

EARLY LIFE STAGES AND EARLY LIFE HISTORY
OF THE
DELTA SMELT, *HYPOMESUS TRANSPACIFICUS*,
IN THE
SACRAMENTO-SAN JOAQUIN ESTUARY,
WITH
COMPARISON OF EARLY LIFE STAGES OF THE
LONGFIN SMELT, *SPIRINCHUS THALEICHTHYS*

Johnson C. S. Wang, Ph.D.

Technical Report 28
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Interagency Ecological Studies Program
for the
Sacramento-San Joaquin Estuary

A Cooperative Program by the:

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SUMMARY

Data collected in 1989 and 1990 indicate Delta smelt spawned both in the Delta and the Sacramento River. The apparent center of spawning was around Bradford Island in the Delta and in the reach of the Sacramento River just below Rio Vista.

The spawning season extended from February through June, with a peak in late April and early May. The nursery ground for the larvae extends from Jersey Island to Medford Island and was concentrated in and around Franks Tract.

Recruitment of juvenile stages proceeded in a much broader range in the Delta and in the upper estuary in summer. Completion of recruitment was demonstrated by the screen catch of adults at the CVP screens during winter.

Taxonomic characteristics used to separate Delta smelt from longfin smelt were:

- Morphological differences of gas bladder formation.
- Relationship of the gut to the gas bladder.

Using these taxonomic characteristics to separate the two species from yolk-sac larvae through pre-juveniles and juveniles was found to be reliable and convenient. Supporting taxonomic characteristics include, but are not limited to, paired thoracic melanophores, relative positions of dorsal and pelvic fins and of adipose and anal fins, the snout, eye size, and maxillary extension. Other body and fin pigmentations are also useful for cross-checking to ensure identification.

As a result of the recent drought, the Delta smelt population has been more concentrated in the Delta than before.

INTRODUCTION

The Delta smelt is a small estuarine fish native to the Sacramento-San Joaquin estuary (Herald 1961; McAllister 1963). Delta smelt are found in water where specific conductance ranges from 500 to 800 $\mu\text{S}/\text{cm}$ (*microSiemens per centimeter*) (DFG 1988), such as the freshwater tidal portions of the Sacramento and San Joaquin rivers, the Delta, Suisun Bay, and Montezuma Slough (Radtke 1966; Moyle 1976). Delta smelt are occasionally found in San Pablo Bay when Delta outflow is high and salinities in the bay are low (Ganssle 1966; Messersmith 1966; DFG 1988). They have been reported as far north as the mouth of the American River, near Sacramento (DFG 1988), and to Mossdale, on the San Joaquin River (Radtke 1966).

In the late 1970s and early 1980s, Delta smelt were abundant in Suisun Marsh, Montezuma Slough, and the upper estuary (Moyle and Daniels 1981; PG&E 1981a,b). In 1983 and 1984, the population began to decline. A lower catch was first noted in samples from Suisun Marsh and Montezuma Slough (Moyle and Herbold 1989), and this spread into the upper estuary and the entire known range of the Delta smelt (DFG 1988, Stevens *et al* 1990).

In 1989, Dr. Peter B. Moyle, professor at the University of California, Davis, filed a petition with the California Fish and Game Commission, asking the State to list the Delta smelt as an endangered species. Dr. Moyle's petition was

denied on August 30, 1990, after a public hearing in Sacramento. However, the Commission urged the Department of Water Resources and Department of Fish and Game to investigate the Delta smelt and to obtain more scientific information.

On June 26, 1990, Dr. Donald C. Erman, professor at the University of California, Berkeley, and president of the California-Nevada Chapter of the American Fisheries Society, filed a petition with the U.S. Fish and Wildlife Service to list the Delta smelt as a Federal endangered species. Dr. Erman's petition was accepted by the Fish and Wildlife Service and is under consideration.

This report has been prepared in response to concerns over the rapid decline of Delta smelt in the estuary. Most studies of Delta smelt have emphasized adult and juvenile recruitment. Information on early life stages and early life history is limited (Simonsen 1977, Wang 1986). This report describes the morphology and ecology of early life stages of the Delta smelt.

In early life stages, Delta smelt are similar in appearance to longfin smelt, which is also native to the Sacramento-San Joaquin estuary, and information concerning the early lives of these two species has almost always been combined. This report compares the species during their early life stages — an important step toward understanding the current ecological status of the Delta smelt.

MATERIALS AND METHODS

Samples were obtained from the following State and Federal agencies:

- Department of Fish and Game

DFG collected ichthyoplankton samples (about 800 in 1989 and 1,135 in 1990) from the following locations:

- » Suisun Bay to Medford Island in the Delta and to Sacramento on the Sacramento River, from mid-April to mid-July 1989 (Figure 1).
- » From Suisun Bay to Medford Island and to Cranmore on the Sacramento River (except in the river section between Rio Vista and Sacramento) from mid-April to mid-July 1990 (Figure 2).

- U.S. Bureau of Reclamation

USBR collected more than 1,000 ichthyoplankton samples from the Sacramento and San Joaquin rivers and the Delta in 1990 (Figure 3):

- » Near the Delta Cross Channel and Georgiana Slough in the Sacramento River, mostly in late April.
- » At the intake to the Delta-Mendota Canal in late February through mid-July.
- » Near Andrus Island and Twitchell Island in the lower San Joaquin River in early April to mid-May.

In addition, more than 460 salvaged juvenile and adult smelt were collected from the intake screens of the CVP from April 1990 to May 1991 (Figure 3).

- Department of Water Resources

DWR collected ichthyoplankton samples near the Central Valley Project and State Water Project from mid-April through mid-July 1990 (Figure 4). A total of 263 of these samples were examined.

Other pertinent information on the catch of smelt was compiled from entrainment studies at Pittsburg and Contra Costa Power Plants contracted

by Pacific Gas and Electric Company (Charles Hanson and Carol Raifsnider, personal communication) (Figure 3).

A Bausch and Lomb Sterozoom 7 microscope, a Bausch and Lomb high-intensity illuminator, and a micrometer were used to examine taxonomic characteristics of specimens. In addition, microanatomy on infrastructures and organs of larvae was used to provide more taxonomic characteristics that could be used to distinguish Delta smelt from longfin smelt.

To differentiate between Delta smelt and longfin smelt during early life stages, a number of techniques were applied.

- Since all specimens were collected from the field, and because Delta smelt and longfin smelt were mixed in the samples, the author worked backward from larger specimens to smaller, unknown specimens.
- Ecological and geographical information was used to separate the newly hatched yolk-sac larvae of Delta smelt and longfin smelt. As a general rule, Delta smelt spawn in fresh water and longfin smelt spawn in brackish water. Therefore, examination of larvae taken at Garcia Bend, on the Sacramento River, and larvae taken from San Pablo Bay allowed for comparison of the two species.
- The literature was examined, particularly Yapchionges (1949), Morris (1951), Follett (1952), Mikita (1958), Hamada (1961), DeLacy and Batts (1963), Baraclough (1964), Dryfoos (1965), Moulton (1970), Simonsen (1977), Hearn (1983 and 1984), Wang (1986), Moyle and Herbold (1989), Shadrin (1989), Moyle *et al* (1990), Spaar (1990a,b and 1991), and Arthur *et al* (1991).

More than 200 voucher species of various life stages of Delta smelt and longfin smelt are temporarily located at National Environmental Sciences, Inc., Concord, California.

Other osmerids found in the Sacramento-San Joaquin estuary are the night smelt, *Spirinchus*

starksi, and the whitebait smelt, *Allosmerus elongatus*. These species have been reported in San Francisco Bay and San Pablo Bay (Roedel 1953; McAllister 1963; Ganssle 1966; Messersmith 1966; Aplin 1967; Hearne 1983), but early life stages of these species were not observed in the upper estuary (Wang 1986).

Larvae of surf smelt, *Hypomesus pretiosus*, have been found in coastal waters, in coastal streams adjacent to San Francisco Bay, and originally in the Sacramento-San Joaquin estuary (Wang 1986). The surf smelt has a more elongated body (Wang 1986) and a higher vertebrae count (62-70; McAllister 1963) than the Delta smelt.

The pond smelt, *Hypomesus nipponesis*, known as "wakasagi" in Japan, was introduced into California in 1959 by the Department of Fish and Game.

Pond smelt were collected from Folsom Lake, on the American River system, in 1989 (Stevens *et al* 1990). It is not known if the pond smelt has descended into the Sacramento-San Joaquin estuary. Characteristics of the wakasagi larvae, translated from Japanese literature, are found in Appendix B.

Other, osmerid-like fish species are found in the Sacramento-San Joaquin Estuary: the early larval stages of clupeids, such as the Pacific herring, *Clupea harengus*, the American shad, *Alosa sapidissima*, and the threadfin shad, *Dorosma petenense*, are often mistaken for osmerid larvae. A careful examination of the midventral melanophores below the gut, the position of the yolk sac, and the position of the anus, permits reliable separation of osmerid and clupeid larvae.

Figure 1
 DFG ICHTHYOPLANKTON SAMPLING STATIONS, 1989

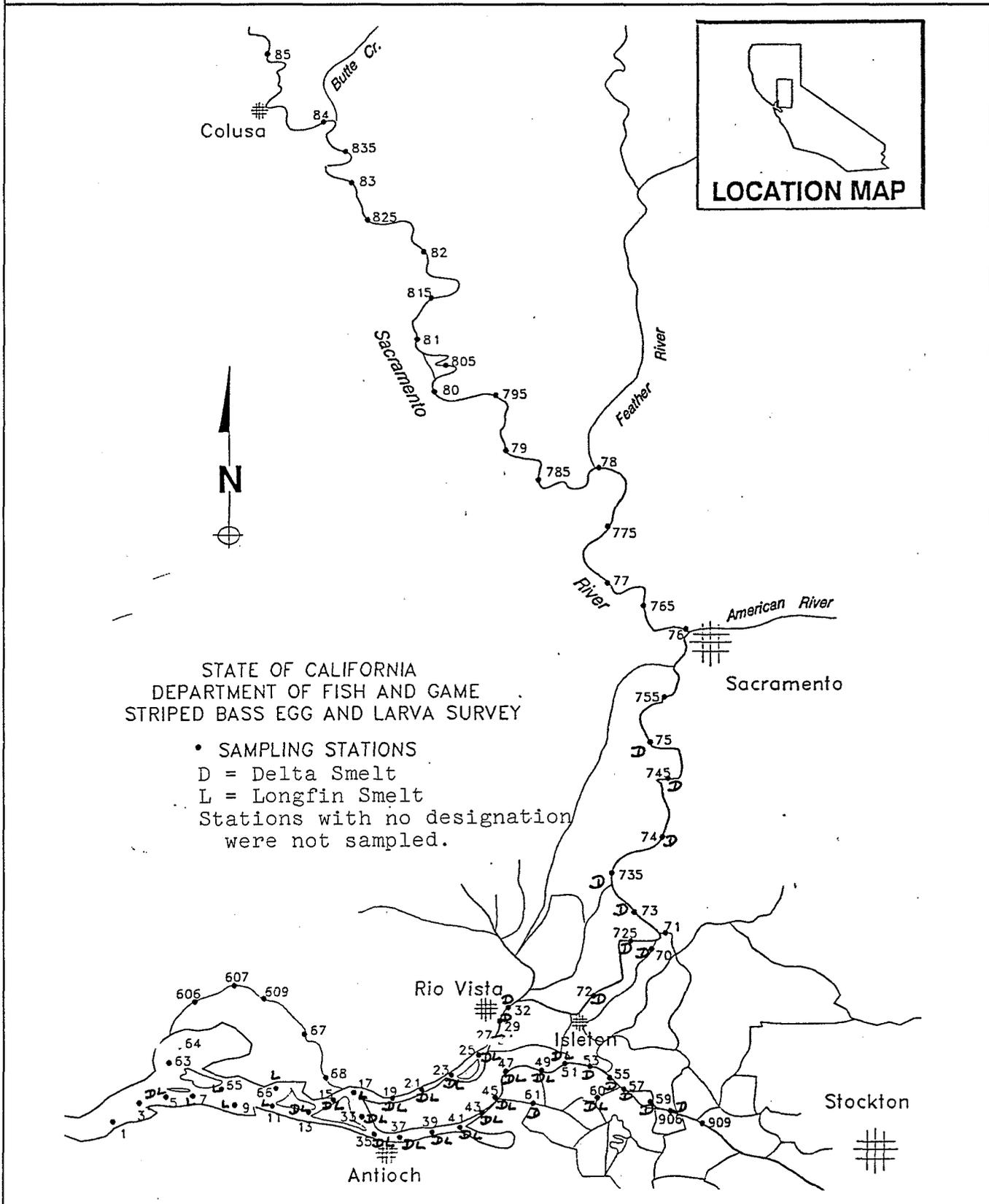


Figure 2
 DFG ICHTHYOPLANKTON SAMPLING STATIONS, 1990

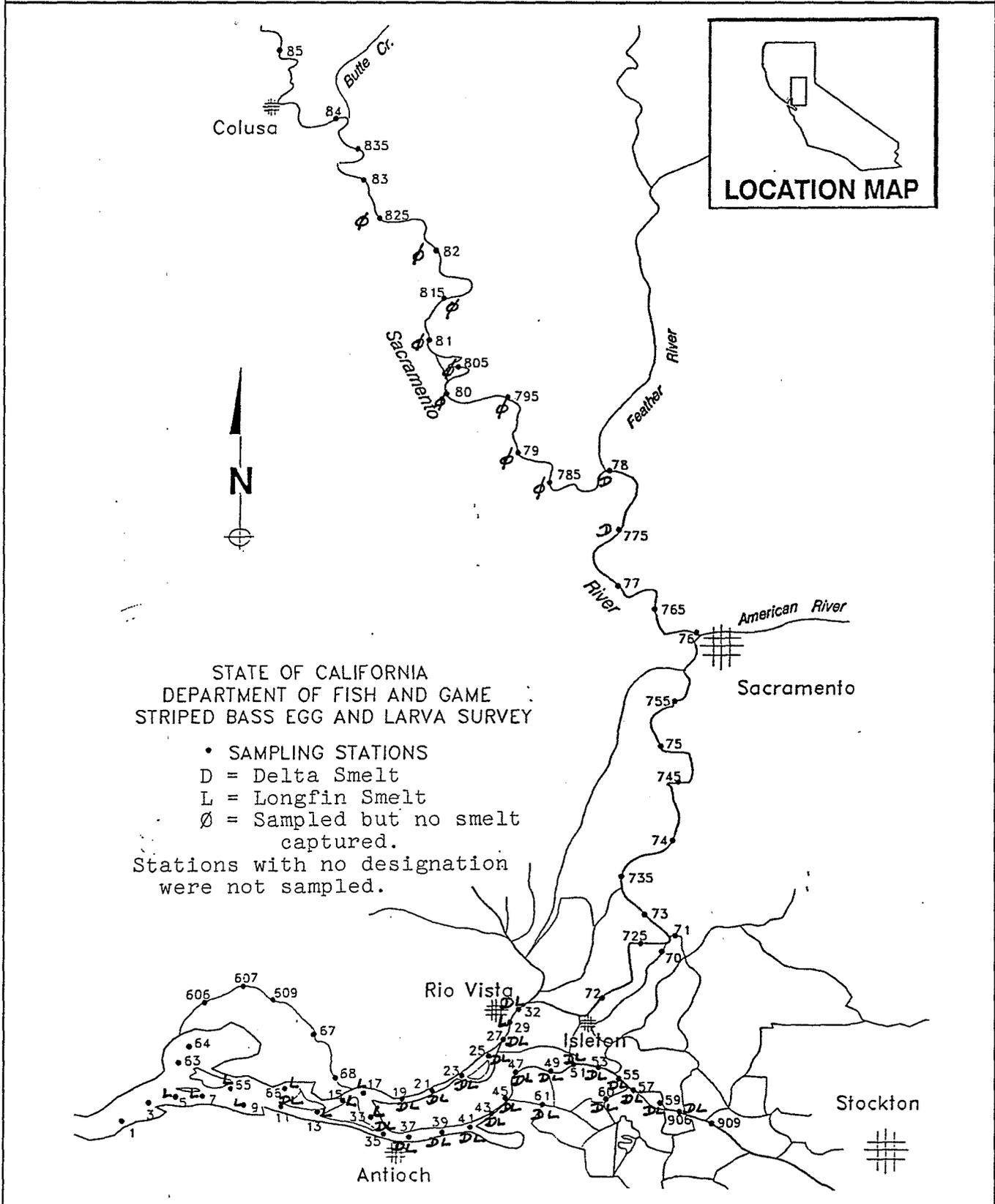


Figure 3
 USBR ICHTHYOPLANKTON AND OTHER LIFE STAGES OF FISH SAMPLING LOCATIONS, 1990

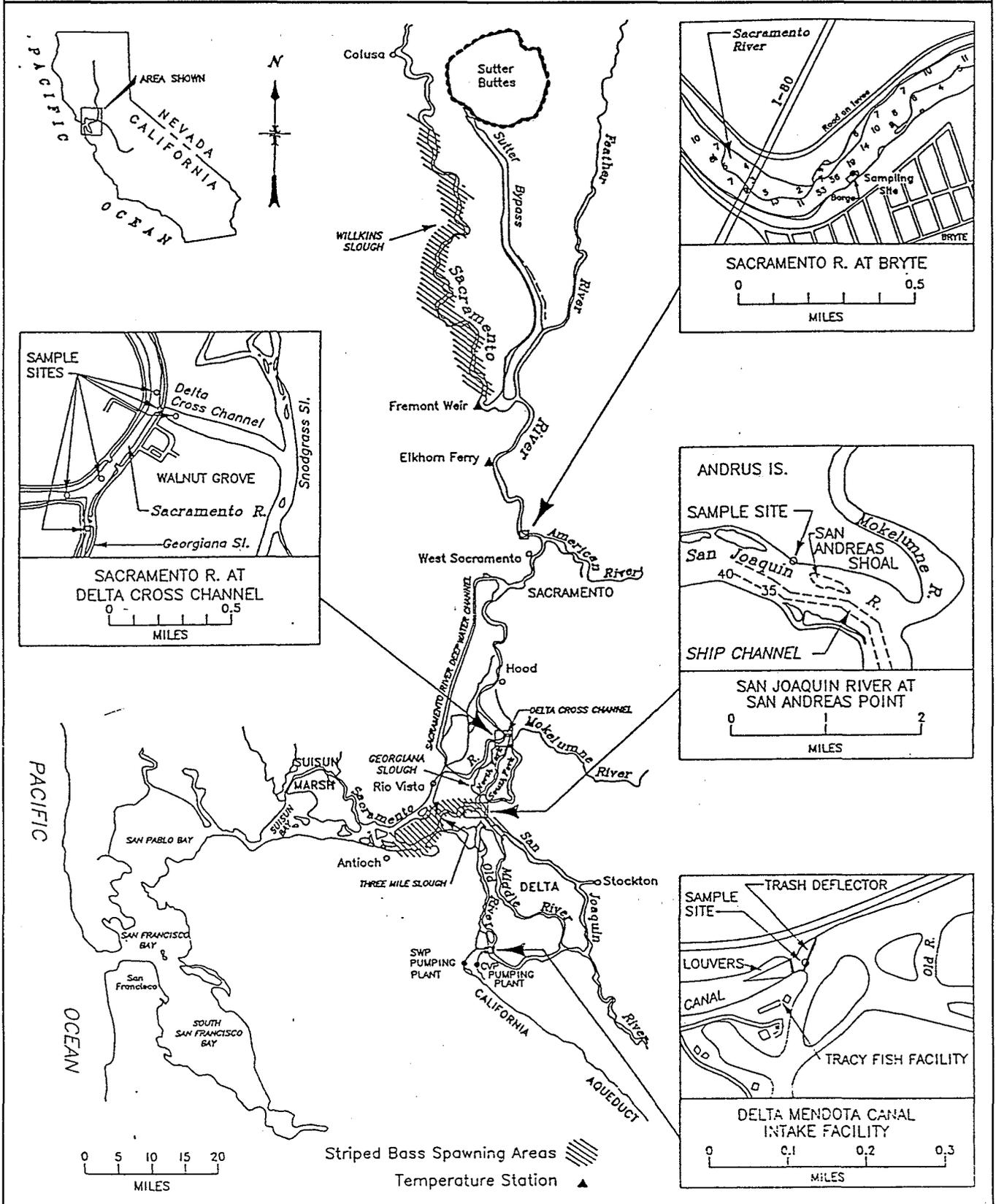
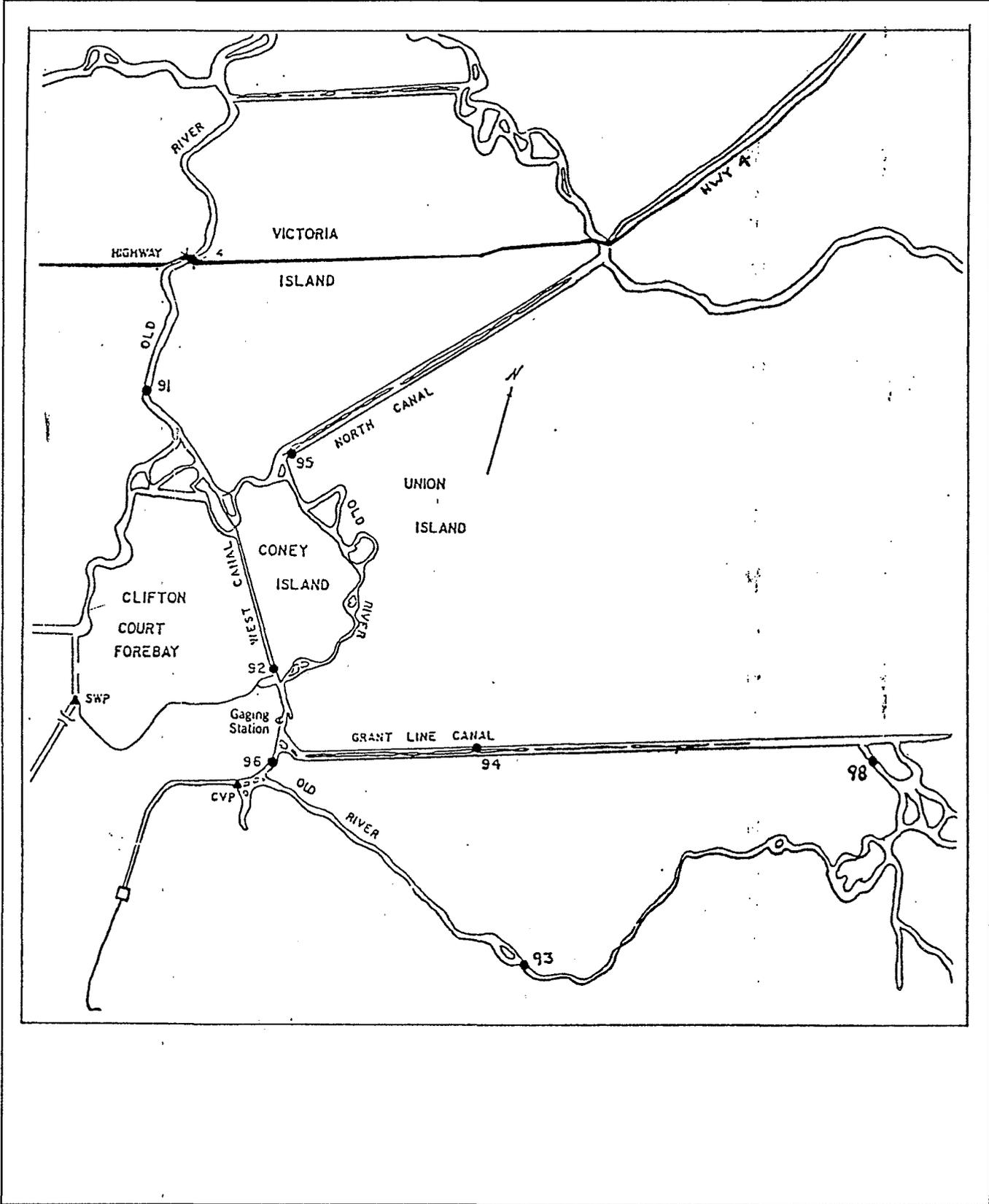


Figure 4
DWR ICHTHYOPLANKTON SAMPLING STATIONS, 1990



RESULTS AND DISCUSSION

Over 3,000 samples were processed, and 1,086 Delta smelt and about 2,000 longfin smelt were identified (Tables 1 through 9). These data were the major source of up-to-date information (1989 and 1990) used to describe the early life history of the Delta smelt in the Sacramento-San Joaquin estuary. Temporal and spatial distribution of early life stages of longfin smelt in the estuary samples are also described briefly. Appendix A is a key to smelt larvae, prejuveniles, and juveniles. Taxonomic characteristics describing the larvae are shown in Appendix B.

Early Life History of Delta Smelt

In moderate- to high-flow years, prespawning adults concentrate in the lower reaches of the Delta and in upper Suisun Bay (Moyle 1976) and then disperse into the Delta for spawning (Radtke 1966). The spawning area apparently includes Montezuma Slough up to the confluence of the Sacramento and San Joaquin rivers (PG&E 1981a,b; Wang 1986). In the mid-1980s, when the drought started, the Delta smelt moved into the Delta and practically deserted Suisun Marsh channels — probably because salinity was too high (Moyle and Herbold 1989).

In 1989, spawning ranged from Roe Island in Suisun Bay to Garcia Bend on the Sacramento River and to Medford Island and the vicinity of the CVP and SWP (DFG sample, this study; USBR and DWR samples, this study; Spaar 1990). In 1990 the range was about the same as in 1989 (this study). Spawning was concentrated in the waters adjacent to Bradford Island and Fishermans Cut (this study).

Spawning took place from mid-February to late June or early July, peaking in late April and early May (this study). Mature adults were seen at the CVP intake screens from late December 1990 to early April 1991 (this study). Based on observations when mature females and newly hatched yolk-sac larvae were collected at a site (Wang 1986), water temperature at spawning is ca. 7-15°C.

Delta smelt spawn mostly in fresh water, but may spawn in slightly brackish water in or above the entrapment zone (this study). Spawning is mostly in river areas under tidal influence, ranging from moderate to fast flow; in rivers and slough (this study); or in dead-end sloughs (Radtke 1966).

No fertilized eggs were found in the field samples, probably because of their adhesive and demersal nature. Judging by the ripe unfertilized eggs stripped from female fish, the chorion has two layers, and the outer layer reverses itself and forms an adhesive anchor to the substrate (such as tules and cattails) after sinking. Unfertilized eggs are about 1 mm in diameter (Wang 1986).

In April 1989, spawning occurred briefly in the vicinity of Roe Island in Suisun Bay after several late rains and releases of a large volume of water from upper reservoirs, then quickly pulled back to east of Chipps Island (Tables 1 and 10). Judging by the numbers of larval Delta smelt taken, spawning was concentrated in the lower reaches of the San Joaquin River (particularly near Sherman Island, Twitchell Island, Andrus Island, Webb Tract, Bradford Island, and Jersey Island), and the center of spawning was in the waters surrounding Bradford Island.

In the Sacramento River, spawning was recorded between the west end of Sherman Island and Garcia Bend. Although DFG took no samples from the Sacramento River between Rio Vista and Sacramento in 1989, Arthur (1990) concluded that Delta smelt did not spawn above Bryte. In general, the Sacramento River was not used as intensively as a spawning ground as was the San Joaquin River.

Some spawning occurred near the CVP and SWP intakes in the southern Delta (Spaar 1990a,b and 1991). Judging by the few larvae caught in a fairly extensive sampling effort (every other day at 7 sites for 3 months), there did not appear to be many Delta smelt spawning in the southern Delta.

As the drought continued into 1990, higher salinity water intruded into the upper estuary. There was no evidence of spawning below Antioch,

indicating spawning had moved upstream by at least 20 kilometers as compared to 1989.

In the Sacramento River, 1990 spawning moved farther upstream, to Verona near the mouth of Feather River. DFG did not collect samples between Rio Vista and Sacramento again in 1990. However, USBR sampled intensively near the Delta Cross Channel and Georgiana Slough for striped bass eggs and larvae in late April 1990, and found several yolk-sac larvae of the Delta smelt. The lack of larger larvae suggests the Sacramento River is a spawning ground for Delta smelt but not a nursery ground.

Near the CVP and SWP intakes, Delta smelt spawning was further discouraged by intrusion of salt water. In this area, Delta smelt yolk-sac larvae were collected with life stages similar to longfin smelt.

The catch of Delta smelt larvae was substantially reduced in 1990. Surprisingly, the highest spawning concentration remained in waters adjacent to Bradford Island (Figure 3), although with a shorter spawning peak that fell in late April. Factors that may contribute to spawning success in the Bradford Island area include:

- The channels surrounding Bradford Island continued to receive fresh water from the Sacramento River via the Delta Cross Channel, Georgiana Slough, and Threemile Slough throughout the spawning season (Kathy Hieb, Randy Baxter, and Lloyd Hess, personal communication).
- Aquatic vegetation thrived in the shore zone of Webb Tract and Franks Tract; flows and tidal actions ranged from moderate to fast, an ideal location for spawning.
- Adult smelt might use Franks Tract as a feeding ground and sanctuary, since Franks Tract is a submerged island, with multiple inlets at breaks in the levee.
- Reverse flow in the Delta was reduced due to reductions in pumping at the CVP and SWP in summer 1990. The entrapment zone was stabilized near Sherman Island and Jersey Island

during the spawning period (Kathy Hieb and Randy Baxter, personal communication).

- Many yolk-sac larvae and postlarvae contained food particles (zooplankton) in their digestive tracts, indicating they may have been feeding well in this area (this study).

Most Delta smelt die after spawning (Erkkila *et al* 1950), although a few may live to 2 years (Moyle 1976). It is unclear whether an individual smelt can spawn more than once (a fractional spawner) during the spawning season or if different individuals reach maturity at different times and spawn once.

The spawning season apparently ranges over at least 4 or 5 months, an impressive strategy for a small fish. Wang (1982, 1984) found that the tide-water goby, *Eucyclogobius newberryi*, also a small estuarine fish native to California coastal brackish lagoons, can spawn in an asynchronous manner almost year-round to ensure that some recruitment will be successful during its 1- to 2-year life span. In this fashion, survival of the species is more likely.

Delta Smelt Larvae, Prejuveniles, and Juveniles

Delta smelt in finfold, fin ray development, and completion of fin ray development are included in this category. Catches of Delta smelt in these early life stages in 1989 and 1990 were as follows:

- DFG catches of Delta smelt in 1989 contained 521 larvae and 7 prejuveniles and juveniles (Tables 1 and 10). Catches in 1990 contained 387 larvae and 41 prejuveniles and juveniles (Tables 2 and 11).
- USBR samples collected near the Delta Cross Channel and Georgiana Slough in 1990 contained 22 larvae, most of which were newly hatched (Table 3).
- USBR samples collected at Andrus Island in 1990 contained 50 larvae and 1 prejuvenile (Tables 4 and 5).
- USBR samples collected at Twitchell Island in 1990 contained 6 larvae (Table 6).

- USBR samples collected at the CVP in 1990 contained 9 larvae (Table 7).
- DWR samples collected near the CVP and SWP in 1990 contained 12 larvae, and 1 juvenile (Table 8).
- USBR salvage samples collected at the CVP intake from April 1990 through May 1991 contained 18 juveniles and 11 adults (Table 9).

In the upper estuary (from Chipps Island to Antioch), larvae were common from April through May 1989, but only a few were collected from this area in the same period of 1990.

In the Delta, larvae were found from Big Break to Medford Island and the southern Delta. Most were concentrated at DFG sampling station 49 (Figures 1 and 2) or at the juncture of the waters of Bradford Island, Twitchell Island, and Webb Tract (Tables 10 and 11). In 1990, it was possible to piece together a picture of the temporal distribution of the early life stages, from the yolk-sac through the preflexion, flexion, and postflexion stages and recruitment to juveniles (see Tables 1, 2, 10, and 11). This development was further demonstrated by the collection of juveniles and adults at the CVP intake screens (Table 9).

In the Sacramento River, larvae were observed from Sherman Island to Garcia Bend in 1989 and extending to the Verona area in 1990. From the size of the larvae, it appears the Sacramento River was used primarily as a spawning ground rather than a nursery. The amount of spawning between Rio Vista and Sacramento, where no sampling was done in 1990, might be greater than the estimates indicate, judging from the USBR smelt larvae data collected near the Delta Cross Channel and Georgiana Slough. If Delta water becomes too salty due to the drought, the Delta smelt population will likely move into less salty waters farther inland — possibly Cache Slough, Steamboat Slough, Sacramento River near the Delta Cross Channel, and Mokelumne River below Walnut Grove. Sampling in these areas should be increased during dry years.

Stevens *et al* (1990) hypothesized that, in “normal” flow years, flows carry newly hatched larvae to the entrainment zone. Two other aspects

of flow in the estuary may affect Delta smelt survival. First, a portion of the Sacramento River water (carrying Delta smelt larvae with it) is diverted into the Delta via the Delta Cross Channel, Georgiana Slough, and Threemile Slough. Second, reverse flows in the lower San Joaquin River move some of the Sacramento River and Delta water “upstream” to CVP and SWP pumps in the southern Delta. These water movements, particularly during spawning season, may be detrimental to Delta smelt recruitment (Moyle and Herbold 1989; Stevens *et al* 1990). Although Delta smelt in various life stages have been observed at CVP and SWP facilities in many years, their spawning origin is not known.

Larval Delta smelt may use a specific physical strategy to position themselves in the water. There is evidence that the gas bladder is not fully developed until 16-18 mm TL (see Appendix A). Fishes without gas bladders, such as the prickly sculpin *Cottus asper*, seek a more protective environment. In this case, Franks Tract and its peripheral waters, ranging from Jersey Island to Medford Island, may have provided the environmental requirements of Delta smelt larvae.

There was a noticeable movement of juvenile Delta smelt from the Delta to the lower estuary in July 1990. This was demonstrated by the absence of juvenile Delta smelt at CVP intake screens from mid-July to December 1990 and the presence of larger juveniles (ca. 40-50 mm TL) in the lower reach of Sacramento River to Chipps Island in late June to mid-July 1990 (Tables 2, 9, and 11). The purpose of the movement is not known, but it may have been related to food supply.

Catches of Delta smelt (probably with some mixture of longfin smelt) became less common at the CVP and SWP intake screens in 1982 and 1983 (Stevens *et al* 1990). The catch has become increasingly rare in Suisun Marsh and Montezuma Slough in the last 10 years (Moyle and Herbold 1989). The catch of larvae (Delta smelt and longfin smelt combined) was smaller in the entrainment studies at Pittsburg and Contra Costa Power Plants. This is in sharp contrast to an earlier study (PG&E 1981a,b; personal communication with Charles Hanson and Carol Raifsnider).

All information confirms findings by Stevens *et al* (1990) that the Delta smelt population remains at depressed levels. In this study, slightly over 1,000 Delta smelt were identified in about 3,000 samples collected; the catch number was very small in comparison with the magnitude of the sampling effort. During the drought, habitats became depleted in the upper estuary, but spawning grounds increased in the Sacramento River.

Delta Smelt Adults

Adult Delta smelt in near-ripe condition were observed at CVP intake screens from late December 1990 to April 1991 (Table 9). Smaller numbers of adults were also collected from impingement samples at Contra Costa Power Plant in the winter of 1989-1990 (personal communication with Charles Hanson and Carol Raifsnider). This observation matches those of earlier studies (Erkkila *et al* 1950; Ganssle 1966; Radtke 1966; Moyle 1976). Adults move into or near the spawning grounds only during or shortly before spawning. Spawning extends 4 or 5 months, and most adults die after spawning. Although Moyle (1976) reported that a few Delta smelt live to 2 years, the proportion has not been quantified.

Temporal and Spatial Distribution of Longfin Smelt

About 2,000 longfin smelt larvae, prejuveniles, and juveniles were identified in the 3,000 samples taken in 1989 and 1990 (Tables 1-9, 12, and 13).

In 1989, longfin smelt were collected from Suisun Bay to the Delta (Medford Island) to the Sacramento River (below Rio Vista) from mid-April through early July. The bulk of the catch was in the stretch from Suisun Bay to Big Break and to the lower reaches of the Sacramento River in April (Table 12).

In 1990, as the drought continued, saltier water moved into the Sacramento River, the Delta, and the southern Delta, and longfin smelt were observed from Suisun Bay to the Sacramento River (above Rio Vista); to the Delta (Medford Island), and to the southern Delta (near the CVP and SWP) from mid-April through late June (Tables 7, 8, and 13). Spawning occurred from the lower San Joaquin River to the southern Delta (Tables 2, 7, 8). Not many longfin smelt were captured, and there was no apparent pattern in distribution. About half as many were caught in 1990 as in 1989.

Table 1
SMELT LARVAE AND JUVENILES COLLECTED IN THE SACRAMENTO-SAN JOAQUIN ESTUARY IN 1989

Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number
	Size (mm TL)	Number			Size (mm TL)	Number			Size (mm TL)	Number	
Date: 04-12-1989											
5		0	~100	25	6.0-6.5	2	0	47	5.0-6.0	3	0
7		0	68	29	4.8-5.0	2	0	49	5.3-9.0	6	0
9		0	15	32	4.8	1	0	51	5.4-5.8	3	0
11		0	9	33	5.0-6.1	2	5	55	5.2-6.0	3	0
13		0	~50	35	5.5-5.6	2	15	57	6.7	1	0
15		0	~50	37	7.0-8.5	3	24	60	4.3-5.0	4	0
17		0	17	39	6.0-7.2	7	4	61	5.5-7.0	4	0
19	5.5-6.0	2	2	43	6.2-7.0	3	0	65		0	13
21	5.8-6.5	3	7	45	5.5	1	0	66		0	50
Date: 04-16-1989											
5	5.7-6.2	2	15	29	5.0-5.2	2	0	51	6.8-6.9	2	0
7		0	1	35	7.0-10.8	2	3	55	6.2-6.7	2	0
9		0	3	39	6.0-6.1	2	4	57	5.0-5.5	2	0
11		0	3	41	5.7-6.7	2	0	59		0	2
15		0	1	43	5.7	1	5	65		0	93
17		0	1	45	6.0-6.5	4	4	66		0	1
19		0	1	47		0	2				
21		0	3	49	5.2-5.5	2	4				
Date: 04-20-1989											
5		0	14	33		0	2	61	6.1	1	0
7		0	10	37	5.0	1	1	65		0	13
9		0	2	41		0	4	70	4.7	1	0
13		0	1	43	6.6-8.4	3	0	71	4.2-4.5	3	0
15		0	1	45	5.5-6.5	7	0	725	4.4-4.7	2	0
17		0	1	51	6.8-7.3	2	0	73	4.0	1	0
25	5.0-5.4	3	0	53	5.4-6.0	2	0	745	3.9	1	0
27	5.5	1	0	55	5.3-6.4	3	0	906	5.2-6.5	6	0
29	4.6-6.8	5	0	57	5.5-6.4	2	0				
Date: 04-24-1989											
5		0	5	33		0	3	61	6.3	1	0
7		0	12	37		0	2	65		0	18
15		0	2	39	7.3	1	2	66		0	1
17		0	7	41		0	1	71	5.0	1	0
19		0	1	43	5.7-7.4	2	1	725	4.8	1	0
21	6.2	1	0	51	5.5-5.6	2	1	73	4.6	1	0
25	5.3-5.7	4	0	53	5.3-5.4	2	0	735	4.2	1	0
27	5.2-5.5	2	0	55	5.3-5.5	3	0	74	4.0-4.5	3	0
29	4.8-5.7	2	0	57	5.3	1	0				
32	4.8-6.0	3	0	60	5.3-7.2	4	1				

NOTE: ~ signifies an estimated number.
Samples were collected by the Department of Fish and Game Stockton Office.

Table 1 (continued)

SMELT LARVAE AND JUVENILES COLLECTED IN THE SACRAMENTO-SAN JOAQUIN ESTUARY IN 1989

Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number
	Size (mm TL)	Number			Size (mm TL)	Number			Size (mm TL)	Number	
Date: 04-28-1989											
5		0	8	35		0	15	59	5.2-5.4	2	0
7		7	1	37	5.2-8.5	11	13	60	5.5-6.1	3	0
9		0	1	39	5.0	1	0	65		0	5
11		0	1	41	5.8-11.6	16	17	70	5.0	1	0
13		0	9	43	5.0-9.2	4	0	71	5.2	1	0
15		0	7	45	5.5	1	0	72	5.3-5.5	2	0
19		0	4	47	5.5-9.2	29	0	73	4.5	1	0
21		0	2	49	4.9-8.0	100	0	735	4.8-11.5	3	0
27	5.0-6.5	2	0	51	4.7-6.5	3	0	74	5.0-5.1	2	0
29	5.0	1	0	55	4.5-7.0	6	0	745	4.5	1	0
33	10.3	1	3	57	5.0-6.4	4	0	906	5.0-6.0	3	0
Date: 05-02-1989											
5		0	3	32	5.2-5.4	3	0	57	4.4-4.7	2	0
7		0	3	33	5.9	1	0	59	5.6-6.3	5	0
9		0	1	35	7.5	1	3	60	5.6-6.6	4	0
11		0	1	37	5.5-5.8	4	0	61	5.3-6.5	13	0
13		0	4	39	5.4-10.1	2	1	65		0	1
15		0	3	41	5.0-6.2	9	0	66		0	1
17		0	9	45	5.2-6.4	6	0	70	4.2-5.5	2	0
19		0	4	47	5.5-8.7	5	0	725	5.2	1	0
21	5.8	1	4	49	5.5-6.2	7	0	73	4.9-5.8	4	0
25	5.0-6.0	2	0	51	4.8-6.0	7	0	906	5.4	1	0
27	5.2	1	0	53	5.0-6.7	3	0				
29	5.0-5.2	2	0	55	5.3-5.8	4	0				
Date: 05-06-1989											
5		0	4	21		0	2	55	5.8	1	0
7		0	1	23	5.5	1	0	57	5.9	1	0
9		0	1	29	5.0	1	0	59	7.2	1	0
13	6.5	1	0	32	4.8-5.0	2	0	65		0	1
15	5.7	1	1	33		0	3	70	4.4-4.6	2	0
17		0	4	39		0	3	725	4.1	1	0
19		0	9	41	13.0	1	0	73	4.5	1	0
Date: 05-10-1989											
5		0	3	25		0	3	49	5.3-5.8	3	0
7		0	4	32	5.5	1	0	55	4.3-5.0	2	0
9		0	5	35		0	3	65		0	2
11		0	5	37	5.5	1	1	66		0	1
13		0	2	39	13.5	1	0	72	4.8	1	0
15		0	12	41		0	1	73	5.3	1	0
17		0	4	43	7.0	1	2	74	4.4	1	0
21	8.0-9.5	3	4	45		0	2	735	5.0	1	0
23		0	1	47	6.4	1	0	906	10.8	1	0

NOTE: ~ signifies an estimated number.

Table 1 (continued)
 SMELT LARVAE AND JUVENILES COLLECTED IN THE SACRAMENTO-SAN JOAQUIN ESTUARY IN 1989

Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number
	Size (mm TL)	Number			Size (mm TL)	Number			Size (mm TL)	Number	
Date: 05-14-1989											
5	0	1	19	0	9	43	6.0-6.5	3	0		
7	0	3	21	0	9	47	4.8-6.6	21	0		
9	0	3	29	5.5	1	55	6.5-7.0	2	0		
11	0	3	32	5.5	1	65		0	4		
13	0	6	33	0	5	66		0	3		
15	0	4	37	0	1						
Date: 05-18-1989											
9	0	1	39	5.5	1	47	7.4	1	0		
17	0	1	41	5.7-8.0	3	49	6.4	1	0		
19	0	2	43	11.1	1	55	7.9	1	0		
Date: 05-22-1989											
5	0	4	9	0	1	17		0	1		
7	0	3	15	0	1	29	5.3	1	0		
Date: 05-26-1989											
5	0	1	21	0	2	43	9.4	1	0		
13	0	2	23	0	1	45	6.0	1	0		
15	0	3	35	0	1	66		0	1		
17	0	1	35	0	2						
19	0	2	41	0	4						
Date: 05-30-1989											
11	0	2	21	0	2	39		0	1		
13	0	4	23	0	1	66		0	1		
15	0	1	33	0	1	75	6.5	1	0		
17	0	2	35	15.0	1						
19	0	3	37	5.5	1						
Date: 06-03-1989											
7	0	1	25	6.3	1	49	6.7	1	0		
9	0	2	35	0	3	65		0	1		
19	0	1	37	0	1	66		0	4		
21	0	4	39	6.5	1						
Date: 06-07-1989											
5	0	1	19	0	4	66		0	4		
11	0	2	21	0	2						
17	0	2	65	0	7						

NOTE: ~ signifies an estimated number.

Table 1 (continued)

SMELT LARVAE AND JUVENILES COLLECTED IN THE SACRAMENTO-SAN JOAQUIN ESTUARY IN 1989

Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number
	Size (mm TL)	Number			Size (mm TL)	Number			Size (mm TL)	Number	
Date: 06-11-1989											
5		0	1	17		0	7	35	22.5	1	0
9		0	3	19		0	8	65		0	1
11		0	4	21		0	4	66		0	1
13		0	1	23		0	2				
15		0	3	33		0	1				
Date: 06-15-1989											
5		0	1	11		0	3	19		0	5
7		0	3	15		0	2				
Date: 06-19-1989											
11		0	1	17		0	1				
15		0	1	27		0	1				
Date: 06-23-1989											
5		0	1	41		0	1	49	17.5	1	0
19		0	4	43	23.5	1	0	53	40.0	1	0
21		0	1	45	32.0	1	0				
Date: 06-27-1989											
5		0	2	13		0	1	23		0	2
9		0	1	15		0	3				
11		0	1	21		0	4				
Date: 07-01-1989											
13		0	1	21		0	2	61	15.0	1	0
19	46.0	1	0	45	42.0	1	0				
Date: 07-05-1989											
25	5.0	1	0	37		0	1				
35		0	1	65		0	1				

NOTE: ~ signifies an estimated number.

Table 2
SMELT LARVAE AND JUVENILES COLLECTED IN THE SACRAMENTO-SAN JOAQUIN ESTUARY IN 1990

Sampling Station	Delta Smelt Size (mm TL)	Delta Smelt Number	Longfin Smelt Number	Sampling Station	Delta Smelt Size (mm TL)	Delta Smelt Number	Longfin Smelt Number	Sampling Station	Delta Smelt Size (mm TL)	Delta Smelt Number	Longfin Smelt Number
Date: 04-12-1990											
66		0	1	21		0	11	43	6.0-7.2	2	0
65		0	6	23		0	4	47	5.8-8.0	4	0
5		0	1	25	5.0	1	2	49	5.8-7.8	7	1
7		0	2	27	5.0-9.8	7	0	51	5.5	1	0
9		0	3	32	4.0-9.0	9	0	55	4.5-5.3	3	0
11		0	9	33		0	1	57	5.0	1	0
13		0	1	35		0	1	60	7.0	1	0
15		0	1	37	5.8-6.5	2	3	906	5.3-7.0	2	0
17		0	4	39		0	4				
19		0	1	41	4.6-7.5	8	11				
Date: 04-14-1990											
35		0	4	45	5.5-6.5	3	0	55	5.6	1	2
37		0	3	47	5.0-7.4	5	4	57	4.8	1	0
39	5.8-6.2	2	3	49	5.7-7.4	6	10	59	5.6-6.0	3	1
41	6.0-7.2	2	16	51	4.8-6.0	8	10	60	7.4-8.8	2	2
43	6.0-6.7	2	2	53	6.2-6.5	2	5	61	5.8-6.8	2	0
Date: 04-16-1990											
66		0	3	23		0	6	47	4.8	1	2
11		0	2	27	5.2	1	0	49	6.0-7.8	4	5
15		0	2	35		0	1	51	5.8-6.0	2	4
17		0	1	39		0	2	53		0	3
19		0	5	41		0	6	57	4.8-6.5	3	0
21		0	4	45	5.0-5.4	2	8				
Date: 04-20-1990											
66		0	2	23	5.2-5.4	3	10	49	5.4-7.8	11	1
65		0	1	25		0	1	51		0	2
5		0	2	27	5.0-7.7	4	0	53	7.2-8.0	2	4
7		0	4	33		0	3	57	5.0	1	1
9		0	2	35		0	2	59	6.7	1	0
11		0	2	37	6.4	1	5	906	6.7	1	1
13		0	4	39	5.2	1	0	60	6.0-6.3	3	0
15		0	6	41		0	1	61	6.3-10.1	4	0
17		0	1	43	5.3-8.4	5	1	78	5.7-6.0	2	0
19		0	7	45	6.8	1	2				
21		0	6	47	4.7-8.0	4	4				
Date: 04-22-1990											
37	5.1	1	1	45	6.5	1	0	57	4.2-5.6	2	0
39		0	1	47	6.7-7.2	4	1	59	5.0-8.2	4	0
41	5.2-9.0	2	0	51		0	2	61	6.0-7.0	3	0
43		0	1	53	5.0	1	0				

Samples were collected by the Department of Fish and Game Stockton Office.

Table 2 (continued)

SMELT LARVAE AND JUVENILES COLLECTED IN THE SACRAMENTO-SAN JOAQUIN ESTUARY IN 1990

Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number
	Size (mm TL)	Number			Size (mm TL)	Number			Size (mm TL)	Number	
Date: 04-24-1990											
66		0	2	32	4.8-5.0	3	0	57	5.0-6.6	2	0
17		0	1	41	8.3-10.5	2	0	60	5.5-9.0	3	0
19		0	5	45	5.3-8.0	12	0	61	8.2-10.8	4	1
23	8.4	1	0	49		2	1				
27	5.7-11.7	2	0	53	4.1-7.5	3	0				
Date: 04-26-1990											
39		0	3	49	5.8-8.0	6	4	59	4.7-5.2	2	0
41		0	3	51	5.1-5.3	4	3	906		0	1
43		0	1	53	5.8-8.0	2	0	60	6.0-7.8	4	0
45	11.2	1	0	55	6.0-9.8	3	3	61	5.5	1	0
Date: 04-28-1990											
65		0	3	23		0	10	37		0	1
7		0	1	27	4.0-4.8	2	0	39		0	1
11		0	3	32	4.8-5.0	2	0	41	6.5	1	2
21		0	2	35		0	1	45	6.0-6.8	4	1
Date: 04-30-1990											
None											
Date: 05-02-1990											
66		0	1	25		0	3	43	5.7-7.4	2	2
5		0	1	27		0	7	49	5.0-6.0	8	1
7		0	2	29		0	2	51		0	1
11		0	1	32	4.8-5.0	3	1	57	5.0-6.8	3	0
13		0	2	39		0	1	906	5.5-9.8	4	0
23		0	2	41	7.2	1	1	60	5.3-6.5	4	0
Date: 05-04-1990											
35	7.1	1	0								
37	6.4	1	0								
39	6.7	1	0								
Date: 05-06-1990											
66		0	1	27	4.5	1	2	53	6.5	1	0
7		0	2	32		0	1	57	5.5-8.5	4	0
17		0	1	35		0	1	906	6.0-6.8	2	0
19		0	7	37		0	1	60	5.9-9.7	5	0
21		0	4	43	6.1	1	0	61	6.7-9.5	3	1
23		0	13	45	5.8-10.0	22	0				
25		0	2	49	5.8-11.0	6	0				

Table 2 (continued)

SMELT LARVAE AND JUVENILES COLLECTED IN THE SACRAMENTO-SAN JOAQUIN ESTUARY IN 1990

Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number
	Size (mm TL)	Number			Size (mm TL)	Number			Size (mm TL)	Number	
Date: 05-08-1990											
33		0	1	45	6.2-6.6	2	0	61	6.2-9.0	3	1
37		0	1	57	7.7-25.0	2	0				
39		0	3	60	6.2-8.2	2	2				
Date: 05-10-1990											
65		0	3	25		0	1	57	14.0	1	0
17		0	2	32	6.0	1	0	60	10.0	1	0
19		0	1	37		0	1	61	15.0	1	0
21		0	1	45	20.5	1	0				
23		0	13	53	11.0	1	0				
Date: 05-12-1990											
43	9.2	1	0	60	9.8-10.4	2	0				
45	7.3	1	0	61	8.0	1	0				
Date: 05-14-1990											
19		0	2	25		0	1	60	10.8	1	0
21		0	2	45		0	1				
23		0	6	906	5.8-8.7	7	0				
Date: 05-16-1990											
41		0	1	57	20.7	1	0	775	8.5-10.5	2	0
51	6.5	1	0	60	8.3-23.0	4	0				
Date: 05-18-1990											
5		0	1	25		0	4	60	16.0	1	0
13		0	1	49	7.0-11.7	20	0	61	9.7	1	0
15		0	1	57	10.8	1	0				
23		0	3	906	15.0	1	0				
Date: 05-20-1990											
37	14.2	1	1	51	11.0	1	0	61	9.0	1	0
47	7.5-8.0	2	0	55	12.0	1	0				
Date: 05-22-1990											
13		0	1	21		0	10	41	9.5-9.7	2	0
17		0	1	23	9.7-10.2	2	0	53	13.3	1	0
19		0	3	27	11.0	1	0				
Date: 05-24-1990											
47	14.7-19.8	2	0	59	10.8	1	0	906	8.4-10.7	2	0

Table 2 (continued)

SMELT LARVAE AND JUVENILES COLLECTED IN THE SACRAMENTO-SAN JOAQUIN ESTUARY IN 1990

Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number
	Size (mm TL)	Number			Size (mm TL)	Number			Size (mm TL)	Number	
Date: 05-26-1990											
23		0	6	49	6.5	1	0	55	14.2-18.5	2	0
25		0	1	51	24.3	1	0	906	14.0	1	0
45		0	1	53	24.0-25.5	2	0	61	13.5	1	0
Date: 05-30-1990											
15		0	1	43	23.0	1	0	60	18.4-26.8	2	0
19		0	1	51	23.5	1	0	61	13.8	1	0
23		0	2	55	20.0	1	0				
Date: 06-01-1990											
None											
Date: 06-03-1990											
5		0	1	43	11.5	1	0	60	22.5	1	0
7		0	1	57	9.2	1	0				
Date: 06-07-1990											
15		0	1								
49	14.3	1	0								
Date: 06-09-1990											
None											
Date: 06-11-1990											
7		0	1								
Date: 06-12-1990											
45	22.5	1	0								
Date: 06-13-1990											
None											
Date: 06-15-1990											
65		0	1	27	17.0	1	0				
19		0	1	32	25.0	1	0				
Date: 06-17-1990											
None											

Table 2 (continued)

SMELT LARVAE AND JUVENILES COLLECTED IN THE SACRAMENTO-SAN JOAQUIN ESTUARY IN 1990

Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number	Sampling Station	Delta Smelt		Longfin Smelt Number
	Size (mm TL)	Number			Size (mm TL)	Number			Size (mm TL)	Number	
Date: 06-19-1990											
25	23.1	1	0	41	29.0	1	0				
Date: 06-21-1990											
None											
Date: 06-23-1990											
45	29.8	1	0								
Date: 06-27-1990											
15		0	1	21	41.5	1	0	47	28.0	1	0
19		0	1	23	31.0-37.0	4	0				
Date: 07-01-1990											
19	43.8	1	0	21	28.5-42.2	8	0	23	22.0	1	0
Date: 07-05-1990											
19	38.0	1	0	21	16.5	1	0	23	36.2	1	0
Date: 07-09-1990											
None											
Date: 07-13-1990											
11	53.5-54.0	2	0	23	5.0	1	0				

Table 3
 SMELT COLLECTED IN THE VICINITY OF THE
 DELTA CROSS CHANNEL AND GEORGIANA SLOUGH OF THE
 SACRAMENTO RIVER IN 1990

Sample Series	Date	Species	Size (mm TL)	Total Catch
SRAG-B	04-24-90	Delta smelt	5.8	1
SRAG-TC	04-24-90	Delta smelt	4.7	1
SRBG-B	04-24-90	Delta smelt	4.6	1
SRBG-T	04-24-90	Delta smelt	4.8	1
SRAX-T	04-24-90	Delta smelt	4.7,4.8	2
SRAX-B	04-24-90	Delta smelt	5.2	1
SRAG-50T	04-25-90	Delta smelt	4.8	1
SRAX-50T	04-25-90	Delta smelt	9.5	1
SRAG-50T	04-26-90	Delta smelt	5.8	1
SRBG-50B	04-26-90	Delta smelt	5.5	1
SRBG-75T	04-26-90	Delta smelt	4.5	1
SRAX-25T	04-26-90	Delta smelt	6.0	1
SRAX-50T	04-26-90	Delta smelt	5.5	1
SRAX-50B	04-26-90	Delta smelt	5.0	1
DXC-25B	04-26-90	Delta smelt	6.5,10.8	2
DXC-T	04-26-90	Delta smelt	10.7	1
SRAX-75T	04-27-90	Delta smelt	5.5	1
DXC-25B	04-27-90	Delta smelt	4.9	1
GSL-50T	04-27-90	Delta smelt	6.8	1
SRBG-B	04-29-90	Delta smelt	4.4	1

Samples were collected by the U.S. Bureau of Reclamation Sacramento Office.

Table 4
 SMELT LARVAE COLLECTED WITH PUMP AT ANDRUS ISLAND,
 LOWER SAN JOAQUIN RIVER, IN 1990

Sample Series	Date	Species	Size (mm TL)	Total Catch
2	04-03-90	Delta smelt	5.2	1
4	04-04-90	Delta smelt	5.2	1
12	04-06-90	Delta smelt	8.2	1
31	04-12-90	Delta smelt	7.5	1
49	04-18-90	Delta smelt	9.0	1
52	04-19-90	Delta smelt	6.0	1
58	04-21-90	Delta smelt	5.3,9.3	2
61	04-23-90	Delta smelt	5.5,5.6	2
67	04-24-90	Delta smelt	8.1	1
73	04-26-90	Delta smelt	9.7	1
98	05-09-90	Delta smelt	5.1,5.5	2
101	05-10-90	Delta smelt	5.3	1
114	05-17-09	Delta smelt	22.5	1

Samples were collected by the U.S. Bureau of Reclamation Denver Office.

Table 5
SMELT LARVAE COLLECTED AT ANDRUS ISLAND,
LOWER SAN JOAQUIN RIVER, IN 1990

Sample Series	Date	Species	Size (mm TL)	Total Catch
T3	04-04-90	Delta smelt	5.5,6.0,6.4,6.6	4
T8	04-05-90	Delta smelt	6.1,6.2	2
T9	04-05-90	Delta smelt	5.8	1
T11A	04-12-90	Delta smelt	6.0	1
T12B	04-12-90	Delta smelt	5.3	1
T12D	04-12-90	Delta smelt	7.0	1
T13A	04-12-90	Delta smelt	5.5,5.7,5.7,6.8	4
T13B	04-12-90	Delta smelt	6.8	1
T13B	04-12-90	Longfin smelt	7.0,8.0	2
T14A	04-12-90	Delta smelt	5.8,6.0,6.8	3
T14B	04-12-90	Delta smelt	7.5	1
T15D	04-12-90	Delta smelt	5.7	1
T17D	04-19-90	Delta smelt	5.7	1
T18D	04-19-90	Delta smelt	4.9,5.7,6.0,6.0,6.2,7.3	6
T21A	04-26-90	Delta smelt	5.0,5.7	2
T21B	04-26-90	Delta smelt	5.0	1
T21B	04-26-90	Longfin smelt	10.3	1
T22A	04-26-90	Delta smelt	5.6	1
T23A	04-26-90	Delta smelt	5.1,5.7	2
T26A	05-17-90	Delta smelt	7.2	1
T34B	05-17-90	Delta smelt	6.7	1

Samples were collected by the U.S. Bureau of Reclamation Denver Office.

Table 6
SMELT LARVAE COLLECTED AT TWITCHELL ISLAND,
LOWER SAN JOAQUIN RIVER, IN 1990

Sample Series	Date	Species	Size (mm TL)	Total Catch
TW2A	05-03-90	Delta smelt	5.9	1
TW2B	05-03-90	Delta smelt	7.7	1
TW3B	05-03-90	Delta smelt	6.0,7.2	2
TW6B	05-17-90	Delta smelt	7.0,8.7	2

Samples were collected by the U.S. Bureau of Reclamation Denver Office.

Table 7
SMELT LARVAE COLLECTED AT THE
CENTRAL VALLEY PROJECT TRACY PUMPING PLANT IN 1990

Sample Series	Date	Species	Size (mm TL)	Total Catch
Net 1	02-28-90	Longfin smelt	6.7	1
Net 2	02-28-90	Longfin smelt	7.2,7.7,8.0	3
Net 3	02-28-90	Longfin smelt	7.1,10.7	2
Net 4	02-28-90	Delta smelt	6.5	1
Net 10	03-09-90	Longfin smelt	6.6,6.7	2
Net 11	03-09-90	Delta smelt	5.4	1
Doug Net 1	03-15-90	Delta smelt	5.0	1
Doug Net 1	03-15-90	Longfin smelt	6.2,6.3,6.5	3
Tank 1	03-15-90	Longfin smelt	6.0,6.2,7.0	3
Tank 2	03-16-90	Longfin smelt	9.1	1
8	03-19-90	Delta smelt	5.7	1
46	04-07-90	Delta smelt	8.7	1
50	04-09-90	Longfin smelt	9.5	1
54	04-11-90	Longfin smelt	13.2	1
58	04-13-90	Delta smelt	7.2,7.6	2
73	04-21-90	Longfin smelt	12.1	1
83	04-30-90	Longfin smelt	20.0	1
87	05-02-90	Delta smelt	8.0	1
87	05-02-90	Longfin smelt	11.8,14.5	2
93	05-05-90	Delta smelt	9.5	1

Samples were collected by the U.S. Bureau of Reclamation Sacramento Office.

Table 8
 SMELT LARVAE COLLECTED IN THE VICINITY OF THE
 CENTRAL VALLEY PROJECT AND STATE WATER PROJECT IN 1990

Sampling Station	Date	Species	Size (mm TL)	Total Catch
92	04-10-90	Delta smelt	6.5,7.0	2
92	04-10-90	Longfin smelt	6.5	1
91	04-12-90	Longfin smelt	10.3	1
93	04-12-90	Longfin smelt	9.1	1
95	04-12-90	Longfin smelt	8.7	1
96	04-12-90	Longfin smelt	9.0	1
93	04-14-90	Longfin smelt	9.5	1
91	04-18-90	Longfin smelt	9.3,9.5	2
91	04-18-90	Delta smelt	6.8,7.6	2
96	04-18-90	Delta smelt	7.7,8.0	2
92	04-20-90	Delta smelt	9.2	1
95	04-20-90	Delta smelt	6.9	1
95	04-25-90	Delta smelt	7.3	1
95	05-07-90	Delta smelt	9.5	1
96	05-07-90	Delta smelt	8.7	1
93	05-12-90	Delta smelt	11.2	1
94	05-31-90	Delta smelt	24.8	1

Samples were collected by the Department of Water Resources.

Table 9
SMELT JUVENILES AND ADULTS COLLECTED AT THE CENTRAL VALLEY PROJECT SCREEN IN
1990 AND 1991

Date	Hour	Species	Life Stage	Total Catch	Date	Hour	Species	Life Stage	Total Catch
04-08-90	1100	Longfin smelt	Juvenile	1	05-10-90	2100	Longfin smelt	Juvenile	8
04-11-90	1300	Longfin smelt	Juvenile	2	05-10-90	2300	Longfin smelt	Juvenile	5
04-11-90	1900	Longfin smelt	Juvenile	3	05-11-90	1900	Longfin smelt	Juvenile	3
04-11-90	2100	Longfin smelt	Juvenile	4	05-11-90	2100	Longfin smelt	Juvenile	3
04-11-90	2300	Longfin smelt	Juvenile	3	05-11-90	2100	Delta smelt	Juvenile	3
04-12-90	1900	Longfin smelt	Juvenile	3	05-12-90	1900	Longfin smelt	Juvenile	3
04-13-90	1900	Longfin smelt	Juvenile	3	05-12-90	2300	Longfin smelt	Juvenile	2
04-13-90	2300	Longfin smelt	Juvenile	2	05-13-90	1900	Longfin smelt	Juvenile	3
04-17-90	0900	Longfin smelt	Juvenile	2	05-13-90	2300	Longfin smelt	Juvenile	4
04-17-90	1100	Longfin smelt	Juvenile	6	05-14-90	1700	Longfin smelt	Juvenile	2
04-17-90	1300	Longfin smelt	Juvenile	1	05-14-90	1700	Delta smelt	Juvenile	2
04-17-90	1500	Longfin smelt	Juvenile	1	05-14-90	1900	Longfin smelt	Juvenile	3
04-18-90	1100	Longfin smelt	Juvenile	6	05-14-90	2100	Longfin smelt	Juvenile	3
04-19-90	0900	Longfin smelt	Juvenile	2	05-15-90	1700	Longfin smelt	Juvenile	2
04-19-90	1300	Longfin smelt	Juvenile	1	05-15-90	2300	Longfin smelt	Juvenile	3
04-19-90	1500	Longfin smelt	Juvenile	2	05-17-90	1900	Longfin smelt	Juvenile	1
04-20-90	1100	Longfin smelt	Juvenile	2	05-17-90	2100	Longfin smelt	Juvenile	5
04-20-90	1500	Longfin smelt	Juvenile	1	05-20-90	1300	Longfin smelt	Juvenile	3
04-24-90	1300	Longfin smelt	Juvenile	3	05-22-90	1300	Longfin smelt	Juvenile	1
04-24-90	1700	Longfin smelt	Juvenile	2	05-30-90	1100	Longfin smelt	Juvenile	1
04-25-90	0700	Longfin smelt	Juvenile	12	05-31-90	1100	Delta smelt	Juvenile	1
04-25-90	1300	Longfin smelt	Juvenile	6	05-31-90	1300	Delta smelt	Juvenile	1
04-25-90	1700	Longfin smelt	Juvenile	16	06-12-90	0900	Delta smelt	Juvenile	1
04-26-90	0700	Longfin smelt	Juvenile	23	06-13-90	0700	Delta smelt	Juvenile	1
04-26-90	1500	Longfin smelt	Juvenile	3	07-10-90	1300	Delta smelt	Juvenile	2
04-27-90	0700	Longfin smelt	Juvenile	30	12-30-90	1700	Delta smelt	Adult	1
04-27-90	1300	Longfin smelt	Juvenile	8	01-08-91	1100	Delta smelt	Adult	1
04-27-90	1500	Longfin smelt	Juvenile	10	01-10-91	1300	Delta smelt	Adult	2
04-27-90	1700	Longfin smelt	Juvenile	10	01-11-91	1100	Delta smelt	Adult	1
04-28-90	1300	Longfin smelt	Juvenile	9	01-16-91	1500	Delta smelt	Adult	1
04-29-90	1300	Longfin smelt	Juvenile	15	01-27-91	0100	Delta smelt	Adult	1
04-29-90	1500	Longfin smelt	Juvenile	10	03-18-91	2300	Delta smelt	Adult	1
04-29-90	1700	Longfin smelt	Juvenile	7	03-21-91	2100	Delta smelt	Adult	1
04-30-90	0700	Longfin smelt	Juvenile	10	04-12-91	1700	Longfin smelt	Juvenile	2
04-30-90	1300	Longfin smelt	Juvenile	34	04-13-91	2100	Longfin smelt	Juvenile	1
04-30-90	1500	Longfin smelt	Juvenile	12	04-14-91	1900	Longfin smelt	Juvenile	2
04-30-90	1700	Longfin smelt	Juvenile	10	04-16-91	1700	Longfin smelt	Juvenile	1
05-01-90	1300	Longfin smelt	Juvenile	20	04-26-91	0500	Longfin smelt	Juvenile	1
05-01-90	1500	Longfin smelt	Juvenile	20	04-26-91	0500	Delta smelt	Adult	1
05-02-90	1300	Longfin smelt	Juvenile	7	04-28-91	0300	Longfin smelt	Juvenile	3
05-03-90	1300	Longfin smelt	Juvenile	5	04-28-91	0500	Delta smelt	Adult	1
05-03-90	1500	Longfin smelt	Juvenile	4	04-29-91	0500	Longfin smelt	Juvenile	1
05-05-90	—	Longfin smelt	Juvenile	1	04-30-91	0300	Longfin smelt	Juvenile	2
05-08-90	1700	Longfin smelt	Juvenile	2	05-01-91	0300	Longfin smelt	Juvenile	2
05-09-90	1100	Longfin smelt	Juvenile	1	05-11-91	0500	Delta smelt	Juvenile	1
05-09-90	2100	Longfin smelt	Juvenile	13	05-25-91	1700	Delta smelt	Juvenile	1
05-10-90	1900	Longfin smelt	Juvenile	11	05-27-91	1700	Delta smelt	Juvenile	1
05-10-90	1900	Delta smelt	Juvenile	3					
05-10-90	0700	Longfin smelt	Juvenile	6					
05-10-90	0700	Delta smelt	Juvenile	1					

Samples were collected by the U.S. Bureau of Reclamation Tracy Office.

Table 10
 TEMPORAL AND SPATIAL DISTRIBUTION OF
 DELTA SMELT LARVAE AND JUVENILES
 COLLECTED IN THE SACRAMENTO-SAN JOAQUIN ESTUARY IN 1989

Date	5	13	15	19	21	23	25	27	29	32	33	35	37	39	41	43	45	47	49	51	53	55	57	59	906	60	61	72	725	70	71	73	735	74	745	75	Total	
04-12	0	0	0	0	2	3	0	2	0	2	1	2	2	3	7	0	3	1	3	7	0	3	3	0	3	3	0	4	4	0	0	0	0	0	0	0	0	52
04-16	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	2	2	0	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	23	
04-20	0	0	0	0	0	0	3	1	5	0	0	0	1	0	0	3	7	0	0	2	2	3	2	0	6	0	1	0	2	1	3	1	0	0	1	0	44	
04-24	0	0	0	0	1	0	4	2	2	3	0	0	0	1	0	2	0	0	0	2	2	3	1	0	0	4	1	0	1	0	1	1	1	1	3	0	35	
04-28	0	0	0	0	0	0	0	2	1	0	1	0	11	1	16	4	1	29	100	3	0	6	4	2	3	3	0	2	0	1	1	1	3	2	1	198		
05-02	0	0	0	0	1	0	2	1	2	3	1	1	4	2	9	0	6	5	7	7	3	4	2	5	1	4	13	0	1	2	0	4	0	0	0	90		
05-06	0	1	1	0	0	1	0	0	1	1	2	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	2	0	1	1	0	0	14		
05-10	0	0	0	0	3	0	0	0	0	0	1	0	0	1	0	1	0	1	3	0	0	2	0	0	1	0	0	1	0	0	0	1	1	0	0	18		
05-14	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	3	0	21	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	28		
05-18	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	8		
05-22	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		
05-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2		
05-30	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3		
06-03	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3		
06-07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
06-11	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		
06-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
06-19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
06-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4		
06-27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
07-01	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0		
07-05	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total	2	1	1	3	8	1	13	6	17	11	4	7	21	16	31	20	22	60	121	19	8	27	13	8	11	15	20	3	5	6	5	9	5	6	2	1	528	

Samples were collected by the California Department of Fish and Game.

Table 11
 TEMPORAL AND SPATIAL DISTRIBUTION OF DELTA SMELT LARVAE AND JUVENILES
 COLLECTED IN THE SACRAMENTO-SAN JOAQUIN ESTUARY IN 1990

Date	Station																												Total	
	11	19	21	23	25	27	32	35	37	39	41	43	45	47	49	51	53	55	57	59	906	60	61	775	78	78	78	Total		
04-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52
04-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39
04-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
04-20	0	0	0	0	0	3	0	0	4	0	0	0	1	1	0	5	1	1	4	11	0	2	0	0	1	1	1	3	4	44
04-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
04-24	0	0	0	0	0	0	1	0	0	2	3	0	0	0	0	12	0	2	0	2	0	2	0	0	0	3	4	0	0	34
04-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	6	4	4	2	2	0	0	0	4	1	0	0	23
04-28	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	9
04-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05-02	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	25
05-04	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
05-06	0	0	0	0	0	0	0	0	1	0	0	0	0	1	22	0	6	0	1	0	4	0	2	5	3	0	0	0	0	45
05-08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	2	1	1	0	0	9	
05-10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	2	1	1	0	0	5	
05-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	
05-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	7	1	0	0	0	8	
05-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	2	0	8	
05-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	24	
05-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	6	
05-22	0	0	0	0	0	2	0	0	1	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	6	
05-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	5	
05-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	8	
05-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	6	
06-01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
06-03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3	
06-07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
06-09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
06-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
06-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
06-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
06-15	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
06-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
06-19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
06-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
06-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
06-27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
07-01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	
07-05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	
07-09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
07-13	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	
Total	2	2	10	13	2	19	19	1	6	6	17	18	53	23	72	19	15	11	23	11	20	36	26	2	2	2	2	428		

Samples were collected by the California Department of Fish and Game.

Table 12
 TEMPORAL AND SPATIAL DISTRIBUTION OF
 LONGFIN SMELT LARVAE AND JUVENILES
 COLLECTED IN THE SACRAMENTO-SAN JOAQUIN ESTUARY IN 1989

Date	Station																																																												Total
	5	7	9	11	13	15	17	19	21	23	25	27	33	35	37	39	41	43	45	47	49	51	59	60	65	66	*429																																		
04-12	100	68	15	9	*50	*50	17	2	7	0	0	0	5	15	24	4	0	0	0	0	0	0	0	0	13	50	*429																																		
04-16	15	1	3	3	0	1	1	1	3	0	0	0	0	3	0	4	0	5	4	2	4	0	2	0	93	1	146																																		
04-20	14	10	2	0	1	1	1	1	0	0	0	2	0	1	0	4	0	0	0	0	0	0	0	0	13	0	49																																		
04-24	5	12	0	0	0	2	7	1	0	0	0	0	3	0	2	2	1	1	0	0	0	1	0	1	18	1	57																																		
04-28	8	4	1	1	9	7	0	4	2	0	0	0	3	15	13	0	17	0	0	0	0	0	0	0	5	0	84																																		
05-02	3	3	1	1	4	3	9	4	4	0	0	0	0	3	0	1	0	0	0	0	0	0	0	0	1	1	38																																		
05-06	4	1	1	0	0	1	4	9	2	0	0	0	3	0	0	3	0	0	0	0	0	0	0	0	1	0	29																																		
05-10	3	4	5	5	2	12	4	0	4	1	3	0	0	3	1	0	1	2	2	0	0	0	0	2	2	1	55																																		
05-14	1	3	3	3	6	4	0	9	9	0	0	0	5	0	1	0	0	0	0	0	0	0	0	4	3	51																																			
05-18	0	0	1	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	10																																		
05-22	4	3	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10																																		
05-26	1	0	0	0	2	3	1	2	13	1	2	0	0	0	0	4	0	0	0	0	0	0	0	0	0	1	30																																		
05-30	0	0	0	2	4	1	2	3	2	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	20																																		
06-03	0	1	2	0	0	0	0	1	4	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	1	4	17																																		
06-07	1	0	0	2	0	0	2	2	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	4	22																																		
06-11	1	0	3	4	1	3	7	8	4	2	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	36																																		
06-15	1	3	0	3	0	2	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14																																		
06-19	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4																																		
06-23	1	0	0	0	0	0	0	4	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7																																		
06-27	2	0	1	1	1	3	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14																																		
07-01	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3																																		
07-05	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	3																																			
Total	*164	113	39	35	*81	*85	58	59	63	7	5	1	23	44	45	15	28	8	6	2	4	1	2	1	160	68	*1127																																		

* Estimated number.
 Samples were collected by the California Department of Fish and Game.

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Pamela Casselman did the word processing and coordinated the production of the report. Editing, style, and format were done by Vera Tharp. Dr. Randy Brown and Stephani Spaar spent many hours reviewing the manuscript. All are of DWR.

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Appendix A

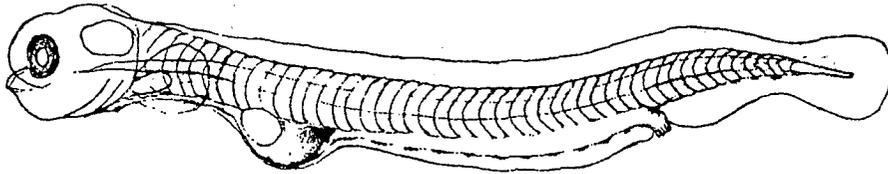
KEY TO SMELT LARVAE, PREJUVENILES, AND JUVENILES

Appendix A
 KEY TO SMELT LARVAE, PREJUVENILES, AND JUVENILES
 (See Figures 5, 6, and 7)

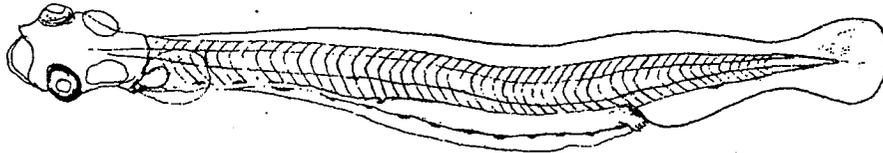
Size Range (mm TL)	Delta Smelt		Longfin Smelt	
	Key Characteristics	Supporting Characteristics	Key Characteristics	Supporting Characteristics
Ca. 4-5	Newly hatched, with yolk sac Gas bladder invisible Postanal region (tail bends ventrally)	Body compressed, more musculature visible Paired thoracic melanophores (on side of gut) developed		
Ca. 5-6	Gas bladder (above pylorus) obscure Tail bent or straight Gut straight	Body compressed, short Paired thoracic melanophores extends from pectoral to yolk sac region	Newly hatched, with yolk sac Nodule-like gas bladder visible above pylorus Tail and gut mostly straight	Body slender, elongate, less musculature visible No paired thoracic melanophores
Ca. 6-8	Gas bladder obscure, nodule-like structure above pylorus Gut straight	Paired thoracic melanophores extend to pylorus or beyond	Gas bladder, a larger nodule Gut straight or bends slightly	None or a few pairs of thoracic melanophores
Ca. 8-10	Gas bladder obscure, short, finger-like above pylorus Gut straight	Many pairs of thoracic melanophores extend halfway along the length of the gut	Gas bladder with a small chamber, pigmented pneumatic duct developed Gut bends	Mostly, a few pairs of thoracic melanophores near pectoral
Ca. 10-12	Gas bladder obscure, thin, fingerlike, pinched above intestine Gut straight	Many pairs of thoracic melanophores extend most or entire length of gut	Gas bladder with an oval chamber Gut bends	Mostly, a few pairs of thoracic melanophores limited to the front of gas bladder
Ca. 12-14	Gas bladder obscure, spindle-like, with a short pneumatic duct Gut straight	Adipose fin outline symmetrical	Gas bladder with a prominent chamber Gut bends	Adipose fin outline with a longer front slope, asymmetrical
Ca. 14-16	Gas bladder obscure, longer, spindle-like, unpigmented Gut straight	Highest point of adipose fin directly over center of anal fin	Gas bladder oval to spherical shape Gut bends	Highest point of adipose fin slightly behind center of anal fin
Ca. 16-18	Gas bladder spindle-shaped, elongate, pigmented Gut straight	Origin of dorsal fin directly over insertion of pelvic fin; over/under relation	Gas bladder, spherical, deep Gut bends	Origin of dorsal fin 2-3 myomeres behind insertion of pelvic fin
Ca. 18-25 (prejuvenile-juvenile)	Gas bladder elongate, large	Eye larger Snout pointed, symmetrical	Gas bladder spherical, deep	Eye smaller Snout pointed upward, asymmetrical

C-045267

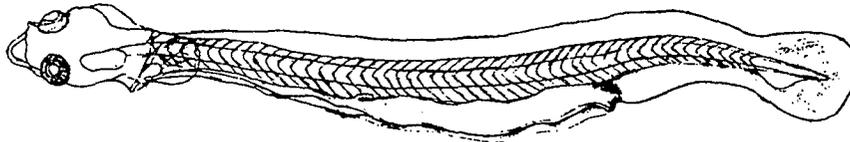
Figure 5
EARLY LIFE STAGES OF DELTA SMELT



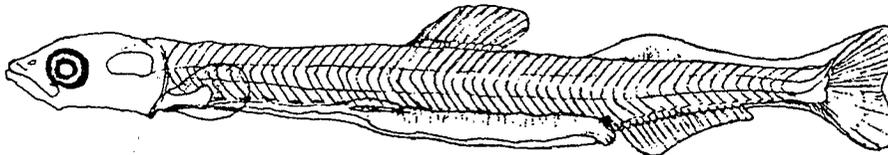
Prolarva, 4.9 mm TL



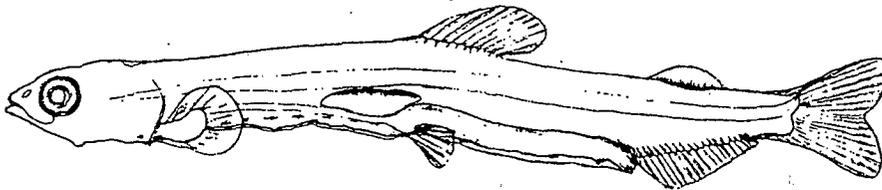
Postlarva, 6.8 mm TL



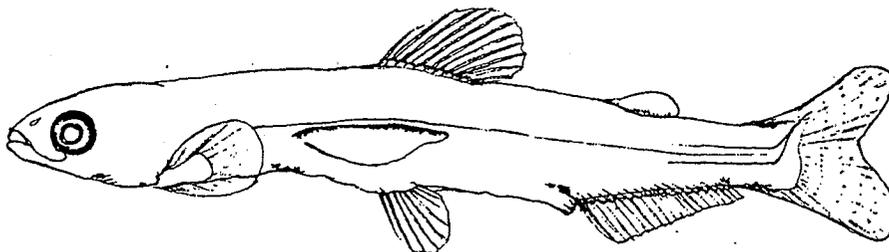
Postlarva, 9.5 mm TL



Postlarva, 13.6 mm TL

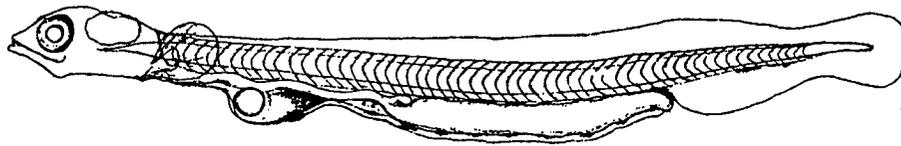


Prejuvenile, 19.5 mm TL

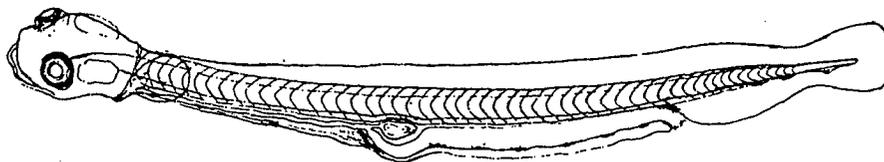


Juvenile, 25.0 mm TL

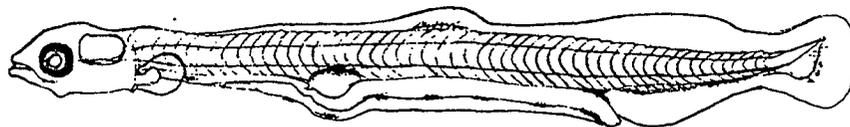
Figure 6
EARLY LIFE STAGES OF LONGFIN SMELT



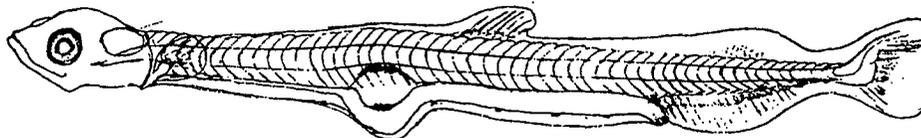
Prolarva, 6.5 mm TL



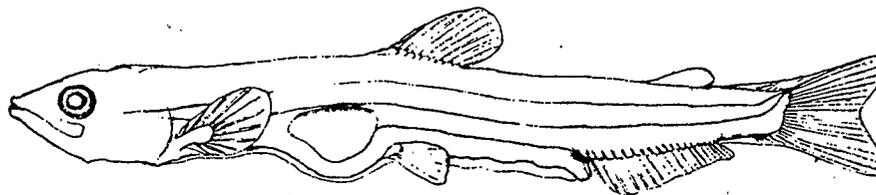
Postlarva, 9.4 mm TL



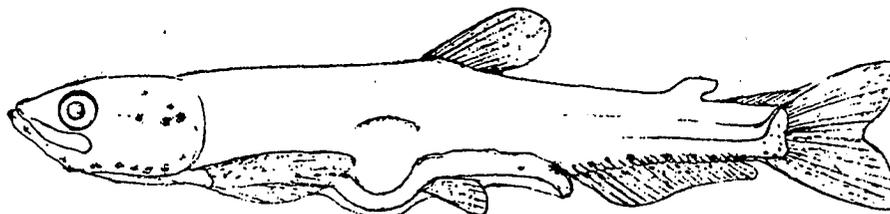
Postlarva, 13.3 mm TL



Postlarva, 16.4 mm TL



Juvenile, 23.0 mm TL



Juvenile, 38.0 mm TL

Figure 7
 GAS BLADDER DEVELOPMENT OF DELTA SMELT AND LONGFIN SMELT

Delta Smelt

Longfin Smelt



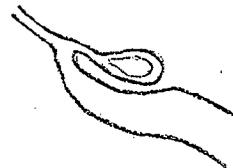
7 - 8 mm TL



5 - 6 mm TL



9 - 10 mm TL



6 - 7 mm TL



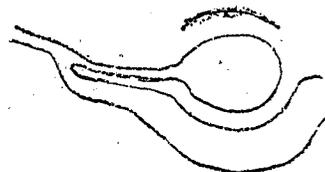
ca 12 mm TL



ca 10 mm TL



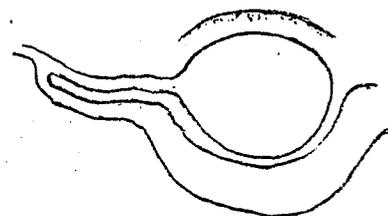
ca 15 mm TL



ca 12 mm TL



ca 18 mm TL



ca 20 mm TL

Appendix B
**TAXONOMIC CHARACTERISTICS OF DELTA SMELT,
LONGFIN SMELT, AND RELATED SPECIES**

Appendix B
 TAXONOMIC CHARACTERISTICS OF DELTA SMELT, LONGFIN SMELT, AND RELATED SPECIES
 (See Figures 5, 6, and 7 in Appendix A)

Findings of this Study	Findings of Previous Studies	Related Species (<i>H. nipponesis</i>)	
DELTA SMELT LARVAE Size Range: Ca. 4 to 18 mm TL Sample Size: 200 specimens			
Total Myomeres:	53-56	51-56 (Wang 1986)	
Preanal Myomeres:	38-42	36-40 (Wang 1986)	39 (Okiyama ed. 1988) 39-41 (Shardin 1989)
Postanal Myomeres:	14-17		17 (Okiyama ed. 1988) 17-19 (Shardin 1989)
Vertebrae:		53-56 (McAllister 1963)	55-58 (Okiyama ed. 1988)
Length at Hatching:	Ca. 4-5 mm TL	Ca. 5.5-6 mm TL (Wang 1986)	
Snout-to-Anus Length:	69-79% of TL	70-75% of TL (Wang 1986)	
Yolk Sac:	Small, spherical to oval, behind the pectoral region (ca. 1.5-2.4 mm from the snout of yolk-sac larvae, 4.8-6.8 mm TL).		
Oil Globule:	Single, located in front of yolk-sac; at about 6th to 11th myomere from head; absorbed at ca. 6-6.5 mm TL.		
Gut:	Mostly straight, some bend slightly below the gas bladder when the gas bladder is inflated.	Mostly straight; some bend slightly below gas bladder when gas bladder is inflated. (Simonsen 1977) Straight. (Wang 1986)	
Gas Bladder Formation:	Because the gas bladder is pinched above the pylorus and deflated, and because it has no pigmentations, it is invisible in newly hatched larvae 4-5 mm TL. It becomes obscurely visible in larvae 5-16 mm TL. Becomes visible and inflated and has pigmentations in 16-18 mm larvae.	Visible at 17 mm (Simonsen 1977)	
Flexion:	Ca. 9-13 mm TL		
Last Fin to Develop:	Pelvic fin at 14-15 mm TL	Pelvic fin at 15 mm (Simonsen 1977)	
Last Fin to Complete Development:	Pectoral fin		

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Appendix B (continued)
 TAXONOMIC CHARACTERISTICS OF DELTA SMELT, LONGFIN SMELT, AND RELATED SPECIES
 (See Figures 5, 6, and 7 in Appendix A)

Findings of this Study	Findings of Previous Studies	Related Species (<i>H. nipponesis</i>)
Pigmentation: A row of dashed melanophores along the midventral region, near the gut or on the midventral finfold. Number varies; ca. 9-20 from yolk sac to anus. A group of small melanophores scattered on yolk sac. Paired dashed melanophores extend from the pectoral fin, extending to yolk sac along side of gut of yolk-sac larvae; may extend to the entire gut in postflexion larvae. 0-10 dotted or dashed melanophores on the ventral side of postanal region, most often 2-4. Large circumanal melanophore on the dorsal side of the anus and a smaller one on the ventral side. A stellate melanophore found at the lower base of the caudal fin in flexion and postflexion larvae.	Same findings as this study. (Wang 1986) 8 dot-like melanophores on the bottom of gut. (Simonsen 1977) Paired dashed melanophores on either side of gut. (Simonsen 1977) A few melanophores near the caudal end of the postanal region. (Wang 1986) Large circumanal melanophore. (Simonsen 1977)	
DELTA SMELT PREJUVENILES AND JUVENILES Sample Size: 20 larger juveniles (ca. 40 mm TL); 20 larger juveniles collected by DFG Stockton office in 1974 were used for morphological comparisons; 35 prejuveniles and juveniles (ca. 18-25 mm TL) collected in 1989 and 1990 were also used.		
Snout:	Blunt or pointed; dorso-ventrally symmetrical or nearly symmetrical.	
Maxillary:	Does not extend beyond the middle of eye.	Mouth small, oblique. (Wang 1986)
Gas Bladder:	Large, elongated.	
Center of Adipose Fin vs. Center of Anal Fin:	Over/under relationship for prejuveniles and juveniles. Adipose fin behind the center of the anal fin in larger (ca. 40 mm TL) juveniles.	
Origin of Dorsal Fin vs. Origin of Pelvic Fin:	Dorsal fin slightly behind pelvic fin.	
Eyes:		Interorbital space smaller than eye diameter; eye large. (Simonsen 1977)
Pigmentation:	Pigments are light on head and trunk, heavier on caudal peduncle and caudal fin. Pigments are not found on the pectoral, pelvic dorsal, and anal fins.	

Appendix B (continued)
 TAXONOMIC CHARACTERISTICS OF DELTA SMELT, LONGFIN SMELT, AND RELATED SPECIES
 (See Figures 5, 6, and 7 in Appendix A)

	Findings of this Study	Findings of Previous Studies	Related Species (<i>H. nipponesis</i>)
Fin Rays:	Caudal fin: 18-20	Dorsal fin: 9-10 (McAllister 1963) Anal fin: 15-17 (McAllister 1963) Pectoral fin: 10-12 (McAllister 1963) Pelvic fin: 8 (McAllister 1963)	Dorsal fin: 7-10 (McAllister 1963) 9 (Okiyama ed. 1988) Anal fin: 13-15 (McAllister 1963); 16 (Okiyama ed. 1988) Pectoral fin: 12-14 (McAllister 1963; Okiyama ed. 1988) Pelvic fin: 8 (Okiyama ed. 1988)

LONGFIN SMELT LARVAE

Size Range: 5-18 mm TL

Sample Size: 150; 200 yolk-sac larvae collected by DFG in San Pablo Bay and Suisun Bay in February-April 1989 were used for morphological comparisons.

Total Myomeres:	51-60	54-58 (Wang 1986)
Preanal Myomeres:	37-42	39-44 (Wang 1986)
Postanal Myomeres:	14-19	11-16 (Wang 1986)
Vertebrae:		54-61 (McAllister 1963)
Length at Hatching:	Ca. 5 mm or more	6.9-8 (Dryfoos 1965) 5.3-6.8 mm TL (Wang 1986)
Snout-to-Anus Length:	Ca. 66-75% of TL of larvae at 5.7-7.7 mm TL. Ca. 65-75% of TL of larvae at 9-12.5 mm TL.	Ca. 68-71% of TL of larvae at 5.3-7.5 mm TL; ca. 65% of TL for postlarvae. (Wang 1986)
Yolk Sac:	Behind pectoral; small and oval.	In thoracic region. (Wang 1986)
Oil Globule:	Single. Located in front of yolk sac, moving into center when yolk sac is absorbed. Located at No. 9-12 myomeres counted from the head. Absorbed when larvae are 7-7.5 mm TL.	2-3 oil globules becoming consolidated into one. (Wang 1986)
Gut:	Straight for newly hatched larvae; bent deeply below gas bladder in postlarvae.	
Gas Bladder Formation:	Visible in yolk-sac larvae as a nodule-like structure located at No. 12-16 myomeres counted from head. Gas bladder becomes inflated and pigmented and has a chamber when larvae are 8-10 mm TL.	
Flexion:	Ca. 12.5-13 mm TL	
Last Fin to Develop:	Pelvic fin, at 16.5-17.5 mm TL	Not until TL = 18 mm (Simonsen 1977)
Last Fin to Complete Development:	Pectoral fin	

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Appendix B (continued)
 TAXONOMIC CHARACTERISTICS OF DELTA SMELT, LONGFIN SMELT, AND RELATED SPECIES
 (See Figures 5, 6, and 7 in Appendix A)

Findings of this Study	Findings of Previous Studies	Related Species (<i>H. nipponesis</i>)
Pigmentation:	In flexion and postflexion larvae, 1-4 paired dashed melanophores extend from pectoral to gas bladder (but not beyond) on the side of the gut. After anal fin formation, 0-4 (mostly 2) dotted or dashed melanophores on ventral side of postanal region posterior to the anal fin. 0-1 large stellate circumanal melanophore on dorsal side of anus. A few stellate melanophores at the lower base of caudal fin in flexion and postflexion.	Row of dotted (mostly) or dashed melanophores along midventral region, near ventral side of gut or on finfold. Numbers range from 5 to 11 between yolk sac and anus. A small group of melanophores surrounds the yolk sac; 0-3 melanophores in the anterior to the gas bladder, 1 at the gas bladder, and a row of 6-10 to the anus. (Simonsen 1977) 2 melanophores anterior to the gas bladder, 1 at the gas bladder, 8-10 from gas bladder to anus. (Dryfoos 1965) 3-5 caudal melanophores. (Simonsen 1977) 1 circumanal melanophore. (Simonsen 1977)
LONGFIN SMELT PREJUVENILES AND JUVENILES Size Range: ca. 23 to 25 mm TL Sample Size: 50		
Snout:	Pointed upward, head slightly curved downward; snout dorso-ventrally asymmetrical.	
Maxillary:	Extends beyond middle of eye.	Extends to posterior margin of the eye in larger juveniles. (Moyle 1976) Mouth oblique. (Miller and Lea 1972) Mouth slightly superior. (Wang 1986)
Gas Bladder:	Spherical and deep.	
Center of Adipose Fin vs. Center of Anal Fin:	Adipose fin is behind the center of the anal fin.	
Origin of Dorsal Fin vs. Origin of Pelvic Fin:	Origin of dorsal fin is a few myomeres behind origin of pelvic fin.	
Eyes:		Interorbital space larger than eye diameter; eye small. (Simonsen 1977)
Pigmentations:	Body mostly free from pigmentation except the circumanal melanophore. Stellate melanophores on fin rays, fin membranes, and in the cheeks of the large (ca. 35 mm TL) juveniles.	
Fin Rays:		Dorsal fin: 8-10 (McAllister 1963) Anal fin: 15-19 (McAllister 1963); 18-21 (Moyle 1976); 15-21 (Miller and Lea 1972) Pectoral fin: 10-12 (McAllister 1963)