility Estimates of Annual Entrainment (numbers of organisms) at the Pittsburg Facility

Monitoring Period	Chinook Salmon	Delta Smelt	Longfin Smelt	Sacramento Splittail	Striped Bass
1978-1979	23,598	65,839,484	190,229	155,289	284,370,000
Avg. 1986-1992	0	1,680,187	232,641	336,037	NA
Mean	11,799	33,759,836	211,435	245,663	—
Minimum	0	1,680,187	190,229	155,289	—
Maximum	23,598	65,839,484	232,641	336,037	—
SD	16,686	45,367,474	29,990	127,808	—
Total	23,598	67,519,671	422,870	491,326	—

NA=Not sampled.
0=Sampled, but none collected.
Mon Jan 21 12:00:44 MST 2002 Raw.losses. ENTRAINMENT; Plant:pittsburg;
PATHNAME:P:/Intake/Calif/Calif_Science/scodes/pittsburgh/tables.output/raw.losses.ent.pittsburg.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

Table E3-11: Annual Entrainment at the Pittsburg Facility Expressed as Age 1 Equivalents

Monitoring Period	Chinook Salmon	Delta Smelt	Longfin Smelt	Sacramento Splittail	Striped Bass
1978-1979	122	392,928	257	16	1,456,810
Avg. 1986-1992	0	10,097	314	34	NA
Mean	61	201,512	285	25	—
Minimum	0	10,097	257	16	—
Maximum	122	392,928	314	34	—
SD	86	270,702	40	13	—
Total	122	403,025	571	50	—

NA=Not sampled.
0=Sampled, but none collected.
Mon Jan 21 12:03:43 MST 2002; Results; E Plant: pittsburg; Units: equivalent.sums Pathname:
P:/Intake/Calif/Calif_Science/scodes/pittsburgh/tables.output/E.equivalent.sums.pittsburg.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

Table E3-12: Annual Entrainment of Striped Bass at the Pittsburg Facility Expressed as Yield Lost to the Recreational Fishery (in pounds)

Year	Striped Bass
1978-1979	530,850

Mon Jan 21 12:03:50 MST 2002; Results; E Plant: pittsburg; Units: yield Pathname:
P:/Intake/Calif/Calif_Science/scodes/pittsburgh/tables.output/E.yield.pittsburg.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

Table E3-13: Annual Entrainment at the Pittsburg Facility Expressed as Production Foregone (in pounds)

Monitoring Period	Chinook Salmon	Delta Smelt	Longfin Smelt	Sacramento Splittail	Striped Bass
1978-1979	1,316	5,691	7	29	289,634
Avg. 1986-1992	0	146	9	64	NA
Mean	658	2,918	8	46	—
Minimum	0	146	7	29	—
Maximum	1,316	5,691	9	64	—
SD	930	3,920	1	24	—
Total	1,316	5,837	17	93	—

NA=Not sampled.
0=Sampled, but none collected.
Mon Jan 21 12:03:46 MST 2002; Results; E Plant: pittsburg; Units: annual.prod.forg Pathname: P:/Intake/Calif/Calif_Science/scodes/pittsburgh/tables.output/E.annual.prod.forg.pittsburg.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

Table E3-14: Facility Estimates of Annual Entrainment (numbers of organisms) at the Contra Costa Facility

Monitoring Period	Chinook Salmon	Delta Smelt	Longfin Smelt	Sacramento Splittail	Striped Bass
1978-1979	10,318	21,755,741	0	189,659	81,000,000
Avg. 1986-1992	0	1,565,933	71,179	94,905	NA
Mean	5,159	11,660,837	35,590	142,282	—
Minimum	0	1,565,933	0	94,905	—
Maximum	10,318	21,755,741	71,179	189,659	—
SD	7,296	14,276,350	50,331	67,001	—
Total	10,318	23,321,674	71,179	284,564	—

NA=Not sampled.
0=Sampled, but none collected.
Mon Jan 21 11:20:57 MST 2002 Raw.losses. ENTRAINMENT; Plant:contracosta; PATHNAME:P:/Intake/Calif/Calif_Science/scodes/contracosta/tables.output/raw.losses.ent.contracosta.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

Table E3-15: Annual Entrainment at the Contra Costa Facility Expressed as Age 1 Equivalents

Monitoring Period	Chinook Salmon	Delta Smelt	Longfin Smelt	Sacramento Splittail	Striped Bass
1978-1979	53	125,313	0	19	493,756
Avg. 1986-1992	0	9,411	96	10	NA
Mean	27	67,362	48	14	—
Minimum	0	9,411	0	10	—
Maximum	53	125,313	96	19	—
SD	38	81,955	68	7	—
Total	53	134,724	96	29	—

NA=Not sampled.
0=Sampled, but none collected.
Mon Jan 21 11:24:22 MST 2002; Results; E Plant: contracosta; Units: equivalent.sums Pathname: P:/Intake/Calif/Calif_Science/scodes/contracosta/tables.output/E.equivalent.sums.contracosta.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

Table E3-16: Annual Entrainment of Striped Bass at the Contra Costa Facility Expressed as Yield Lost to the Recreational Fishery (in pounds)

Year	Striped Bass
1978-1979	179,921

Mon Jan 21 11:24:27 MST 2002; Results; E Plant: contracosta; Units: yield Pathname: P:/Intake/Calif/Calif_Science/scodes/contracosta/tables.output/E.yield.contracosta.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

Table E3-17: Annual Entrainment at the Contra Costa Facility Expressed as Production Foregone (in pounds)

Monitoring Period	Chinook Salmon	Delta Smelt	Longfin Smelt	Sacramento Splittail	Striped Bass
1978-1979	575	1,816	0	36	96,797
Avg. 1986-1992	0	136	3	18	NA
Mean	288	976	1	27	—
Minimum	0	136	0	18	—
Maximum	575	1,816	3	36	—
SD	407	1,187	2	13	—
Total	575	1,952	3	54	—

NA=Not sampled.
0=Sampled, but none collected.
Mon Jan 21 11:24:25 MST 2002; Results; E Plant: contracosta; Units: annual.prod.forg Pathname: P:/Intake/Calif/Calif_Science/scodes/contracosta/tables.output/E.annual.prod.forg.contracosta.csv
Source: Appendix B in the draft Habitat Conservation Plan (Southern Energy Delta, LLC, 2000).

E3-6 Summary: Combined Impacts of Pittsburg and Contra Costa

Table E3-18 summarizes EPA's estimates of annual impingement at the Pittsburg and Contra Costa facilities combined, and Table E3-19 summarizes annual entrainment. Based on available data, EPA estimates that, on average, 247,448 striped bass and 108,811individuals of special status species may be impinged at the facilities each year. This represents 286,705 age 1 equivalents of striped bass or 104,473 pounds of lost fishery yield, and 145,004 age 1 equivalents of special status species, or 5,477 pounds of biomass production foregone. The available data also indicate that over 365 million striped bass and over 46 million individuals of special status species are entrained annually at the two facilities, representing 1,950,565 age 1 equivalents of striped bass or 710,770 pounds of lost fishery yield, and 269,334 age 1 equivalents of special status species or 4,923 pounds of biomass production foregone.

Table E3-18: Average Annual Impingement and Entrainment of Striped Bass at Pittsburg and Contra Costa (both facilities combined)

	Impingement	Entrainment
Raw losses (# of organisms)	247,448	365,370,000
Age 1 equivalents (# of fish)	286,705	1,950,565
Fishery yield (lbs of fish)	104,473	710,770
Production foregone (lbs of fish)	37,070	386,431

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Table E3-19: Average Annual Impingement and Entrainment of Special Status Species at Pittsburg and Contra Costa (sum of annual means of all species evaluated at the two facilities combined)

	Impingement	Entrainment
Raw losses (# of organisms)	108,811	46,072,601
Age 1 equivalents (# of fish)	145,004	269,334
Fishery yield (lbs of fish)	-----	----
Production foregone (lbs of fish)	5,477	4,923

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EPA's analysis of I&E at Pittsburg and Contra Costa was based on historic I&E rates and assumes that these rates would be observed once populations of special status species recover. However, sampling data from the late 1980's and early 1990's may underestimate potential I&E losses because populations of many special status species were depressed during those years as a result of drought conditions, increasing water exports, and elevated salinities during spawning (Meng and Moyle, 1995). Since the previous drought of 1976-1977, the average estuarine inflow diverted by water projects increased from 30 percent to 50 percent (Moyle et al., 1992). Under the low flow conditions that prevailed during the sampling in the late 1980's and early 1990's, most fish that were present were concentrated east of the power plants on the Sacramento River, further reducing their potential abundance in I&E samples (Southern Energy Delta, LLC, 2000). Thus, I&E rates during these years most likely underestimate losses that can occur when environmental conditions are favorable.

On the other hand, Contra Costa data may overestimate potential losses because Contra Costa Units 1-3 are now on long-term standby status and Units 4 and 5 are operated as synchronous condensers and do not require cooling water from circulating pumps. Because of this, estimated I&E for Units 6 and 7 only may provide better estimates of potential losses (Southern Energy Delta, LCC, 2000). Although annual estimates for Units 6 and 7 alone are not presented in available documents, Southern Energy Delta, LLC (2000) has estimated that impingement of delta smelt and longfin smelt is reduced by 67 percent and 44 percent, respectively, with only Units 6 and 7 of the Contra Costa facility operating.