Western Delta Seine Survey 2005-2006

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Introduction

The Fishery Foundation of California with a grant from the US Fish and Wildlife Service (FWS), conducted a seine survey of the western Delta in the winter of 2005 and 2006. The survey was in conjunction with FFC monitoring at Kimball Island, a wetland mitigation bank developed by Wildlands Inc. on the southwest edge of west Sherman Island (Figure 1). The survey was also a supplement to the FWS Lower Sacramento River Seine Survey, which samples weekly at four boat-ramp seine sites in the western Delta.

The purpose of the survey was to determine use of shallow water habitats in winter in the western Delta by young Chinook salmon. The importance of the Delta, especially the western Delta and Suisun Bay as rearing habitat has long been questioned – "*There is very little information on the extent to which these fish rear in the Delta, or on the extent to which doing so affects their survival"* (Williams 2006). The importance of shallow water wetland habitats in the recovery of Delta native fishes remains a critical issue to be resolved – "*there is a high degree of uncertainty regarding the benefits of tidal wetland restoration for native fishes, including special status species such as delta smelt (Hypomesus transpacificus), Chinook salmon (Oncorhynchus tshawytscha), steelhead rainbow trout (O. mykiss) and splittail (Pogonichthys macrolepidotus)*" (Brown 2003).

Our study focused on the timing, relative abundance, and habitat use patterns of young wild Chinook salmon. We did not attempt to address the importance of Delta rearing to the salmon populations.

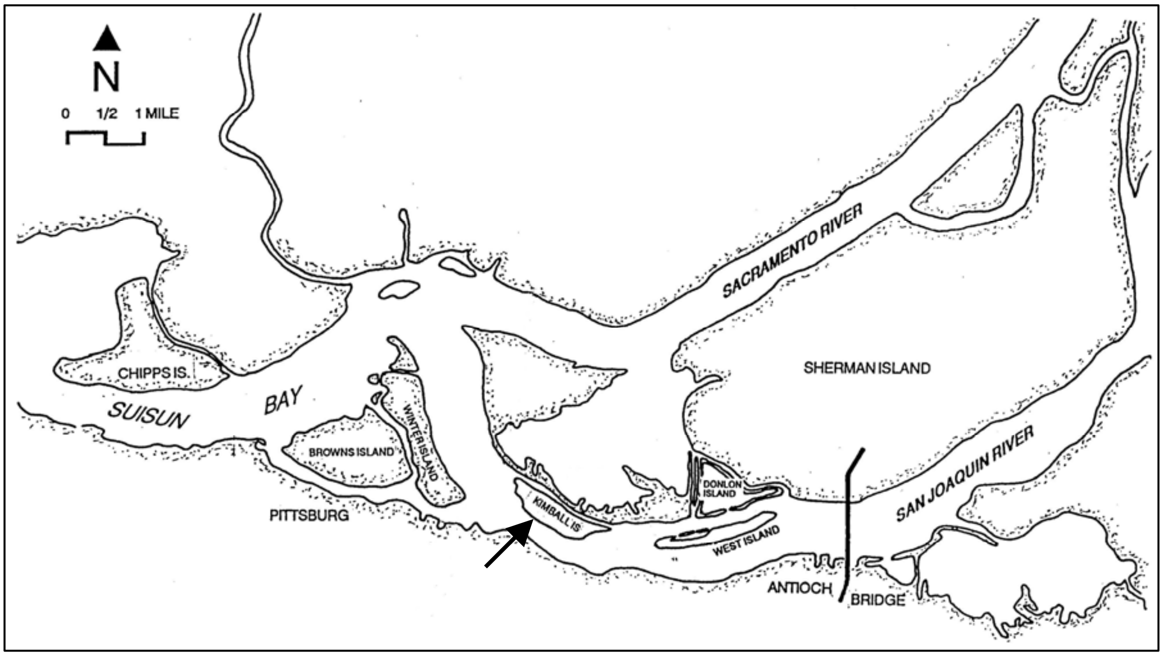

Figure 1. Location of Kimball Island in western Sacramento-San Joaquin Delta.

Methods

We employed a standard "50-ft" seine with bag as employed by FWS Seine Survey. Where there was sufficient room the seine was deployed by towing approximately 100-ft perpendicular to the bank and then pulling the offshore end to shore prior to pulling both ends of the seine onto the beach. The procedure was modified as necessary on beaches with sharp dropoffs or obstacles that precluded the standard procedure. The seine size was 1.3-by-15 m with 3-mm mesh in wings and bag.

Surveys were conducted approximately every 10-14 days beginning in January and continuing into April or May. Four areas were surveyed in 2005: southwest Sherman; northwest Sherman; north Sacramento River channel shore, and northeast Sherman (Figure 2). In 2006 locations including Collinsville/Montezuma Island were added near the northwest end of West Sherman Island, and four stations were added around Decker Island. A station was also added on the south San Joaquin channel shore near Antioch.

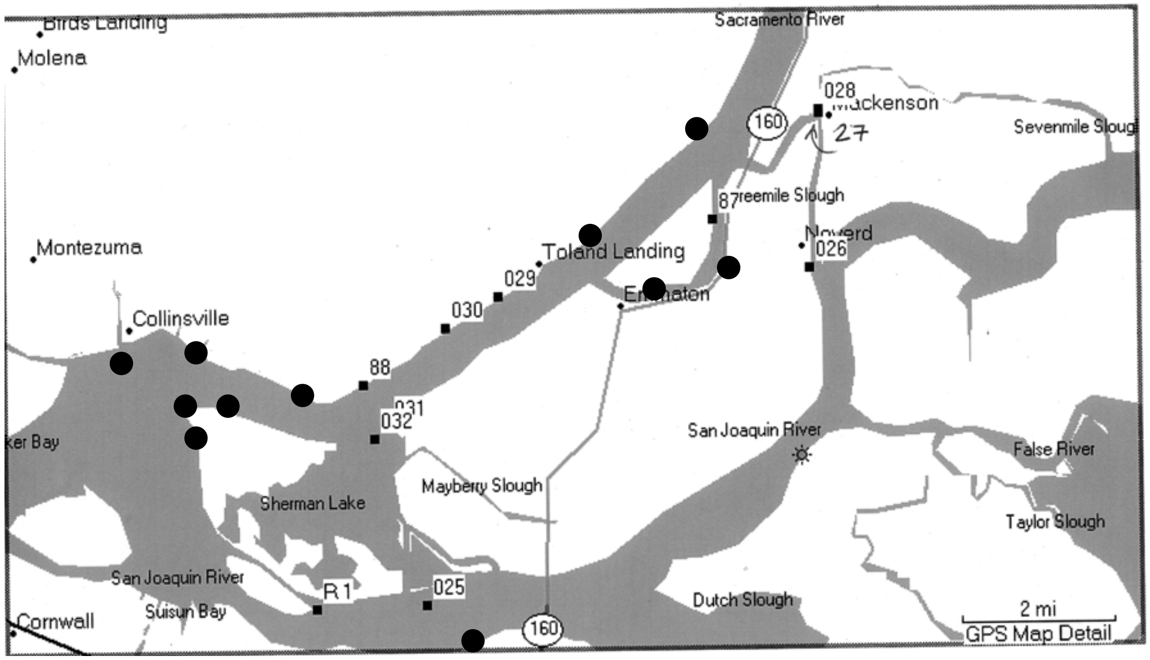

Figure 2. Seine locations in 2005 and 2006 surveys. Numbered sites were surveyed in both years. Solid circle sites were added in 2006.

Results

A total of 25 fish species including 12 native to the Delta were collected in the two winter seasons surveyed (Table 1).

Table 1. Fish species observed in Western Delta in winter seine surveys in 2005 and 2006.

Native	Non-Native
Chinook salmon (*O. tshawytscha*)	American shad (*Alosa sapidissima*)
Delta smelt (*Hypomeses transpacificus*)	Bigscale logperch (*Percina macrolepida*)
Longfin smelt (*Spirinchus thaleichthys*)	Black crappie*(Pomoxis nigromaculatus)*
Pikeminnow (*Ptychocheilus grandis*)	Bluegill (*Lepomis macrochirus)*
Prickly sculpin (*Cottus asper*)	Golden shiner (*Notemigonus crysoleucas)*
Sacramento sucker(*Catostomus occidentalis)*	Inland silversides (*Menidia beryllina)*
Splittail (*Pogonichthys macrolepidotus)*	Largemouth bass (*Micropterus salmoides)*
Staghorn sculpin (*Gymnocanthus tricuspis)*	Mosquitofish *(Gambusia affinis)*
Starry flounder (*Platichthys stellatus)*	Redear sunfish (*Lepomis microlophus)*
Steelhead (O. mykiss)	Shimofuri goby (*Tridentiger bifasciatus)*
3-spine stickleback (*Gasterosteus aculeatus)*	Striped bass *(Morone saxatilis)*
Tule Perch (*Hysterocarpus traski)*	Threadfin shad *(Dorosoma petenense)*
	Yellowfin goby (*Acanthogobius flavimanus)*

Winter 2005 Survey

The predominant catch in 70 seine hauls in the winter 2005 survey was inland silverside and Chinook salmon, making up 62 and 28 percent of the catch, respectively (Table 2). Together pikeminnow and splittail made up another 5% of the catch. Native fishes made up approximately 36% of the catch.

Average catch of Chinook salmon per seine haul was highest in the two February surveys and lowest in the May survey (Figure 4). Average catch was significantly negatively related to water temperature with lowest catch occurring after water temperature increased to 18.5°C in early May. Water temperature was significantly negatively related to net lower Sacramento River flow (Figure 5).

Average catch was highest in eastern areas of the western Delta survey area with highest average catch in Three-mile Slough (Figure 6). Highest variability also occurred at Three-mile Slough, reflecting sporadic large catches especially at mouth of Seventeen-mile Slough.

Over 95 percent of the catch of Chinook salmon were fry (30-50 mm) and fingerling (50-70 mm) even in April, with pre-smolts and smolts (70-110 mm) making up the remainder (Figure 7).

Table 2. Catch in 70 total seine hauls in winter 2005 seine survey.

Species	Number	Proportion
inland silverside	2343	0.62
Chinook salmon	1049	0.28
splittail	101	0.03
pikeminnow	89	0.02
shimofuri gobi	33	0.01
tule perch	30	0.01
staghorn sculpin	21	0.01
threadfin shad	18	0.00
yellowfin goby	16	0.00
bigscale logperch	14	0.00
mosquitofish	13	0.00
striped bass	7	0.00
threespine stickleback	7	0.00
delta smelt	5	0.00
largemouth bass	4	0.00
golden shiner	3	0.00
steelhead	3	0.00
redear sunfish	2	0.00
prickly sculpin	1	0.00
bluegill	1	0.00

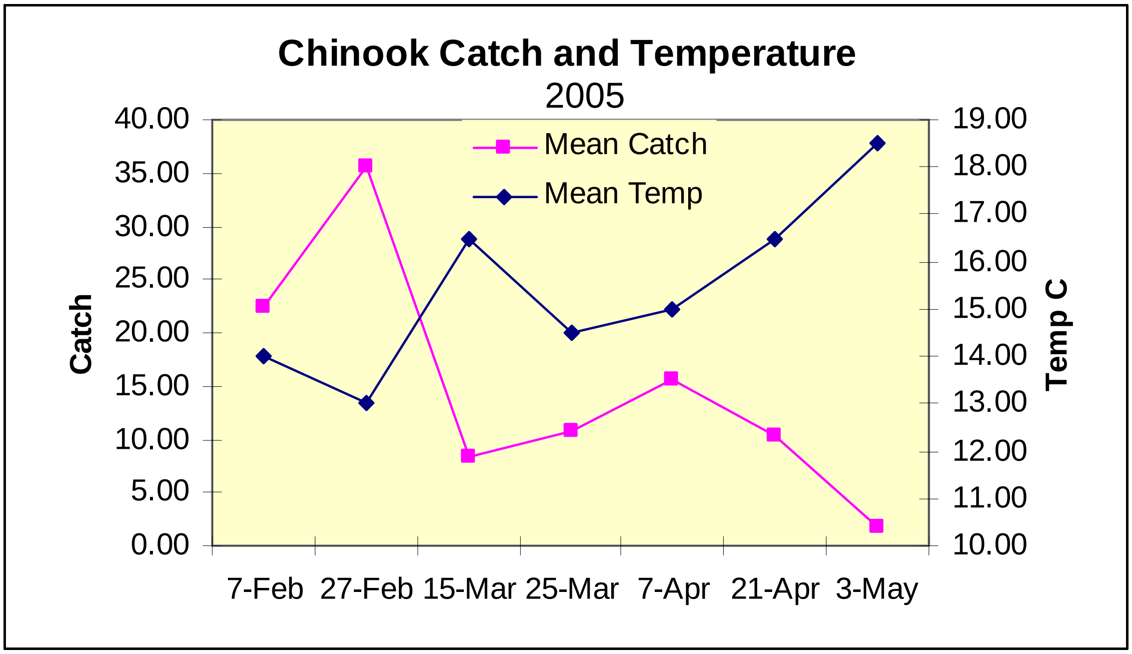

Figure 4. Average catch of Chinook salmon per seine haul by survey with average water temperature of seined locations in 2005.

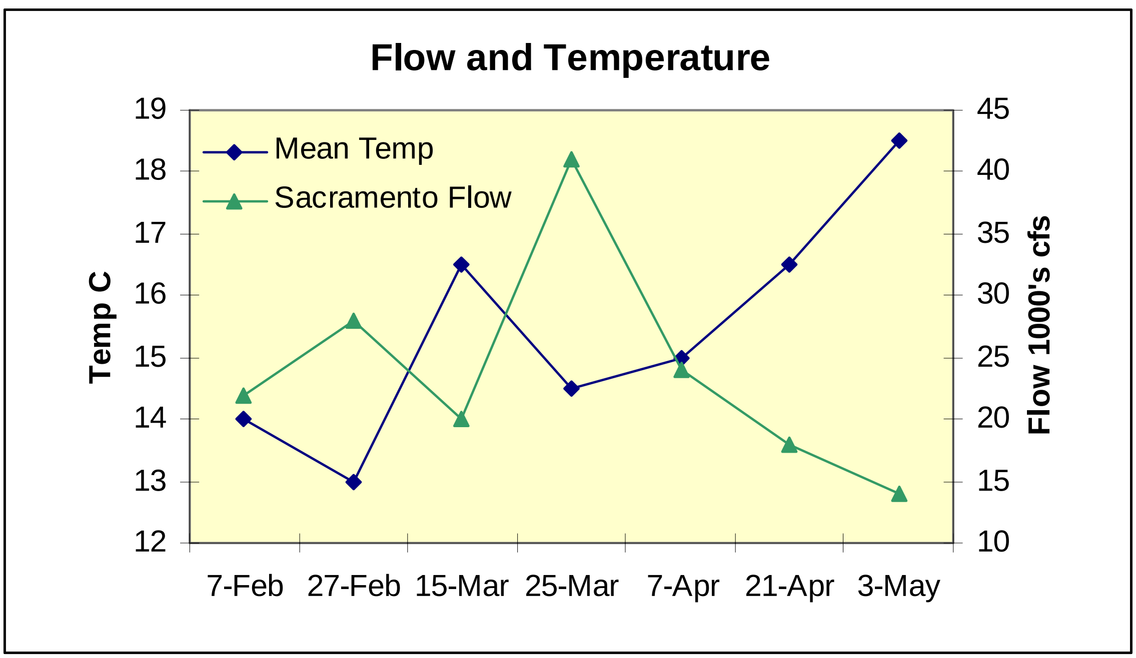

Figure 5. Average water temperature of seined locations versus lower Sacramento net flow (Rio Vista gage) by survey date in 2005.

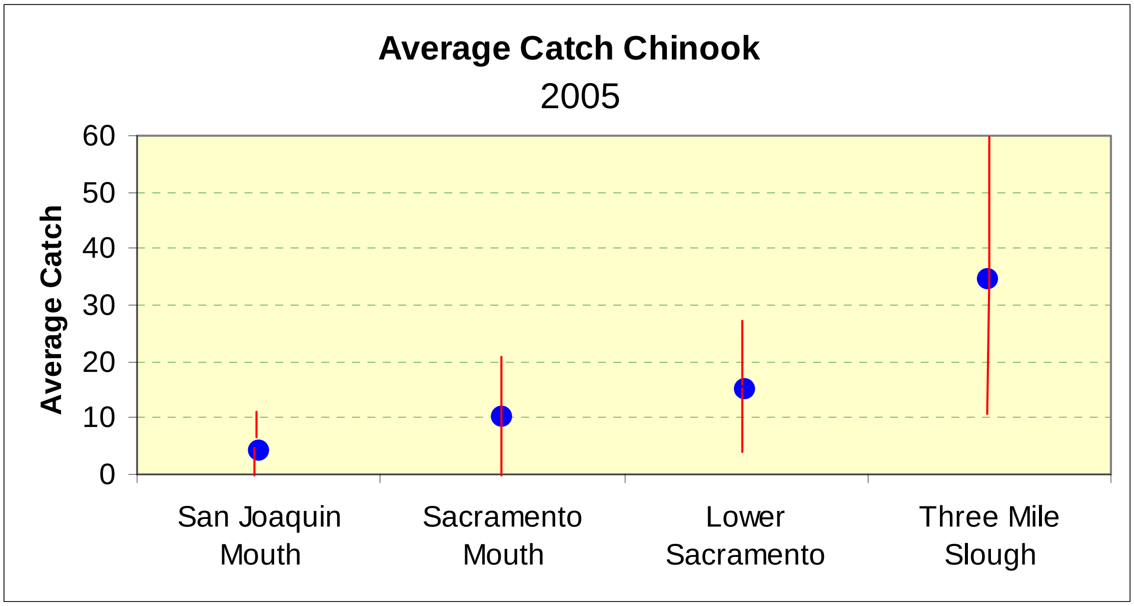

Figure 6. Average catch by geographic region for 2005 seine survey. Error bounds are standard deviation of the mean.

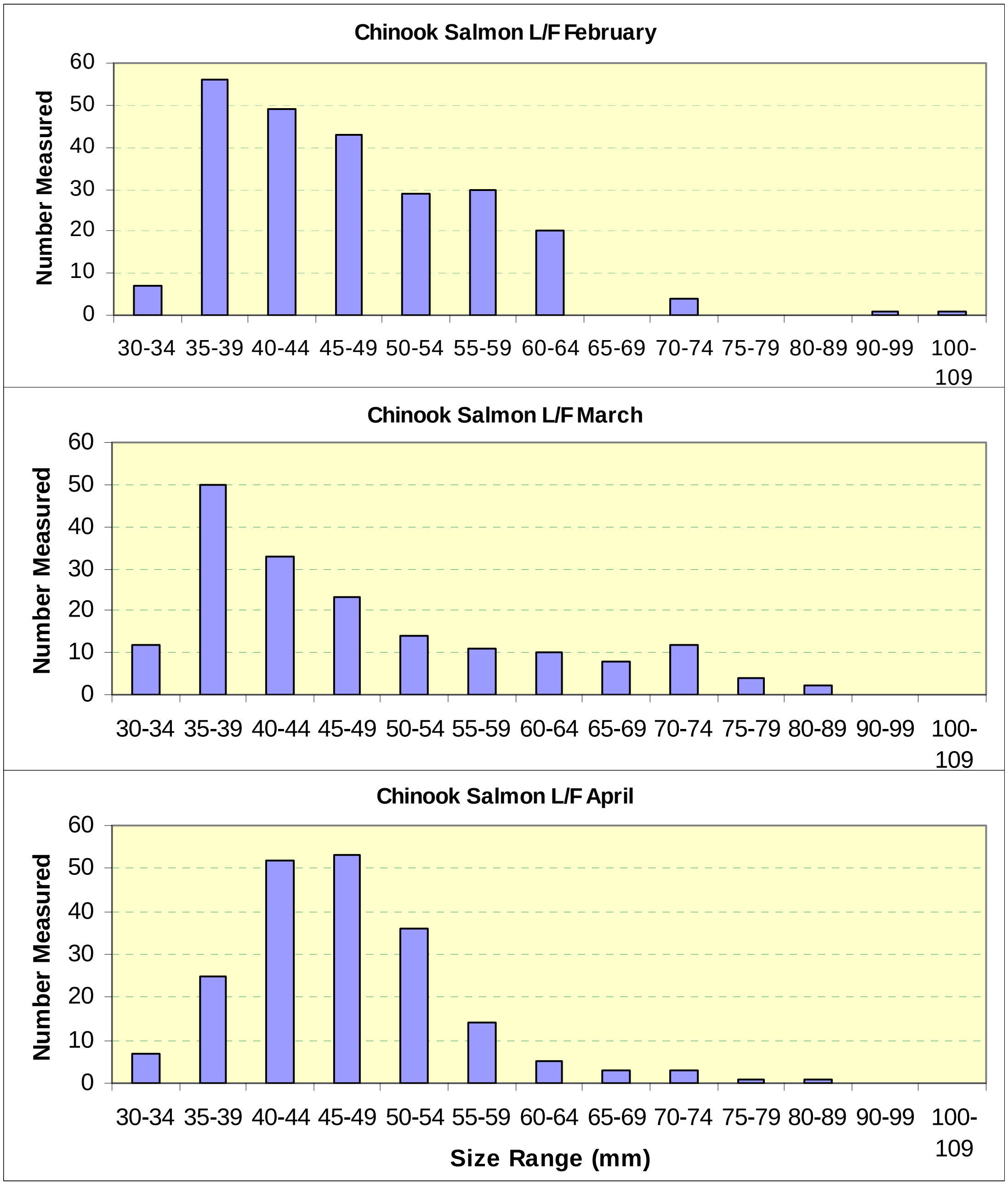

Figure 7. Length-frequency of Chinook salmon collected in seine hauls by month in 2005.

Winter 2006 Survey

The predominant catch in the winter 2006 survey was inland silverside and Chinook salmon, making up 55 and 34 percent of the catch, respectively in 43 total seine hauls (Table 3). Together pikeminnow and splittail made up another 1% of the catch. Native fishes made up approximately 43% of the catch.

Table 3. Catch in 43 total seine hauls in winter 2006 seine survey.

Species	Number	Proportion
Inland Silverside	2017	0.548
Chinook salmon	1261	0.343
pikeminnow	299	0.081
bluegill	15	0.004
splittail	14	0.004
threadfin shad	12	0.003
mosquitofish	11	0.003
golden shiner	11	0.003
Shimofuri goby	10	0.003
largemouth bass	7	0.002
prickly sculpin	6	0.002
yellowfin goby	5	0.001
threespine stickleback	3	0.001
delta smelt	3	0.001
staghorn sculpin	2	0.001
bigscale logperch	1	0.000
tule perch	1	0.000
striped bass	1	0.000
Sacramento sucker	1	0.000

Average catch of Chinook salmon per seine haul was high from late February to late April and lowest in late May and early June surveys (Figure 8). Average catch was significantly negatively related to water temperature with lowest catch occurring after water temperature increased to 20°C in late May. Water temperature was significantly negatively related to net lower Sacramento River flow (Figure 9).

Catch of Chinook salmon in February was equally divided between fry (30-50 mm) and fingerling (50-70 mm) even in April, with pre-smolts and smolts (70-110 mm) making up the remainder (Figure 10). Approximately ten percent of the late April catch were smolt sized fish (70-110 mm). The majority of the numericallysmall May-June catch were smolt-sized fish.

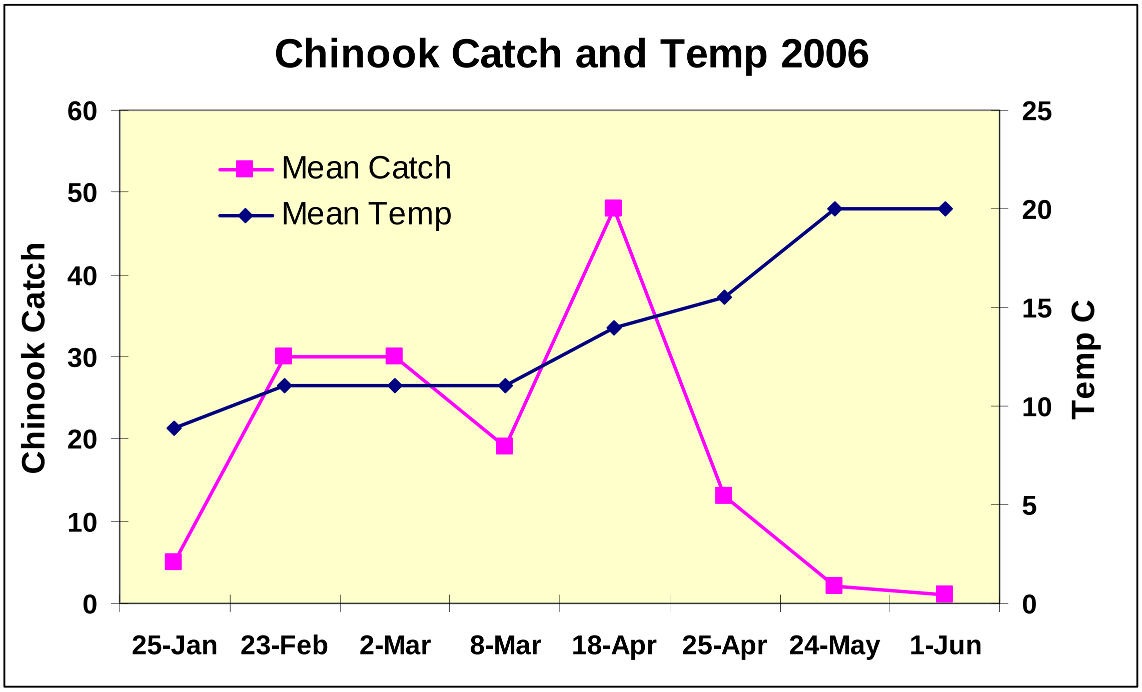

Figure 8. Average catch of Chinook salmon per seine haul by survey with average water temperature of seined locations in 2006.

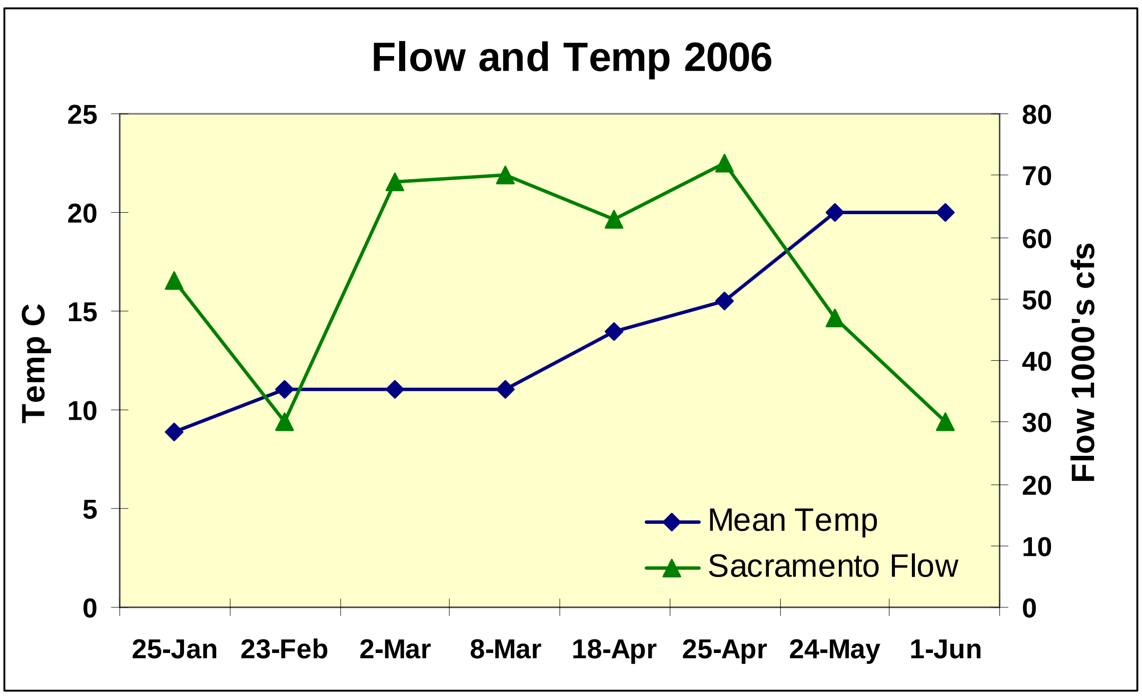

Figure 9. Average water temperature of seined locations versus lower Sacramento net flow (Rio Vista gage) by survey date in 2006.

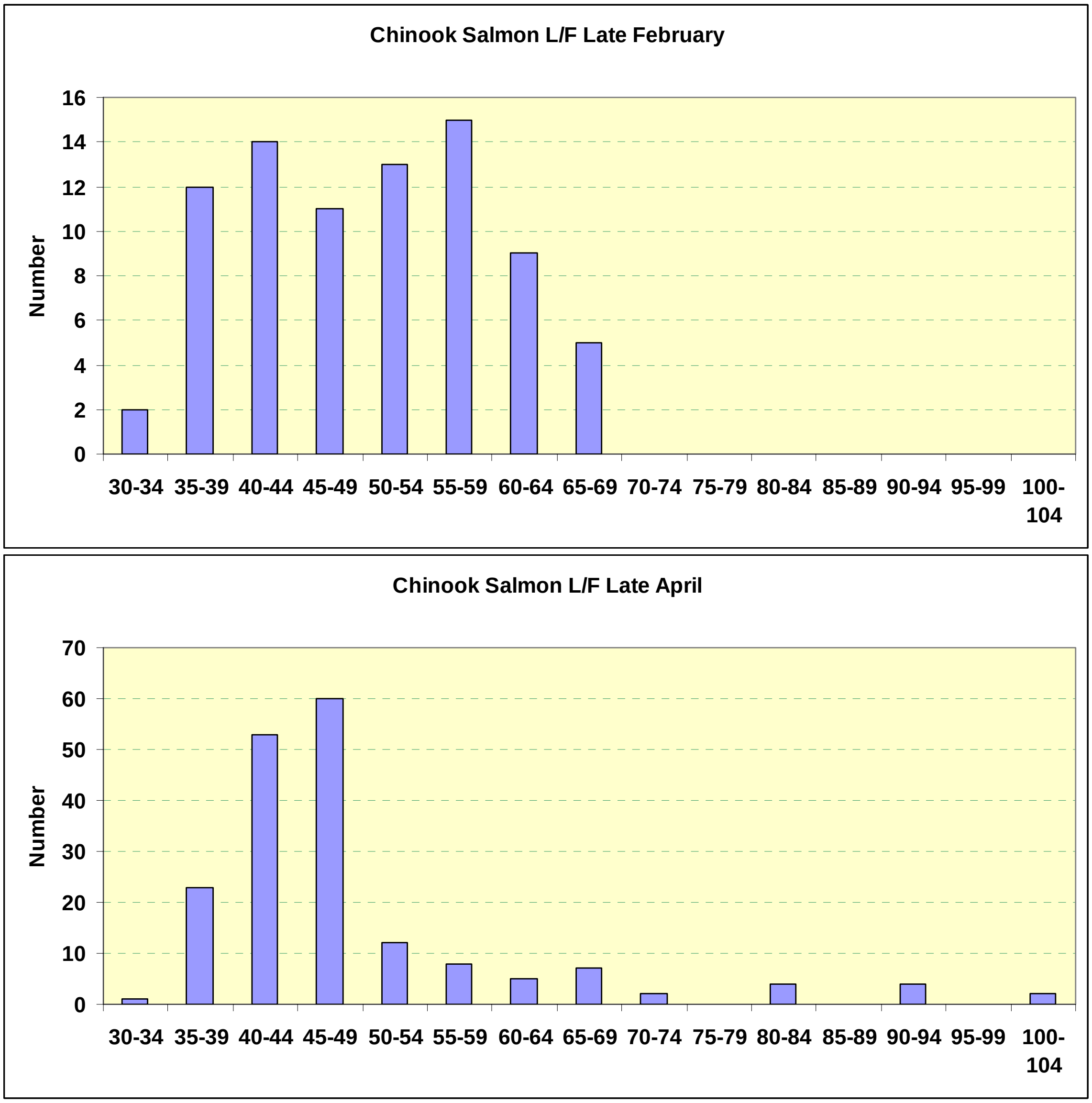

Figure 10. Length-frequency of Chinook salmon collected in seine hauls in late February and late April in 2006.

Discussion

Young salmon were captured throughout the Western Delta in almost every seine haul in the winters and early spring of 2005 and 2006. In 2006 the average catch was 30 young salmon per seine haul, a remarkable achievement given the relatively small size of the seine and nearly 100 miles of total shoreline habitat in the survey area. Catches were high at both ends of the survey area indicating that the distribution of young salmon extended well upstream and downstream of the Western Delta. Salmon were second in abundance only to silversides in winter and early spring surveys of the western Delta in 2005 and 2006. Both species were found together in similar habitats. Silversides tended to be more abundant in shallow quiet backwaters with abundant vegetation as compared to open hard bottom beaches as found on the north shore of the lower Sacramento River between Rio Vista and Collinsville. Both species were very abundant in Three-mile Slough, especially in the backwater at the mouth of Seventeen Mile Slough. This location was also where most of the delta smelt were caught.

Our 2005 survey showed a similar pattern to the FWS 2005 seine survey for the winter period. Further upstream on the lower Sacramento River, Chinook salmon young dominated the catch (41%) in the FWS Delta seine survey (Marshall 2005; Wichman and Hanni 2005). In their North Delta seines young salmon made up 48% of the catch compared to 43% for inland silversides. Inland silversides dominated the catch in the Central and South Delta (44% and 71%, respectively). Our survey also found less salmon on the San Joaquin side of the Delta.

Most of the Chinook salmon captured were 35-70 mm. The relative proportion of fingerlings (50-70 mm) to fry (30-50 mm) was highest in February early in the survey year. We can only speculate that the initial pulse of fish from the rivers included both groups and perhaps more of the spring run salmon that spawn earlier than the fall run. By March and February, fry of the fall run predominated.

Young salmon were abundant throughout the western Delta from February through April when water temperature was in the optimal[1] 10-15°C range. In 2005 water temperatures warmed early under lower river flow and reached above optimal temperatures (>16°C) by late April. In 2006 under higher Sacramento River inflow, water temperatures were cooler early and late in the survey compared to 2005. Water temperature remained optimal (<16°C) into late April in 2006. Water temperature was above optimal by late May of 2006 despite relative high river flows. By June young splittail and tule perch replaced salmon as the most abundant native fishes in the shallow waters of the Western Delta.

Salmon density was highest in the Sacramento River where it enters the western Delta near Three-mile Slough and then declined in the open Delta. The decline may be related to a greater surface area in which the young salmon may spread at the west end of Sherman Island.

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[1] Optimum temperature range for growth and survival is considered 10-16°C based on Marine and Cech (2004).

Yearling striped bass and pikeminnow shared shallows with young salmon and silversides with pikeminnow being the more abundant. Salmon and silversides were of similar size (30-120 mm). Pikeminnow and striped bass were generally in 150-250 mm range.

The band of shallow shorelines and off-channel shallow water habitat is relatively limited and represents only a small portion of the total area of the Western Delta. On both the lower Sacramento and San Joaquin channels shallow water (< 2 m) is very limited (often the length of our boat from shore) because the dredged shipping channels influence is close to shore. The amount of beach habitat is especially limited. Many shorelines are actively eroding. Shallow tidal channels, especially dead-end channels and back-water marshes are clogged to a great extent by floating aquatic vegetation (FAV) Most of the channels and backwaters, as well as shallow shoals, are also dominated by non-native submerged aquatic vegetation (SAV) including Egeria, Potamogeton, and Parrots Feather (milfoil).

The amount of riparian shoreline vegetation that helps form Shaded Riverine Aquatic (SRA) habitat is very limited in the Western Delta. For example the entire north shore of the lower Sacramento River between Collinsville and Rio Vista is not leveed or rocked and is highly eroded with little SRA and limited shoreline or off-channel marsh habitat. Most of the shoreline is dominated by Arundo *(Arundo donax)* stands. Patches of tules occur along some sandy beaches. Much of the channel shorelines of the two rivers are rocked levees with limited vegetation and SRA habitat. Areas around West Sherman Island and Sherman Lake have considerable shoreline and marsh habitat, however the remnant levee shorelines with moderate amounts of riparian and marsh vegetation are actively eroding and the interior marshes and channels are filling in with sediment, SAV, and FAV. For example, Montezuma Island's back channel that accommodated naval craft in WWII and otter trawls in the 1970's is now nearly completely filled with sediment and SAV beds.

The young salmon habitat that is being lost or degraded is the "intertidal-upland coupling zone" described by Williams and Thom (2001) "*where fringing vegetation shades the intertidal zone and contributes insects and leaf litter directly into the aquatic environment*". With the loss of riparian trees there has been a loss of large woody debris (LWD) that provides cover and habitat for young salmon. In many areas of the Western Delta, rocking of the levee shorelines has eliminated this zone of habitat. Dredging of shipping channels of the lower Sacramento and San Joaquin has also contributed to the loss of shallow water, intertidal, and fringe upland habitats. Williams and Thom relate considerable literature that shows that young Chinook salmon concentrate in the shallow (0.1 to 2.0 m) shoreline zones of the upstream edge of estuaries where there is plentiful food, refuge from predators, and a transition zone to physiologically adapt to salt water. They also relate how hardening of shorelines alters wave energy leading to erosion of beach profiles and beach gradients, which in turn may fragment nearshore landscape and alter habitat use and fish movement, attract predators, and/or reduce habitat complexity and cover.

Though our study is not proof that Delta rearing is important to Central Valley Chinook salmon populations, at a minimum it would appear that it is an important rearing area for Sacramento River Basin populations, especially those of the Feather and American Rivers whose mouths are located on the Sacramento River just upstream of the Delta. Others have also generally made this claim (Brandes and McLain 2001). However, Brown (2003) states: *"Much of the speculation regarding the importance of tidal wetlands and associated nearshore habitats to anadromous salmonids revolves around differences in survival of chinook salmon fry rearing in the Delta compared with tributary streams or survival of smolts taking different migration routes through the Delta (Brandes and McLain 2001). Survival of fry in the Delta appears to be lower than in the tributary streams. Nevertheless, the relative contribution of Delta-reared fry to adult production is unknown and may have been substantial under natural conditions."* Brown's statement about fry survival in the Delta is taken from results of Brandes and McLain code-wire tag releases of hatchery fry released into the lower Sacramento River in the Delta. Brandes and McLain hypothesized that higher survival of fry released above the Delta as compared to survival of fry released in the North Delta in wet years was a consequence of large amounts of flooded river floodplain habitat (in the Yolo and Sutter Bypasses) upriver that was of better quantity and quality than that available in the Delta. Their statement implies that habitat quantity and quality in the Delta may be a bottleneck for salmon production, which would make the Delta rearing habitat an important element of salmon recovery. A reduction in shallow water habitat quantity from erosion and sedimentation, and a reduction in quality from non-native SAV-FAV infestations and inter-specific competition from expansion of the non-native inland silversides population could be narrowing the bottleneck of salmon populations depending on the Delta for rearing. If this is the case, then expanding the bottleneck through habitat restoration would potentially increase salmon production. We believe that more studies like ours can help toward identifying those habitats more preferred by salmon while being less preferred by inland silversides.

Recommendations for Further Study

The following additional studies are recommended:

- Study specific habitat relationships for salmon and other Delta species
- Map habitats.
- Add electrofishing and fyke nets to gear types used.
- Conduct comparative studies with other areas (Bay, floodplains, rivers)
- Study reference sites with natural habitat conditions.

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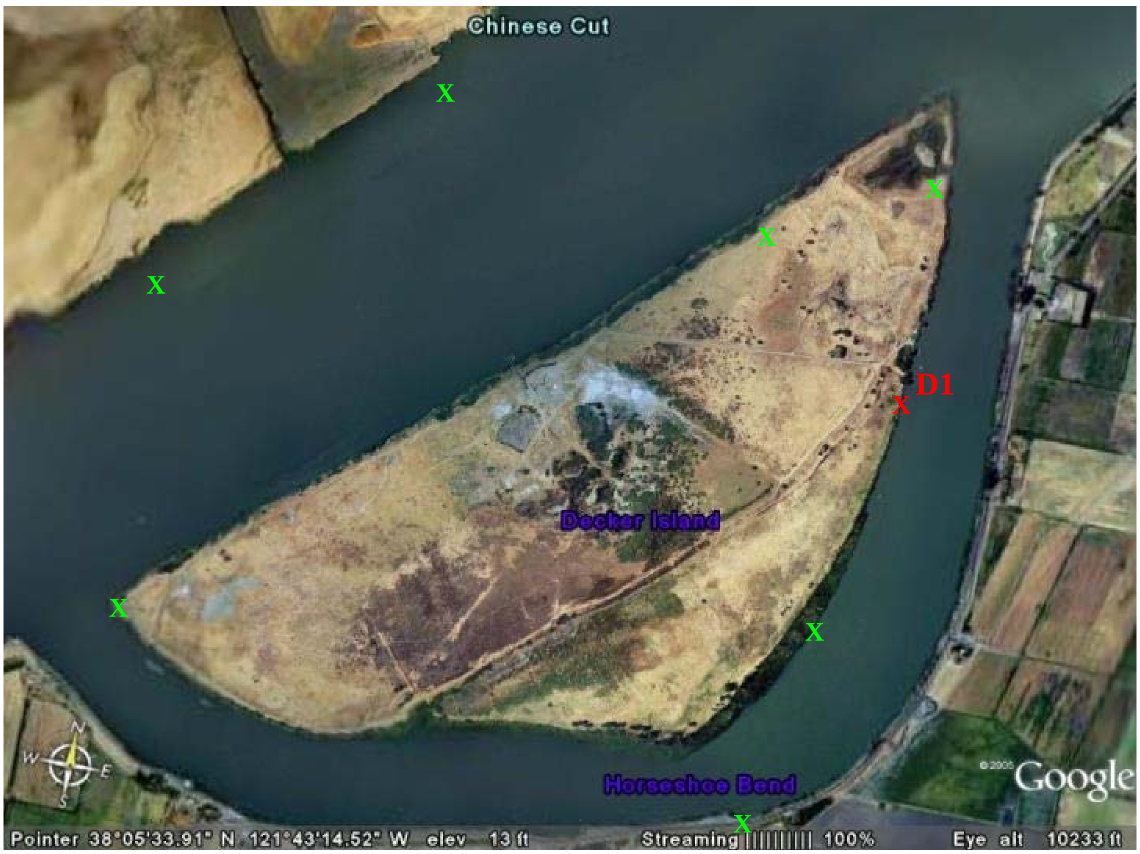
Appendix A

Aerials and photos of selected survey areas in the Western Delta

Decker Island Area

The Decker Island area of the lower Sacramento River has considerable shallow water habitat and seining beaches (see X's in aerial below). Vegetation is minimal and there are many opportunities to restore shoreline habitats.



Above: Shallow water habitat on south side of Decker Island. This area held large numbers of inland silversides and Chinook salmon. Below: north shore.

Point Sacramento

February 23, 2006
Delta Seine
Survey

Four 50-ft seine samples were taken on beaches at Point Sacramento at the confluence of the Sacramento and San Joaquin Rivers at the entrance of Broad Slough.

The four sites sampled are eroding tules benches on historical levees. Sites X/1 and X/2 have extensive peat materials as the eroding banks are tule beds with extensive root systems holding the bank, while 3 and 4 have more sand mixed in with tules. X/1 to X/2 is remnant of the former tule bench that has eroded back into the island. The bench extends out to the remnant shoreline in Broad Slough (small tule islands in photo). At X/1 the beach is actively eroding from a sandy loam substrate. Tules protect much of the beach area and are holding their own. The tule bench along the channel all along the west shoreline of this part of Old Sherman Island at Point Sacramento on Broad Slough is eroding slowly – there is a sharp drop-off at the outer edge that is being held mainly remnant peat soils with extensive tule root systems. The embayment at X/1 is shallow with only 1 to 4 ft depth at low tide. The embayment appears very productive based on high amounts of allocthonous plant debris feeding a detrital food chain in the warm shallow waters. Phyto and zooplankton production is likely high given moderate turbidity, high solar radiation, and warmer water (about a degree warmer than the main channel waters). The aquatic vegetation is tules along the margins with no sign of submergent vegetation common to the area (no Egeria, Eurasian milfoil, or Potamogeton), possibly due to the tule root and peat substrate. The shoreline area had high numbers of juvenile and adult inland silversides and small numbers of juvenile fall-run Chinook salmon (35-60 mm).

The tule-bench shelf narrows at Sacramento Point as the channel reaches within a few dozen feet of the shoreline. The tule root system again holds the peat shoreline of the bench with the shoreline and substrate at low tide being the typical black peat intermixed with hard tule roots representative of an actively eroding tule bench. Though hard to sample with seines because of the uneven bottom (tule roots), there appears to be a lower density of silversides with small numbers of salmon.

Around the point on the north side of Old Sherman on the Sacramento River the habitat changes to a sand shelf dominated by shoreline tules and small sandy beaches. Some of the beach area is hard compact soil remnants of the original shoreline levees. The density of salmon appears higher in this area, possibly due to the higher energy sandy beaches of the Sacramento River. Silverside were also abundant with a few three-spine stickleback. Density of salmon was highest in a small embayment at X/4 (created by shoreline erosion behind bordering beds of tules) with hard sandy bottom and large amounts of large woody debris. The north shore is basically a narrow shelf with a sharp dropoff at the tule bench, with small open pockets of sand between and behind the tule beds (probably caused by shoreline erosion and sand deposition). The habitat is predominantly tule beds with some open sandy shoreline pockets and small embayments. Pockets of open sandy-beach habitat are probably important to fish, and large woody material may improve the habitat as it does in streams by providing
cover.

West Sherman Area

Remnants of West Sherman Island levees (site 32 in Figure 2 of text) provide considerable shallow water habitat at the west end of Sherman Island. The state park beach is the red X at right on Sherman Island.

Three Mile Slough Area

Seine locations on Three-mile Slough.

Montezuma Island

Montezuma Island is eroding on the south, shipping channel side and filling in on the north side channel side. Salmon were abundant at this location in winter 2006.

West Island Area of Lower San Joaquin