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by
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Abbreviations

ACOE	Army Corps of Engineers
BMI	Benthic macroinvertebrate
CCRB	Cachuma Conservation Release Board
CDFG	California Department of Fish and Game
COMB	Cachuma Operations and Maintenance Board
DO	Dissolved oxygen
km	Kilometers
LWD	Large Woody Debris
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
POST	Pacific Ocean Salmon Tracking
ppt	Parts per thousand
psu	Practical salinity units
PVC	Polyvinyl chloride
SAR	Smolt-to-adult return
SCR	Santa Clara River
SCRE	Santa Clara River Estuary
SYR	Santa Ynez River
SYRE	Santa Ynez River Estuary
USDA	United States Department of Agriculture
UWCD	United Water Conservation District
VFD	Vern Freeman Diversion
VWRF	Ventura's Wastewater Reclamation Facility

Executive Summary

Steelhead trout (*Onchorhynchus mykiss*) populations on the Santa Clara and Santa Ynez rivers were historically two of the largest runs in southern California. These two runs also represent some of the best possibilities for restoration and preservation for southern steelhead, the only federally endangered steelhead taxon. Smolt survival into and through estuaries can be a critical factor for the long-term health of salmonid populations. Southern steelhead smolts were tagged with acoustic and PIT tags on the Santa Clara and Santa Ynez Rivers during the spring of 2008. On the Santa Clara River, 133 smolts were counted and 81 were successfully tagged. Forty-eight smolts tagged smolts survived the migration on the Santa Clara River resulting in a 59% survival rate. On the Santa Ynez River, 56 smolts were counted overall, 46 before water releases to the ocean were ended on April 11th. Eight of these 45 smolts were tagged on the Santa Ynez River (unfortunately tagging personnel were unavailable on this river during the peak of the migration). Two of the 8 tagged smolts on the Santa Ynez River survived resulting in a 25% survival rate, although there were potential problems with detections on that river (theft of one receiver, downward orientation of receivers from river action). Predation likely accounts for the low survival rates, and several stressors, such as trapping and translocation by humans, water temperature, and lack of cover may have affected smolt survival, especially on the SCR. Contrary to expectation, larger smolts had lower survival rates that smaller ones, perhaps as a result of disproportionate predation rates. Smolts generally resided in the estuaries for less than three days. Surveys of water quality, potential smolt prey, and cover in both estuaries revealed that the major potential problems for smolts are high turbidity, high water temperatures, insufficient cover to hide from predators, and resident populations of avian predators. Given the high annual variability both of rainfall in southern California and of the numbers of smolts migrating, multiple years of monitoring smolt survival and estuary conditions would provide a more complete picture of the health of these populations. However, currently too few smolts are emigrating or surviving their migration on the Santa Clara and Santa Ynez rivers to recover these steelhead runs. Recommendations for improving and assessing the runs are proposed, including management actions such as increasing water releases, further monitoring of smolt survival and estuary conditions in conjunction with management actions (adaptive management), and further research into the life-history of this important and critically endangered, but poorly understood fish.

Introduction

Species in the family Salmonidae are a culturally important and ecologically diverse group of fish that often are of great management and conservation significance. Salmonids generally endure long migrations to spawn, spend their life cycle in both fresh and salt water, and have a variety of life forms within a single species. Many populations or subspecies of chinook, coho, chum, and sockeye salmon, and steelhead trout are endangered or threatened along the U.S. Pacific coast. Currently southern steelhead trout (*Oncorhynchus mykiss*) are the only endangered population of steelhead on the west coast. Southern steelhead exist at the edge of the species range and consequently appear to possess distinctive tolerances and adaptations to environmental conditions that are particular to these runs. Southern *O. mykiss* can exhibit greater temperature tolerance (Matthews and Berg 1997, Spina 2007) and may display different life stage timing and life history behavior than other *O. mykiss* populations. Recognizing the uniqueness, importance, and precarious status of southern steelhead trout, the National Marine Fisheries Service (NMFS) listed them as endangered under the federal Endangered Species Act in August of 1997.

Historically, the Santa Ynez and Santa Clara Rivers had the two largest *O. mykiss* runs in southern California (NMFS undated). The Technical Recovery Team convened by the National Marine Fisheries Service ranked the Santa Clara and Santa Ynez Rivers as two of the potentially most viable rivers for restoring southern steelhead trout populations (Boughton et al. 2006), yet we understand little about those populations (NMFS 2007). We also understand little about *O. mykiss* use of the estuaries at the mouths of both of these rivers.

The size and survival of smolt populations (the seaward migrating life stage of salmon) is critical to determining future sizes of adult runs, and estuaries can play an important role in smolt survival and growth (Coots 1973, Smith 1990, Marston 1992). Estuaries may provide habitat diversity, large quantities of food, and shelter from predation. There are indications that juvenile salmonids not provided the opportunity to adjust to saline environments may experience a high degree of stress attempting to suddenly adapt to salt water (Macdonald et al. 1988). The use of estuaries by southern steelhead smolts was undocumented prior to this project.

This project addresses two high priority tasks in the California Department of Fish and Game's Steelhead Restoration and Management Plan: assessing the steelhead population in southern California (Task number SC-30), and investigating and evaluating the suitability of the Santa Clara River estuary to support steelhead smolts (Task number SC-08).

In order to better understand southern steelhead smolt survival and use of estuaries, smolts were tagged during their seaward migration on the Santa Clara and Santa Ynez Rivers using both acoustic and PIT (Passive Integrated Transponder) tags. In northern California and the Pacific Northwest acoustic tracking technology is being used to understand salmonid migrations and movement both within watersheds and in the ocean (Welch et al. 2003, Melnychuk et al. 2007). The acoustic tags were used to assess smolt survival and residence time in estuaries. The PIT tags can be used in the future to evaluate return rates of adult steelhead. In addition to tagging smolts, we surveyed the Santa Clara and Santa Ynez River estuaries for water quality, cover availability, and the smolt prey base in order to assess the potential ability of the estuaries to support smolts.

Watersheds

The Santa Clara River (SCR) and Santa Ynez River (SYR) watersheds located in southern California (Figure 1) are 1,600 and 900 square miles in area, respectively. Rainfall is variable year-to-year due to the semi-arid, Mediterranean climate. Streamflow on both rivers can rise and fall quickly in response to winter rainstorms.

The Santa Clara River

Landuse in the SCR floodplain has historically been predominantly agricultural. Large tracts of the watershed are located in the Los Padres and Angeles National Forests where vegetation cover is scrub, grassland, and occasional forest. The river's headwaters are in Los Angeles County and the river flows westward into Ventura County. There is increasing population growth and development in the floodplain within towns such as Santa Paula and Fillmore, resulting in mounting urban influences on the river. The river receives runoff from urban and agricultural sources as well as wastewater effluent from several treatment plants. In the past five years there has been a significant effort by The Nature Conservancy and The California Coastal Conservancy to purchase riverine property for conservation and to allow the river to regain its natural floodplain.

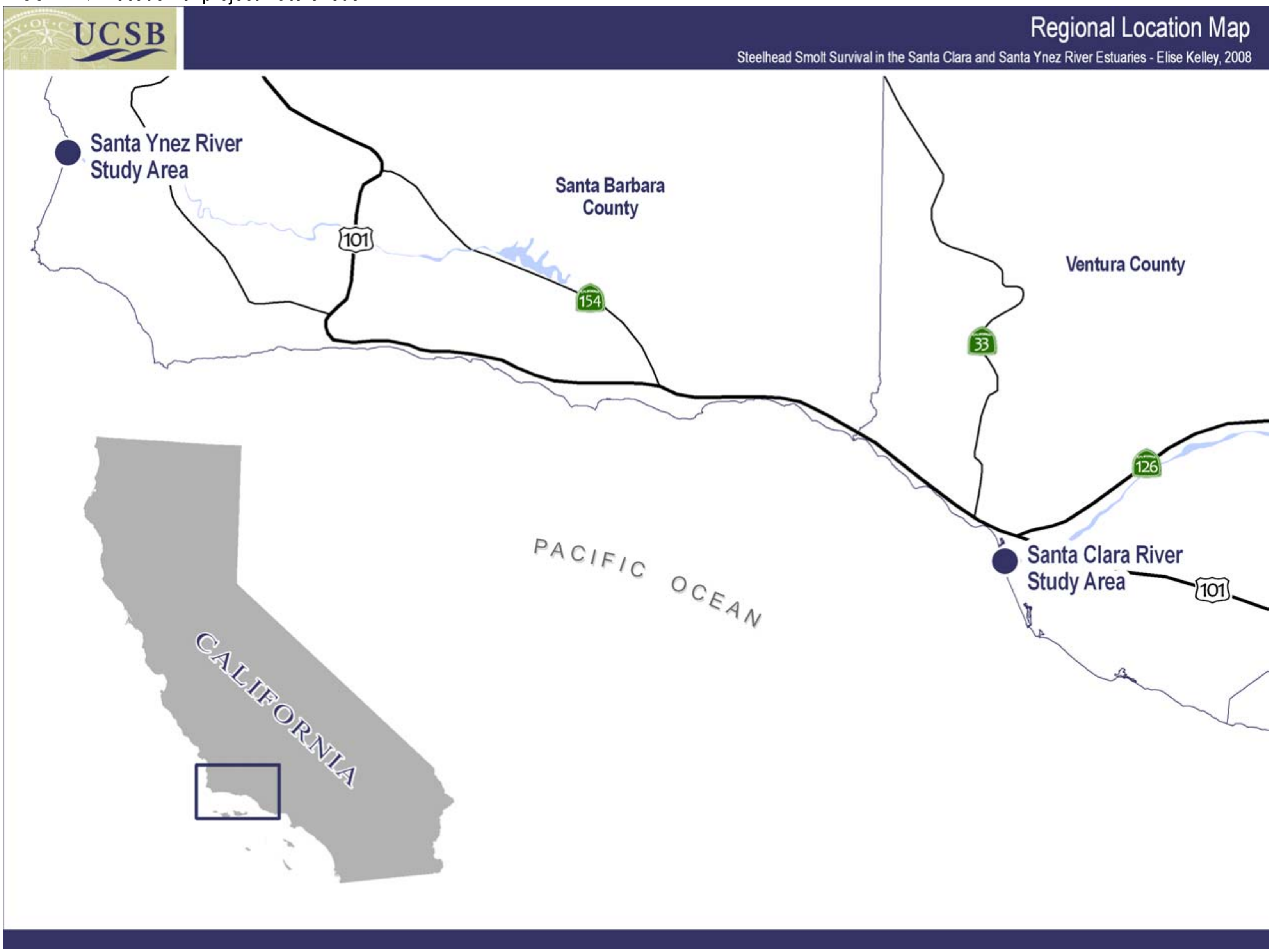
The Vern Freeman Diversion (VFD) managed by United Water Conservation District (UWCD) is the largest water diversion project on the mainstem. When no migration corridor exists below the VFD, smolts on the Santa Clara are trapped at the Vern Freeman Diversion and then transported by truck to the estuary. Annual counts of migrating *O. mykiss* have been taking place on the Santa Clara River at the VFD since 1993. There are also smaller diversions on the mainstem and tributaries that may have an impact on smolt survival and migration. The most significant dam in the Ventura County section of the river is Santa Felicia Dam on Piru Creek, a major tributary.

The Santa Clara River Estuary (SCRE) historically encompassed approximately 121 hectares of open water habitat, but is currently limited to approximately 12 hectares a reduction of 90% since the turn of the century (Nautilus Environmental 2005). The estuary is bordered on the north by the city of Ventura's Wastewater Reclamation Facility (VRWF) and to the south by McGrath State Beach and campground. An impermeable clay layer and the consequent groundwater near the surface (Environmental Science Associates 2003) affect the filling and breaching of the estuary. Special status species of the SCRE are listed in Appendix I.

The Santa Ynez River

Ranching and farming predominate along the lower Santa Ynez River with single families owning large tracts of land. There are three major dams (the Bradbury, Gibraltar, and Juncal) on the mainstem that supply water to Santa Barbara County for residential, industrial, and agricultural use. These dams and water demands in Santa Barbara County mean that the migration corridor for smolts can disappear when water releases from the dams cease. The lower river passes the City of Lompoc several miles upstream of the estuary and is the recipient of the town's runoff and wastewater effluent. Steelhead use of the watershed has historically been in the upper watershed (U.S. Bureau of Reclamation 1999) above what is now Lake Cachuma behind Bradbury Dam. Counts of migrating populations of *O. mykiss* have been taking place on the Santa Ynez River since 1997 by the Cachuma Operations and Maintenance Board (COMB).

FIGURE 1: Location of project watersheds



The Santa Ynez River Estuary (SYRE) is less than 100 hectares (250 acres) in area, and remains in a relatively natural state. It is bordered on the north by Vandenberg Air Force Base, and on the south by Ocean Park, a Santa Barbara County park. Special status species of the SYRE are listed in Appendix I.

Field Personnel

Sarah Green, the field technician for the project, and I conducted the smolt tagging and fieldwork on the project except for the smolt tagging on the Santa Ynez River. Scott Engblom and Scott Volan conducted the tagging for that river.

Tagging and Receivers

Receivers

Prior to smolt tagging, acoustic receivers were moored in various locations for each river. The placement of the receivers and the moorings were adapted to the character of each river and to the environmental conditions off each river's mouth.

The Santa Clara River

In January of 2008 nine receiver moorings were deployed in the SCR estuary and three weeks later only four were recovered. Displacement and burial of some of the moorings indicated that sediment movement resulted in the loss of the moorings, despite there being no rainfall or storm events. Because there often is no migration corridor below the VFD, no receivers were deployed in the mainstem. It was recommended by the acoustic receiver manufacturer as well as experienced acoustic receiver users that the receivers be deployed in the ocean in order to increase the likelihood of tag detection (Matthew Holland and David Welch pers. comm.). The acoustic receivers for the SCR were deployed in two lines of seven and eight receivers off the river mouth in February 2008 (Table 1). The receivers were deployed approximately 200 meters apart (Figure 2) just past the surf zone approximately 400-500 meters offshore (see Receiver range discussion below). A smolt reaching any of these receivers would be considered to have survived the migration. Placement of the receivers was started across from the river mouth with receivers first deployed southward and then northward both to cover smolt movement as well as any potential late season breaches of the estuary. Two receivers came free of their moorings (either from rusting or being pulled free by ocean forces), and were recovered by Vessel Assist from Ventura Harbor. One of the recovered receivers was replaced (creating the 16^{th} mooring). Boat availability, cost, and the need to tag smolts permitted only one boat trip during the migration season to download two receivers (by retrieving and replacing them); the 16^{th} mooring was deployed at that time. This resulted in a total of 18 deployed receivers over the course of the project. Another receiver was lost and its mooring anchor was found bent at a 45º angle indicating that the receiver was pulled out by a strong force. Lack of recovery of this latter receiver is not surprising since algal biofouling was extensive on all receivers, difficult to remove, and obscured the labeling and phone number.

FIGURE 2: Locations of acoustic receivers (with serial numbers) for the Santa Clara River, 2008.

TABLE 1. Numbers of receivers deployed and recovered on the Santa Clara and Santa Ynez Rivers, 2008.

	Santa Clara River	Santa Ynez River
Number of receivers deployed in the mainstem	0	2
Number of receivers deployed in upper estuary	0	2
Number of receivers deployed in lower estuary	0	2
Number of receivers deployed in ocean	18	0
Number of moorings	16	6
Number of receivers recovered	17	5
Number of receivers lost	1	1

The Santa Ynez River

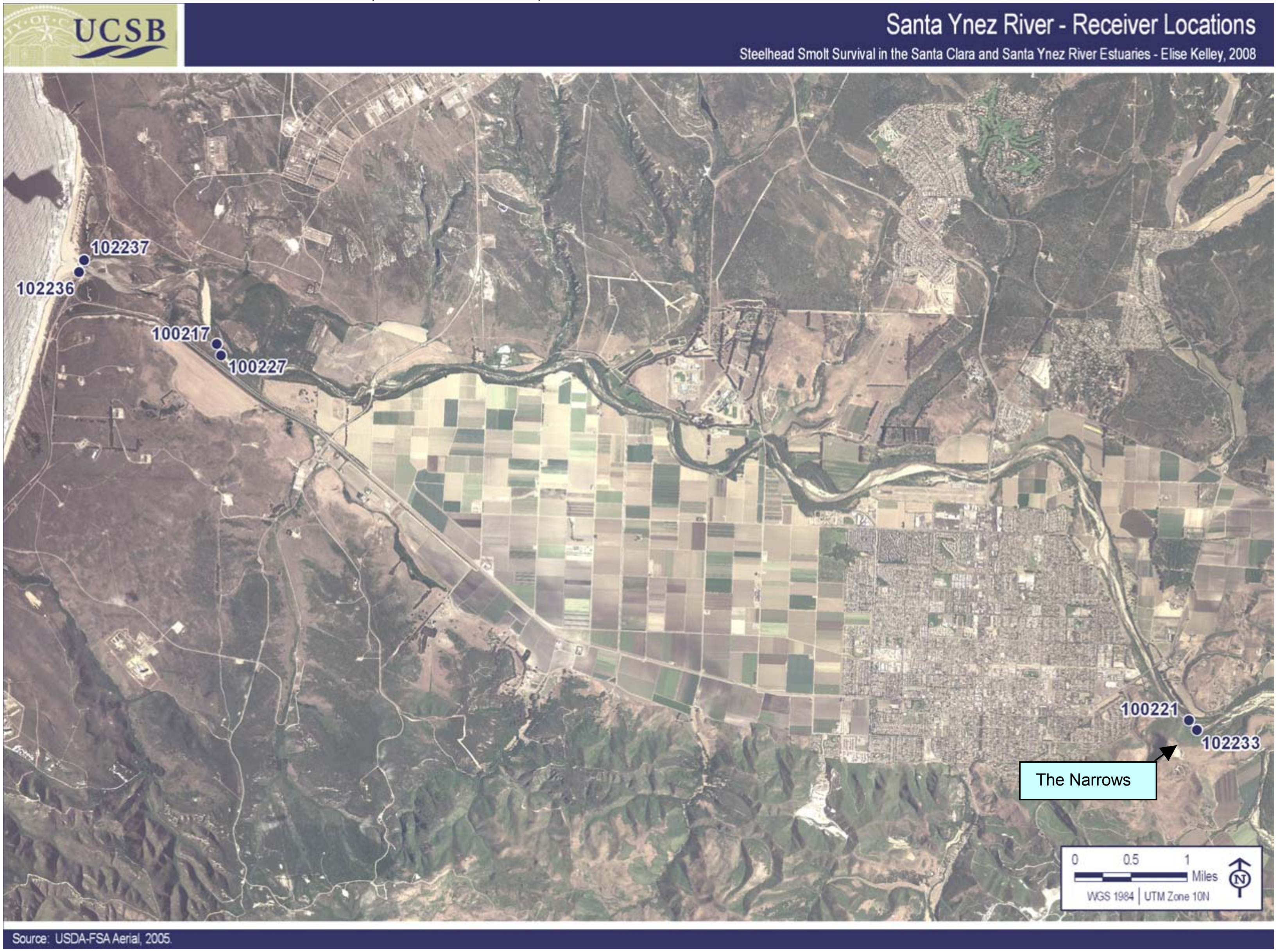
It was neither practical nor cost effective to place receivers in the ocean off the Santa Ynez river mouth. The surf is noted to be treacherous making it difficult to deploy or retrieve receivers. Additionally there are no nearby harbors and boating costs are prohibitively high. All six receivers were therefore deployed in the mainstem and estuary (Table 1). The two receivers placed in the mainstem were in "The Narrows" approximately 22 km upstream from the river mouth. At the time of deployment the Santa Ynez River mainstem had sufficient water depth for acoustic receivers to function. In April a reduction in the amount of water released from Bradbury Dam eliminated the smolt migration corridor in the lower river.

There was sufficient water depth (and little sediment movement) in the estuary to deploy four acoustic receivers. These were deployed in February and March when the river mouth was already open. Water remained in the Santa Ynez estuary thalweg due to inputs from upstream and from ocean inflow. Two receivers were placed in the upper estuary to record smolts as they entered the estuary and two at the river mouth to detect smolts on their final exit to the ocean (Figure 3). Smolts reaching these last two receivers were assumed to have survived their migration and emigrated to sea.

Overall the placement of the receivers on the SYR worked well, however the mooring design was of necessity different from that for the Santa Clara River, and may have resulted in poorer detection of tagged smolts. The Santa Clara receivers could be placed at the base of the mooring line with the hydrophone pointed upward to detect any tag signals. The best placement of the receivers on the mooring lines for the SYR was near the water's surface with the hydrophone pointing downward. The receivers were tightly zip tied to the mooring line near the buoys. However, the effects of water, salinity, tidal action, and temperature eventually slid the receivers to the bottom considerably reducing the effective range of the hydrophones. This may mean that the receivers did not detect some smolts. For the purposes of these analyses, it is assumed that the receivers recorded all migrating smolts, and that a lack of detection at the river mouth indicates mortality. Also, one of the receivers at the Narrows on the mainstem was not retrieved (the cut zip ties around the mooring indicated that it was stolen).

Additional zip ties through the buoy and the bottom hole in the receiver would solve the problem with the mooring design on the Santa Ynez. Alternate designs may also work that would allow the receiver to sit at the bottom of the mooring line. The theft of receivers is less easily solved. One problem was that we could not get to the SYR when the water dropped because we were conducting smolt tagging on the Santa Clara. An option would be to have an estuary team that monitors smolt location and movement with a mobile hydrophone in each estuary, monitors estuary conditions, and also regularly downloads receiver data during the smolt season.

FIGURE 3: Locations of acoustic receivers (with serial numbers) for the Santa Ynez River, 2008.



Receiver range

Receiver range tests were conducted in the Santa Clara River estuary in the winter of 2008. The effective range of receivers in the highly turbid waters was 40 meters (in freshwater the range can be up to 350 meters). Forty meters was assumed to be the effective range for the Santa Ynez estuary as well. The receivers in the SYR were at most 60 meters from each other, and less than 40 meters from either shore.

Receiver range tests were conducted in the ocean off the Santa Clara River also in the winter. The water offshore of the SCR has very low visibility and this interfered with detection. Tags were detected up to 100 meters from the receivers, but there was decreasing signal strength and less likelihood of detection at ranges over 100 meters. The receivers needed to be placed outside the surf zone but in water deep enough for the boat to maneuver in, which resulted in the receivers being deployed 400-500 meters offshore. Noise from the surf or from passing boats can interfere with detection. Therefore, receivers on the Santa Clara were less likely to detect smolts if they swam parallel to the shore directly outside the surf zone rather than straight out to sea from the surf zone. Smolts who didn't move straight out to sea had to swim parallel to shore for 500 meters moving southeast or for over 800 meters moving northwest to escape detection.

In most aquatic systems where acoustic technology has been used, non-detections have been assumed to be mortalities (Welch et al. 2004), however other researchers have been able to conduct additional range tests that we could not conduct due to time and boat availability issues. The problems with the moorings on the Santa Ynez, and the need to place the SYR receivers farther offshore than their detection range, means that it is possible some smolts survived but weren't recorded. Therefore rather than referring to undetected smolts as mortalities, they will be referred to as non-detections. Non-detections are discussed in the context of predation and other potential effects on survival because the most conservative approach is to assume that non-detections are mortalities.

Tagging

From March 27 - May 5, 2008 wild, steelhead smolts were tagged with acoustic and PIT tags on the SCR and SYR. Tagging of smolts on the Santa Clara and Santa Ynez Rivers was conducted according to scientific permit #1593 issued by NMFS. Trapping on the SCR took place at the VFD (Figure 4). Smolts on the SYR were trapped and tagged on Salsipuedes Creek (Figure 5), a tributary to the SYR, by employees of the CCRB. Smolts were tagged by the following (abbreviated) procedure:

1. Smolts are retrieved from the trap.
2. One smolt at a time is sedated in a bath of light anesthesia (MS-222, conc. 10-25 mg/l), sodium bicarbonate (buffer), and Vidalife® (a mucus protectant).
3. Once sedated, the smolt is moved to an anesthesia bath (MS-222, conc. 70-105 mg/l, buffer, and Vidalife®).
4. Smolt fork length (FL) is measured, and if 150 mm or larger the smolt is fully anesthetized. If the smolt is not large enough, it is placed in recovery bath of fresh, oxygenated, river water.
5. The anesthetized smolt is placed on a surgical cradle with oxygenated, anesthesia water flowing over its gills and skin while acoustic and PIT tags are implanted through an incision in the belly. The incision was sutured closed. Smolts were in surgery for an average of 4-5 minutes..

FIGURE 4: Locations of estuary and trapping location for the Santa Clara River, 2008.

FIGURE 5: Locations of estuary and trapping location for the Santa Ynez River, 2008. The Bradbury, Gibralter, and Juncal dams are upstream of the trap site.

6. The smolt was then placed in an oxygenated bath of fresh, river water for recovery.

Once recovered, a smolt on the Santa Ynez would be released back into the river to complete its migration. On the Santa Clara the smolt was placed in a dark, oxygenated cooler with other smolts and kept quietly until the smolts were placed on a truck to be transported to the estuary and released.

In studies of tag mortality it has generally been fish smaller than 130 mm that have had problems with acoustic tags (Welch et al. 2006). The required size for tag implantation under the NMFS permit associated with this project is 150 FL mm or larger. The tagging of wild smolts on this project was preceded by two practice sessions on hatchery rainbow trout in which no mortality resulted from 25 tag implantations.

During the 2008 season, one wild smolt (154 mm FL) died after surgery and prior to release on April 11, 2008. After this mortality, no fish smaller than 165 mm FL was tagged. A second mortality occurred on April 27th while a smolt was in anesthesia. All surgeries were halted until a probable explanation for the death was determined. It is likely that the anesthesia powder (MS-222) had been exposed to heat greater than 85ºF and had become unreliable. New MS-222 was obtained, and smolts showed no further signs of distress. In addition to the two smolt mortalities from tagging, six smolts were found expired in the VFD trap but appeared to have been dead for at least a day prior to entering the trap.

In general smolts were in sedation for shorter times, and in anesthesia for longer times on the SCR than the SYR. This may be an effect from the different trap types. For the SCR the density of smolts in the trap and the artificiality of the trap itself may cause stress that is not present for SYR smolts, which are caught in smaller traps that remain instream. The VFD trap is a heavy trap raised from a holding pool by a winch and which loses all but approximately six inches of water depth as it is being raised. The mechanical movement, crowding if there are many smolts or other species in the trap, noise, and loss of water can all be stressors that may adversely affect smolts.

Smolt Survival

In 2007, there was no smolt tagging on either river. The 2006 - 2007 rainfall year (starting July 2006) was one of the driest on record with rainfall in Ventura County generally below 25% of normal and Santa Barbara County 30-45% of normal (NOAA 2007). Smolt movement was likewise low. UWCD counted 12 smolts in their trap at the VFD on the Santa Clara River in 2007 from January 4 to June 15. One smolt was counted on the SYR in Salsipuedes Creek but there was no connection from the tributaries to the estuary, so no smolts emigrated.

The 2008 smolt run for the Santa Clara River totaled 133 fish. Of these 81 smolts were tagged and released. Of the 81 smolts, 48 survived to enter the ocean (Table 2); a survival rate of 59%. The pattern of smolt detections indicates that fewer smolts were detected on the northern receivers but that detections in that area were fairly steady (Figures 6 and 7).

The 2008 smolt run on the SYR totaled 56 fish. The greater proportion of the run occurred from March 29 – April 15 when over 40 smolts were trapped. Unfortunately, the surgical team who had other job responsibilities and were out of town part of the time, missed this peak. The team was able to tag eight smolts upon their return, but shortly afterward the Cachuma Operations and Maintenance Board (COMB) stopped releasing water from Bradbury Dam. There continued to be smolts available for tagging on the Santa Ynez River after April 10th, but without water the project and migration of smolts that remained in the tributaries was halted (smolts that are unable to emigrate eventually desmolt and revert to being juvenile, Hoar 1976).

A total of five smolts were tagged on April 9th on the SYR, and three on April 10th. The April 10th smolts and one of the April 9th smolts were not detected on any receivers. Of the four April 9th smolts that were detected two were recorded at the Narrows but nowhere further downstream, and the other two were not detected at the Narrows but were recorded both in the upper and lower estuary (Figure 8). One of the smolts spent a disproportionate amount of time in the upper estuary (12 hours) within range of the two receivers (Figure 9), while the other passed by in less than five minutes.

Table 2. Number of smolts that were trapped, tagged, and detected on the Santa Clara and Santa Ynez Rivers in 2008.

	Santa Clara River	**Santa Ynez River**
Number of smolts trapped	133	56
Number of smolts measured	95	56
Total number of smolts tagged	82	8
Total number of smolts released	81	8
Number of tags undetected	33	4
Number of smolts recorded at estuary mouth/ocean	48	2
Smolt survival/detection rate	59%	25%*
Number of smolts not tagged	51	48

*If all tagged fish were detected

Smolt size and survival

On the SCR, smolt size affected survival - smaller smolts survived in higher numbers than larger smolts ($X^2 = 0.0035$; Figure 10). Smolts under 17 cm survived the best with smolt size classes above 19 cm having the worst survival rates (Table 3). This was somewhat surprising since smaller smolts are often noted to have lower survival rates than larger smolts. Ward and Slaney on the Keogh River in British Columbia (1989) found that smolts that survived to adulthood had an average FL of 192 mm compared to an average size during migration of 176 mm. Bond (2006) working on Scott Creek near Santa Cruz, CA found that steelhead trout with a mean smolt FL of approximately 200 mm comprised the majority of the adult run. However, Collis et al (2001) suggested that terns and cormorants may preferentially predate upon larger smolts, possibly because larger smolts are easier to catch and have higher energy content.

FIGURE 6: Number of tag detections by receiver for the Santa Clara River, 2008.

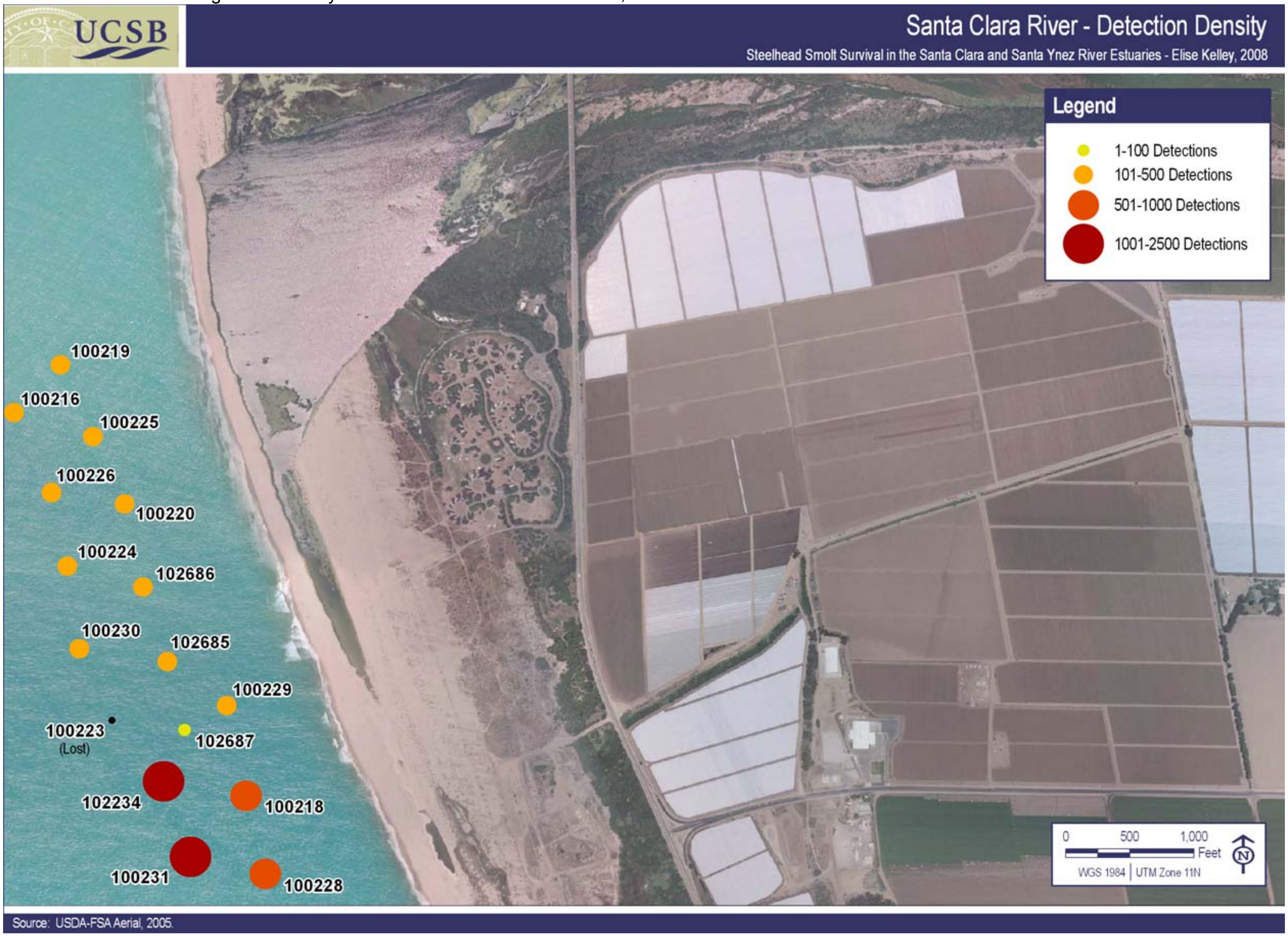


FIGURE 7: Number of smolts detected by each receiver for the Santa Clara River, 2008.

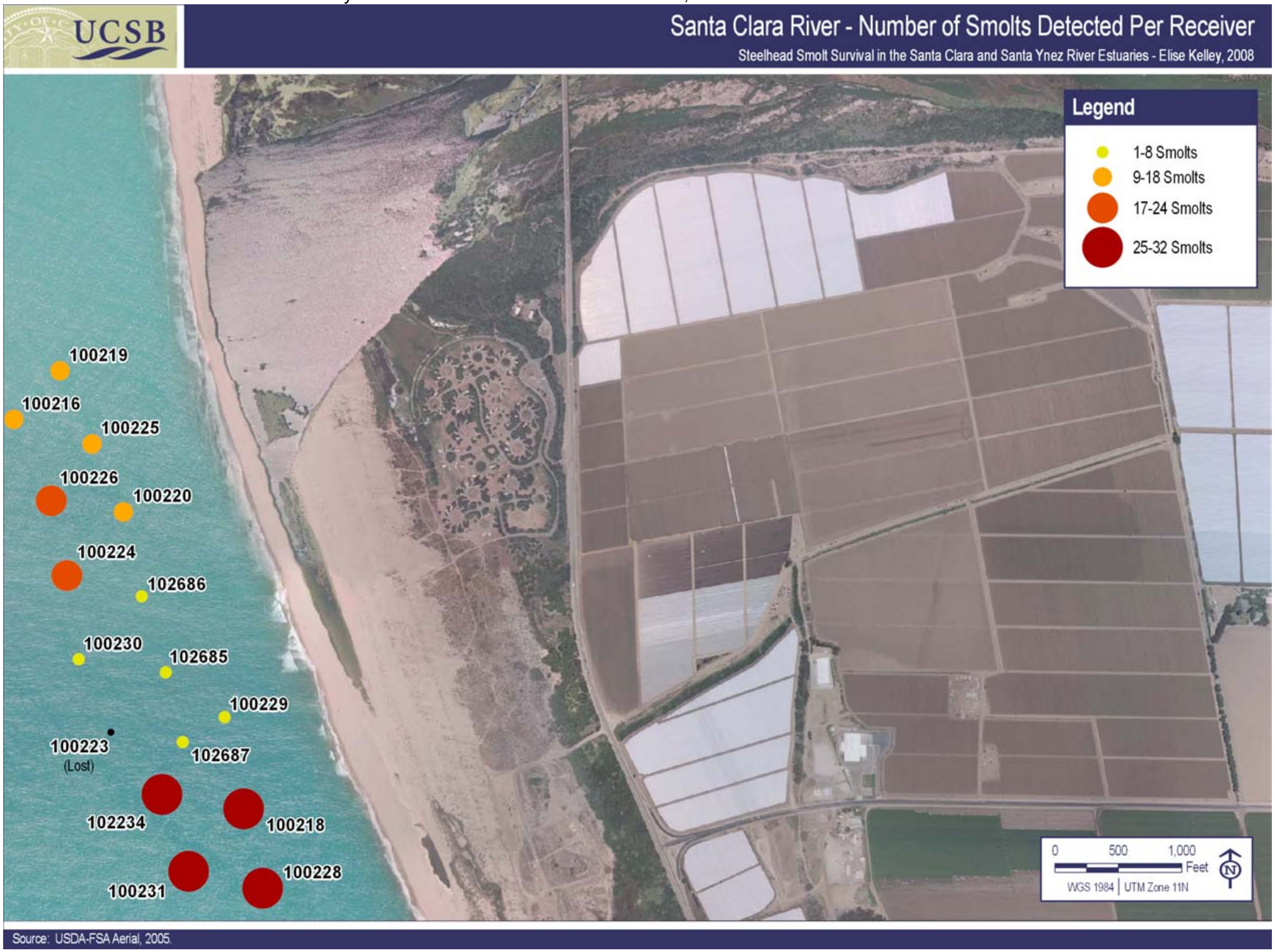


FIGURE 8: Number of smolts detected by each receiver for the Santa Ynez River, 2008

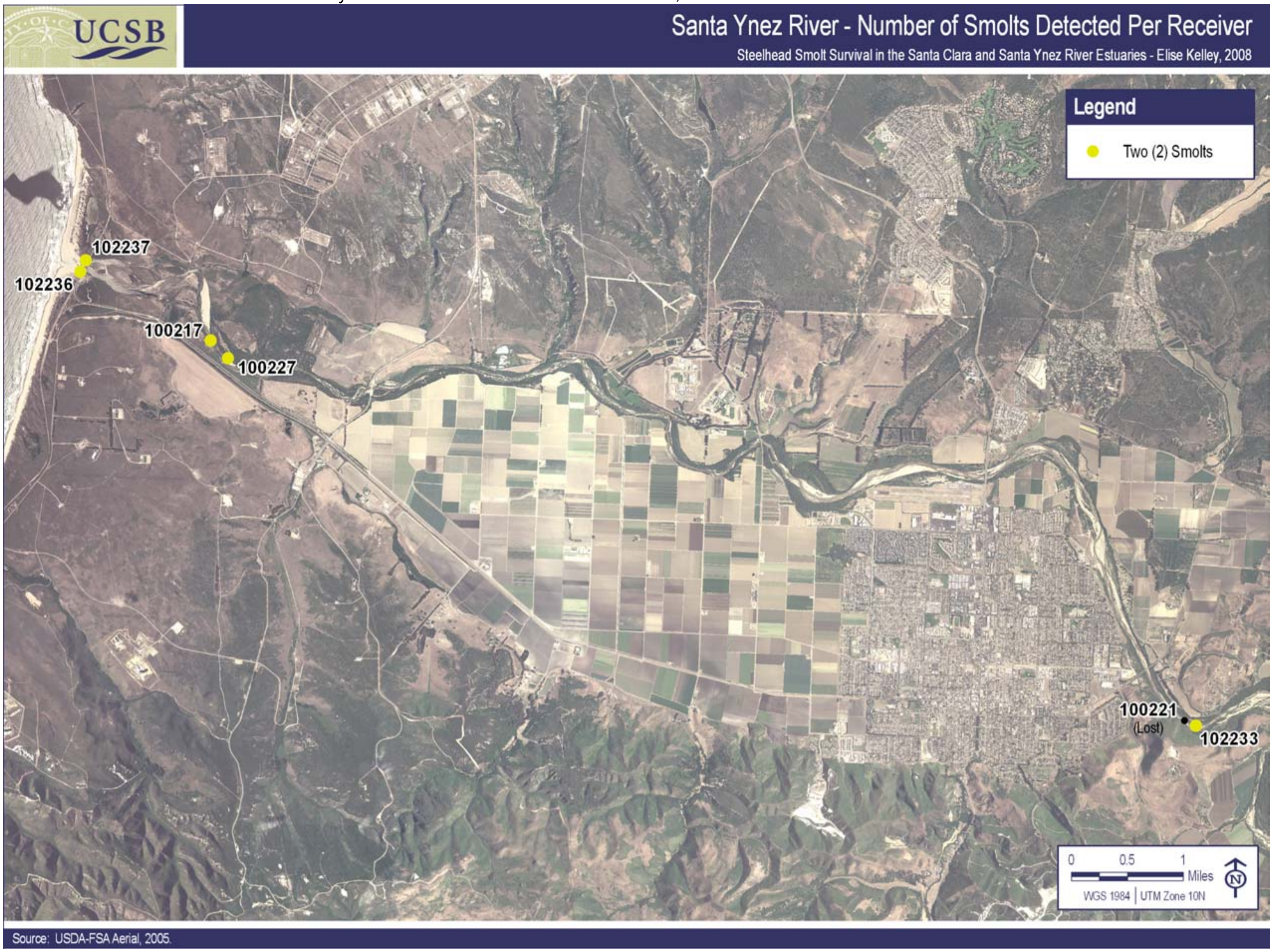


FIGURE 9: Number of tag detections by receiver for the Santa Ynez River, 2008

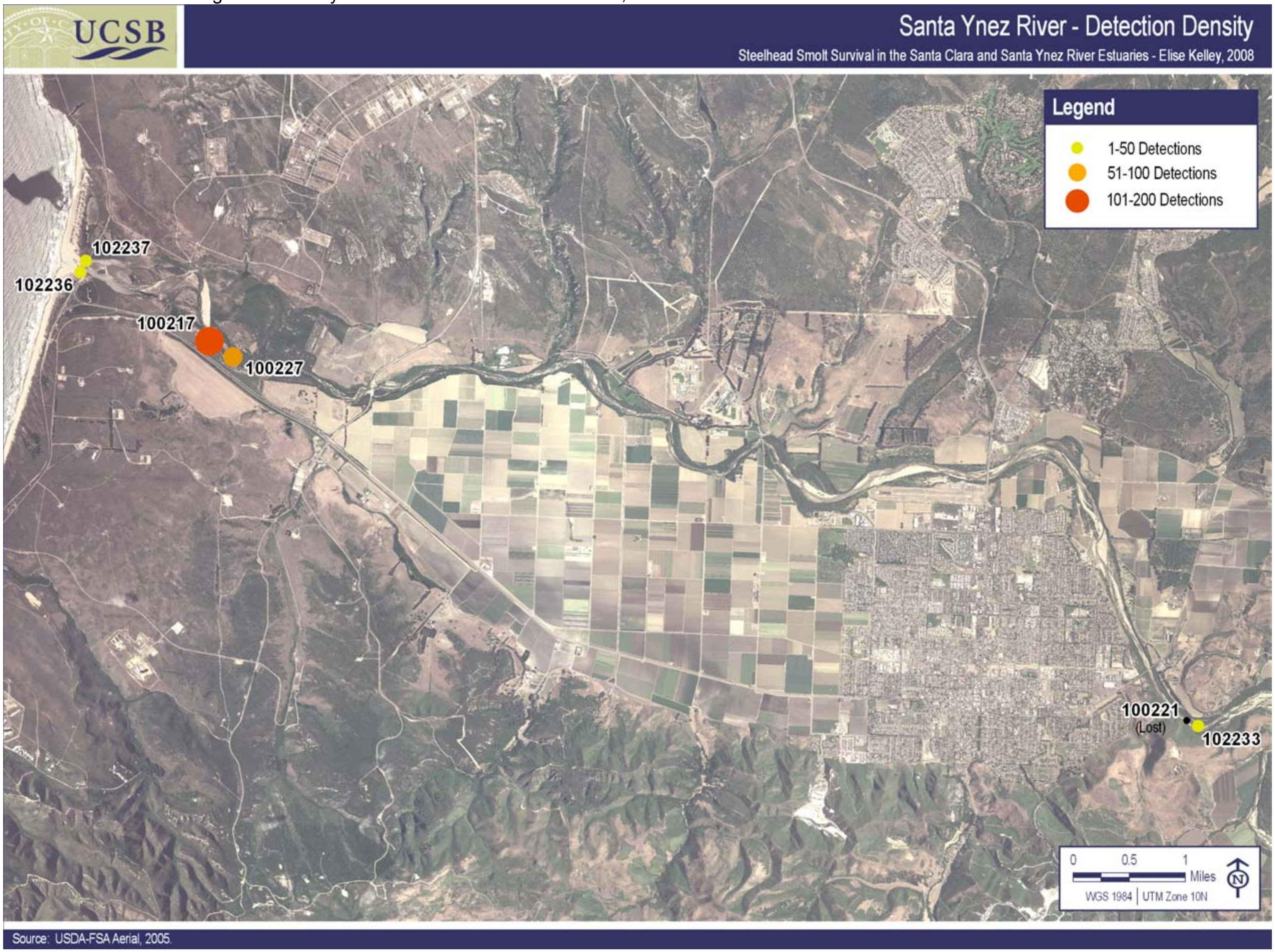


FIGURE 10. Santa Clara River smolt survival (in blue) and non-detections (in red) by size class, 2008.

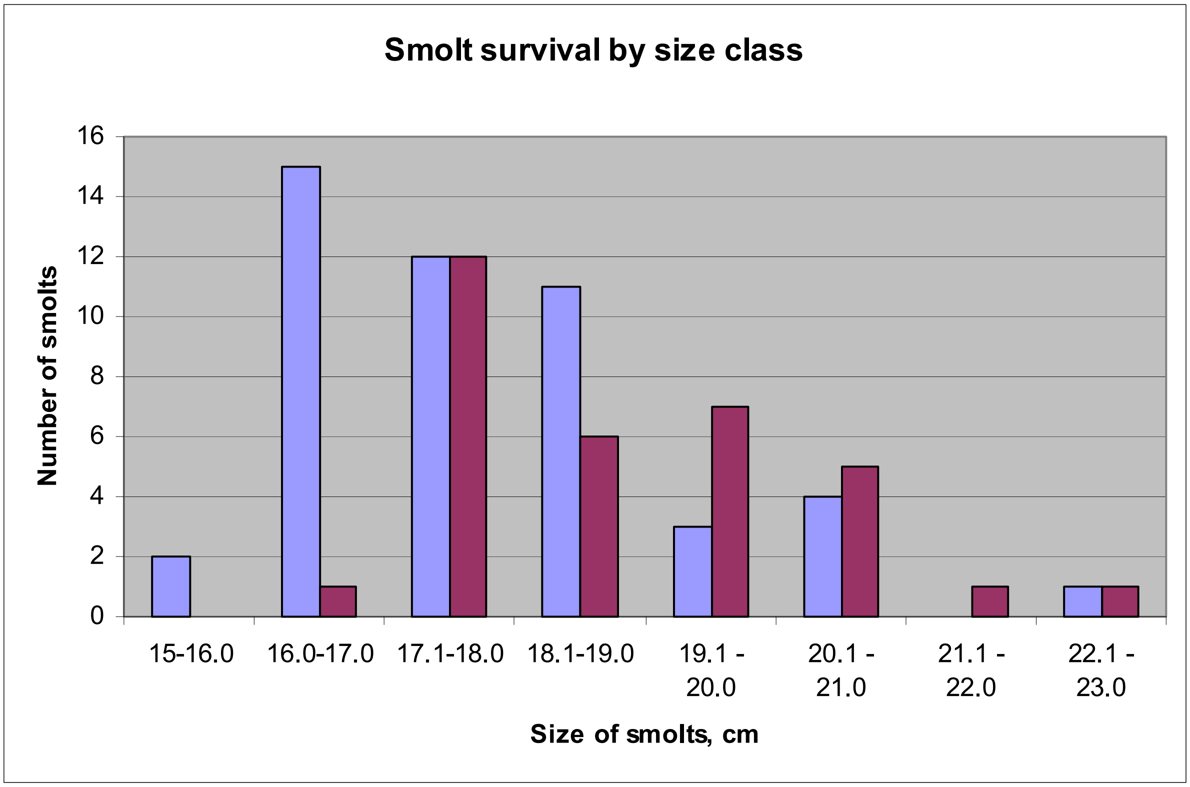


TABLE 3. Smolt survival by size class for the Santa Clara and Santa Ynez Rivers, 2008.

Fork length, cm	Number of survivals	Number of non-detections	Total size class	Percent survival by size class
15-16.0	2	0	2	100.0%
16.0-17.0	16	2	18	88.9%
17.1-18.0	12	13	25	48.0%
18.1-19.0	11	6	17	64.7%
19.1 - 20.0	3	9	12	25.0%
20.1 - 21.0	5	6	11	45.5%
21.1 - 22.0	0	1	1	0.0%
22.1 - 23.0	1	2	3	33.3%

Smolt survival rates

Smolt migration survival rates for some Pacific Northwest watersheds are shown in Table 4. The survival rate on the SCR is low even for smolts completing a migration of 15+ kms.

TABLE 4. Smolt migration survival rates before entering salt water in various years and watersheds.

Watershed	State/Region	Survival rate	Year	Distance migrated	Source
Nehalem River	Oregon	71%	2002	20.2 km	Clements and Schreck 2003
Squamish River	British Columbia	75% 86%	2004 2005	>15 km	Melnychuk et al. (2007)
Keogh River	British Columbia	77%	2004/ 2005	n/a	Ward and McCubbing (2005)
Santa Clara River	California	59%	2008	< 500 meters	This report

Avian predators

Common smolt predators such as cormorants and terns (Collis et al. 2001, Clements & Schreck 2003) were frequently present on both the SCRE and the SYRE (Table 5). The birds were observed and counted during water quality surveys, however these observations were casual and not an official bird count. Peter Gaede conducted the one official bird survey on April 25, 2008, on the SYRE. His numbers and identifications are combined with the other observations in Table 5. A discussion of avian predators and impacts is in the Synthesis and Implications section.

Smolt Residence and Migration

Depending upon water availability and ocean sediment movement, an estuary may be closed off from the ocean before the smolt migration is complete. For 2008, the SYRE stayed open throughout the migration season. The SCRE was open until late April at which point it began to open and close with tidal influence and the force of the water in the estuary. While the majority of the run was finished by the end of April, there was a small, late run of smolts in mid-May and a single and final smolt on June 3rd. The river mouth opening and closing potentially affected a third of the SCR smolts. Delay of emigration may result in increased mortality from predation or fromadverse conditions in the estuary (see Synthesis and Implications).

Residence time

The residence times for SCR smolts assumes there is no delay between when the smolt exited the estuary and when it was first detected by an ocean receiver. On the SCR, the majority of smolts spent less than three days in the estuary before exiting to the ocean and ½ of the smolts on the SCR migrated to the ocean within two days of release (Table 6). The shortest time a smolt spent in the SCRE was 16 hours and 27 minutes. The longest was 12 days, 15 hours, and 11 minutes.

TABLE 6. Residence time for smolts in the Santa Clara and Santa Ynez River estuaries, 2008.

	Number of SCR smolts	Number of SYR smolts
Less than a day	10	2
1-2 days	14	0
2-3 days	13	0
3-4 days	5	0
Greater than 4 days	6	0

TABLE 5. Observations of piscivorous and non-piscivorous bird species in the Santa Clara River and Santa Ynez River estuaries. Observations were made June – December 2007, and April and May 2008. Blue highlights the most frequent count for that species. The number of individuals sighted during each day are divided into categories, and the number of times that category was recorded is shown in the Number sighted column. The number of days that the birds were sighted is divided by the total number of possible observation days to obtain the frequency of observation.

	SANTA YNEZ RIVER ESTUARY						SANTA CLARA RIVER ESTUARY					
	Number sighted					Observation Frequency	Number sighted					Observation Frequency
	<10	10-25	25-50	>50	# Days sighted*		<10	10-25	25-50	>50	# Days sighted**	
SMOLT PREDATORS												
Black-crowned Night-Heron	2	3			5	45%	12				12	71%
Double-crested Cormorant	6	1	1	1	9	82%	9	6			15	88%
Great Blue Heron	8				8	73%	14				14	82%
Great Egret	8	1			9	82%	6				6	35%
Gull (various spp.)	1	1		6	8	73%		1	2	12	15	88%
Tern (various spp.)	1	1	1		3	27%	1	2	3	3	9	53%
PISCIVOROUS***						0%						
American Avocet	1				1	9%	4	3			7	41%
American Coot	2				2	18%	7	1	2		10	59%
Brown Pelican	3	1	2	5	11	100%	2	2	2	11	17	100%
Grebe (Clark's, Western, Pied-billed)	6	3	1	1	11	100%	4				4	24%
Green Heron	1				1	9%	1				1	6%
Snowy Egret	4				4	36%	8	1			9	53%
Red-breasted Merganser	1				1	9%					0	0%
Red-throated Loon	1				1	9%					0	0%
Ruddy Duck	7			1	8	73%	7	3	1	1	12	71%
NON-PISCIVOROUS						0%						
Black-necked Stilt	3	2			5	45%	4	1			5	29%
Brant					0	0%	2				2	12%
Canadian Goose					0	0%	1				1	6%
Eared Grebe	2				2	18%	5				5	29%
Mallard	1		1	1	3	27%	2	1		1	4	24%
Mute Swan†					0	0%	4				4	24%
Red-necked Phalarope					0	0%	3	2	1	1	7	41%
Surf Scoter	1				1	9%	1				1	6%

*Number of observation days on the SYRE = 11, **Number of observation days on the SCRE = 17, ***Includes opportunistically piscivorous birds or birds that only occasionally eat fish.
†Verified by photo. Sources of species information: www.audubon.org, birdweb.org, and www.birds.cornell.edu.

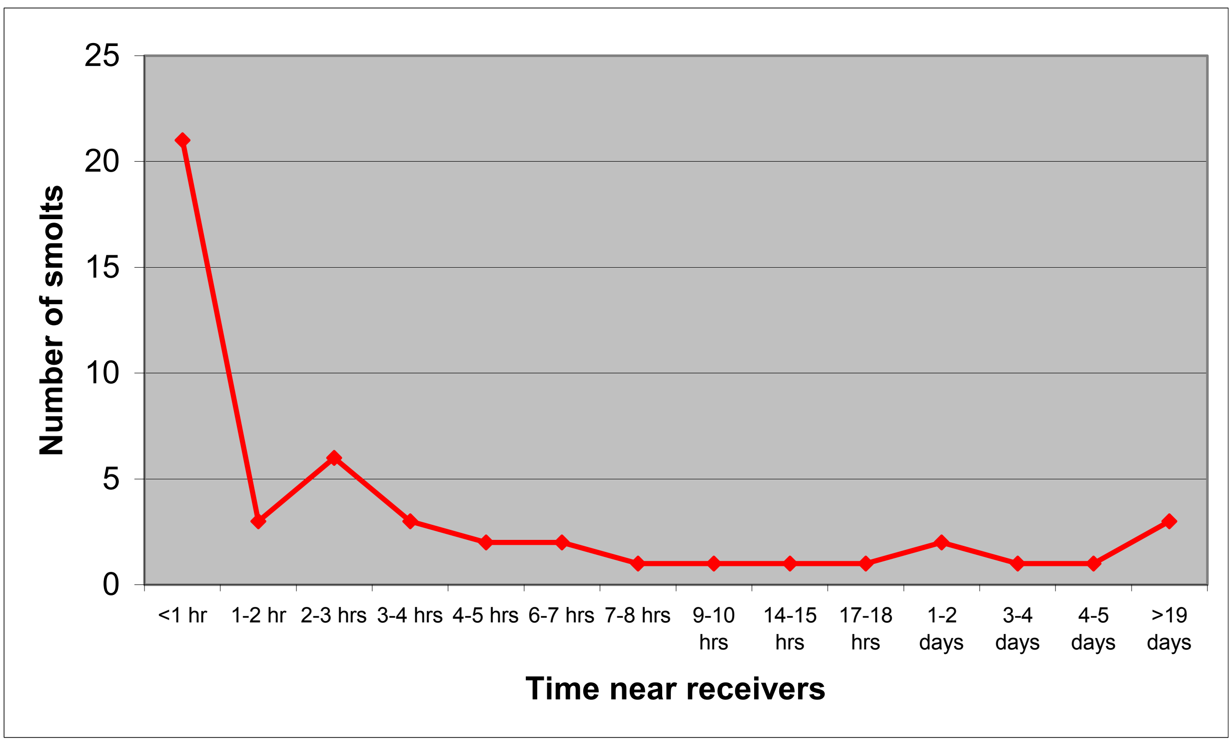
On the Santa Ynez, it was less than a day's travel for the two smolts from the upper estuary to the estuary mouth, though it was approximately 24 hours after they entered the upper estuary before they exited (one spent approximately eight hours near the estuary mouth before exiting, and the other approximately four hours). While based on a small sample size, this observation is consistent with other reports of steelhead smolts moving continuously downstream and out into the ocean rather than milling about in the estuary (Clements & Schreck 2003, Welch et al. 2004). However, exceptions have been noted to this behavior in steelhead smolts smaller than 15 cm on Scott Creek on the central coast of California. Bond (2006) found that smolts with an average fork length of 112 mm stayed in the estuary until the following winter. By the time of their emigration to the ocean the smolts had generally doubled in fork length.

Migration rate and time at receivers

For the two known smolts on the SYR that completed the approximately 30 km migration to the ocean, it was two to three days from the time of release in Salsipuedes Creek to the first time they were recorded at the river mouth indicating migration speeds of 0.41 km/hr and 0.64 km/hr respectively.

In the ocean, Santa Clara smolts typically spent less than an hour within range of the receivers (21 of 48, 44%; Figure 11). A total of 41 smolts were within range of the receivers for less than 24 hours. Four smolts were around the receivers for one to five days, and another three smolts were around the receivers for more than 19 days.

FIGURE 11. Time that SCR smolts spent near the ocean receivers from the first detection until the last detection, 2008.



Timing of smolt emigration from the estuaries

Salmonid smolts have been observed emigrating from estuaries both at night and during the day (McCormick et al. 1998, Quinn 2005). For this evaluation night is defined as the hours between 8 pm and 6 am. The majority of SCR smolts migrated during the day (39) as opposed to at night

(9). On the SYR, both recorded smolts exited the estuary during the day. Tides did not appear to influence emigration. Nearly equal numbers of smolts migrated on incoming and outgoing tides (Table 7).

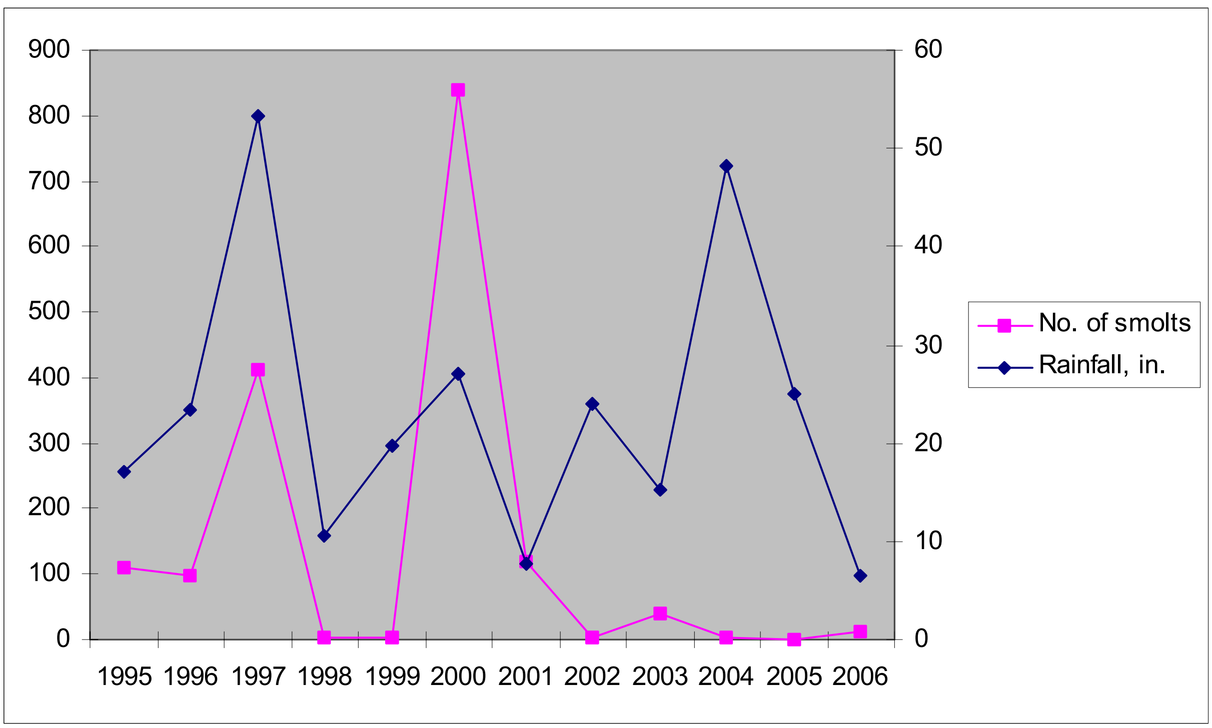
TABLE 7. The number of smolts that exited the Santa Clara and Santa Ynez River estuaries during incoming, outgoing, and slack tides, 2008

	Number of smolts that migrated
Incoming Tide	20
Outgoing Tide	21
Slack Tide	9

Rainfall and run timing

Several UWCD employees have discussed with me the possibility that SCR smolt movement correlates with rainfall. From 1995 through 2000 there does appear to be a correlation between these two factors (Figure 12), however in subsequent years the number of smolts has been consistently low, potentially confounding the correlation.

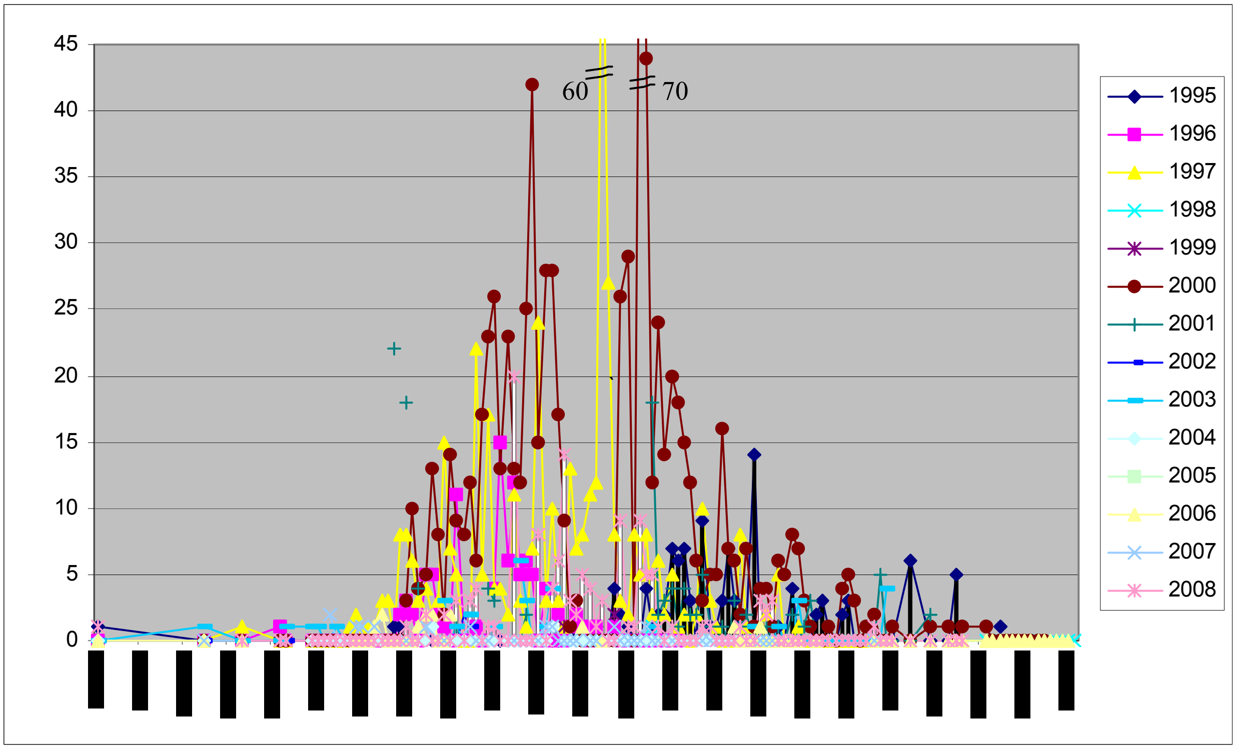
FIGURE 12. Rainfall and smolt data for the Santa Clara River, 1995 – 2006. There is some indication that rainfall may correlate with smolt movement but the pattern disappears when smolt count is consistently low.



Data sources: Ventura County and United Water Conservation District.

The smolt run on the Santa Clara River when including all smolt run data, appears to be bimodal with one peak occurring in early to mid-April, and another in late April/early May (Figure 13).

Figure 13. Number of smolts on the Santa Clara River trapped at the Vern Freeman Diversion from February – July, 1995 – 2008.



Source: Steve Howard, UWCD.

Returning Adults

Because no smolts were tagged in 2007, no adults will be returning within the timeframe of this project. COMB employees trap upstream migrants (resident and steelhead) each year and can hand scan for PIT tags. The optimal location to detect returning adults on the SCR would be immediately above the Harbor Blvd Bridge shortly after they have entered the watershed. However designing a PIT tag recording station that can withstand debris flow, flooding, vandalism, and other issues would be a challenge.

Adult return rates

Reported wild winter steelhead smolt-to-adult return (SAR) rates in the Pacific Northwest have ranged from 0.1 to 5.5% (Schultz et al. 2004). SAR rates should not be confused with other reported adult survival rates, which may be based on number of fry, juveniles, or eggs. Using the above range the possible number of adult returns for the 2008 smolt class on the Santa Clara River is 0 –7 adults. For the Santa Ynez River 0 – 3 adults could be expected to return from this year's smolt class.

Estuarine Habitat

In addition to evaluating the smolt migration, we assessed the estuaries' likelihood to support smolt growth and survival. We measured water quality parameters, prey base, cover (as protection from predators), and the timing of estuary breach events. We also deployed water level loggers in both estuaries to assess water levels. Unfortunately on the SCRE the logger was buried in a foot of sand by the time it could be retrieved. The SYRE water level logger operated well but the data isn't particularly revealing. Based on experience it would be more useful to evaluate the river mouths daily during the smolt season, and to arrange to be notified when the estuary breaches.

Water quality

Both the SCRE and the SYRE receive effluent from wastewater treatment plants. The city of Lompoc treats sewage at an advanced secondary level (includes screening, primary clarification, infiltration, aeration, secondary clarification, and disinfection; Parsons Corporation 2008), and discharges to the river approximately 13 km upstream of the estuary. The plant has a capacity of 5 million gallons of wastewater per day.

The city of Ventura's Wastewater Reclamation Facility (VWRF) has an outfall directly into the SCRE. The sewage is treated at a tertiary level (effluent undergoes an additional stage of filtering either through sand, a lagoon, treatment wetlands, ponds or a nutrient removal process) and the facility processes approximately 9 million gallons of wastewater per day (City of Ventura 2008). There is currently a Santa Clara River Estuary Stakeholders group that is discussing the effects of this effluent, and examining potential alternatives to the effluent directly entering the estuary.

A Hanna multimeter was used to measure salinity, dissolved oxygen, pH, and temperature. The dissolved oxygen (DO) probe initially malfunctioned, so that only DO data collected after July 25, 2007 is reliable. Depth was measured using a meter tape and weight. Turbidity was measured using a Secchi disk.

Each estuary had nine sample points (Figures 14 and 15): sample points 1-3 are in the lower section (Zone 1) of each estuary, sample points 4-6 are in the middle section (Zone 2), and sample points 7-9 are in the upper section (Zone 3). Samples at each point were taken at 0.5-meters and at each successive 0.5 meter depth until the bottom.

In general, both estuaries are deeper near the mouth and shallower upstream (Table 8). The SYRE is significantly deeper than the SCRE (χ^2_1= 16.6, $p<0.0001$) with a maximum depth at sample point 8 of 5.55 meters. The deepest measurement taken on the SCRE was 2.32 meters in December 2007 just one week before it breached (see Breaching section).

TABLE 8. Averages of water parameters, by zone, for the Santa Clara River and Santa Ynez River estuaries, 2008.

	Santa Clara River Estuary			**Santa Ynez River Estuary**		
Parameter, units	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
Depth, m	1.71	1.17	0.50	2.02	2.19	1.87
DO, ppm	12.14	15.39	11.56	7.92	8.16	8.82
pH	8.93	9.14	8.43	8.69	8.69	8.86
Salinity, psu	2.65	1.61	1.74	7.68	7.68	7.34
Secchi depth, m	0.39	0.20	0.11	0.24	0.25	0.24
Temperature, ºC	20.78	21.27	19.98	19.42	19.71	20.22

Salinity

Measurement of salinity was in practical salinity units (psu), which are equivalent to parts per thousand (ppt; i.e. 35 ppt = 35 psu). The SYRE was significantly more saline (χ^2_1= 23.0, $p<0.0001$) with an average of 7.56 psu, while the SCRE had an average salinity of 2.14 psu. While both estuaries qualify as brackish, they are still close to freshwater (freshwater salinity is <0.5 ppt while ocean salinity is 35 ppt). No saltwater lens formed in either estuary. A salinity

FIGURE 14. Water quality sample points in the Santa Clara River estuary, 2008

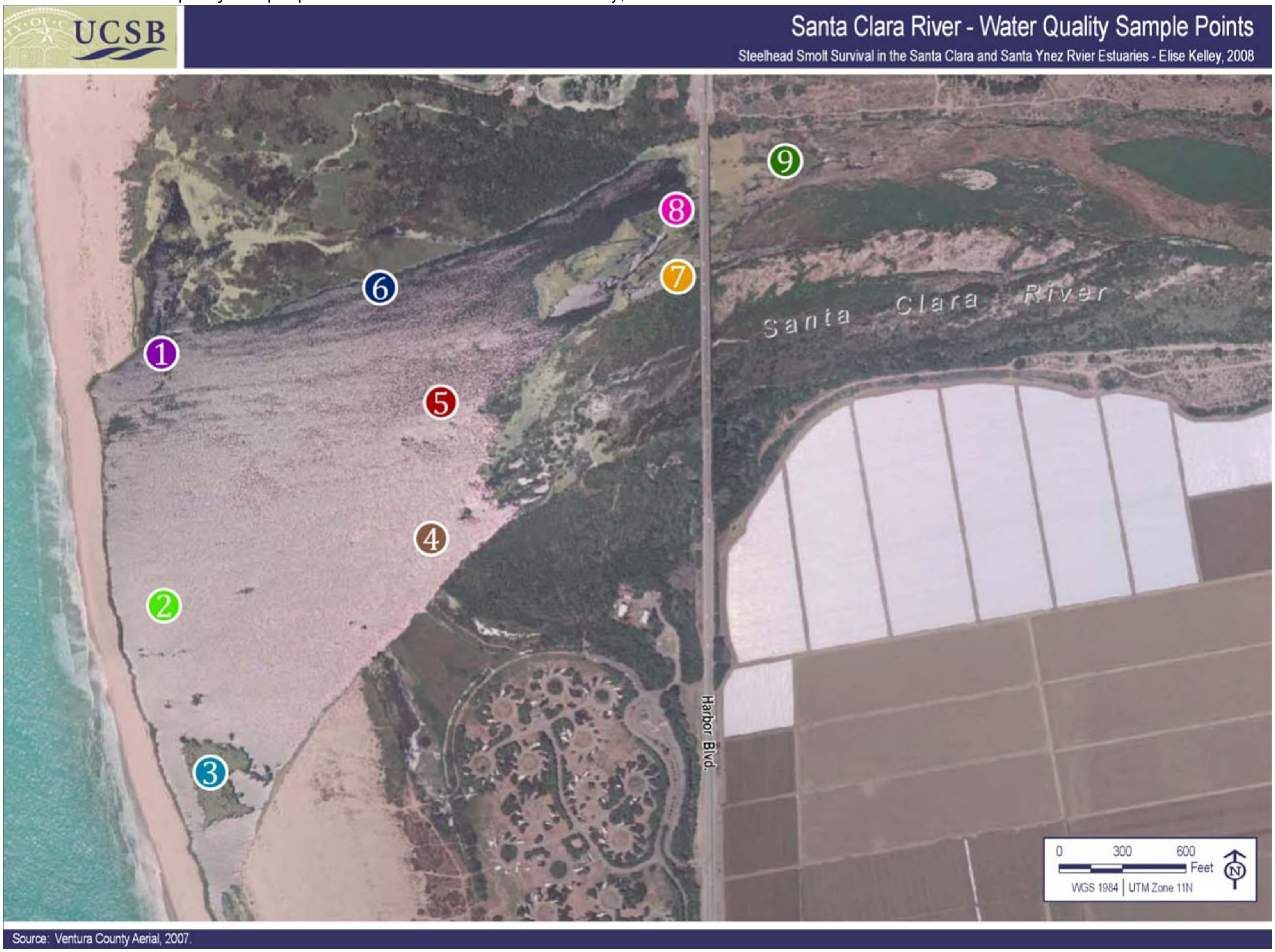
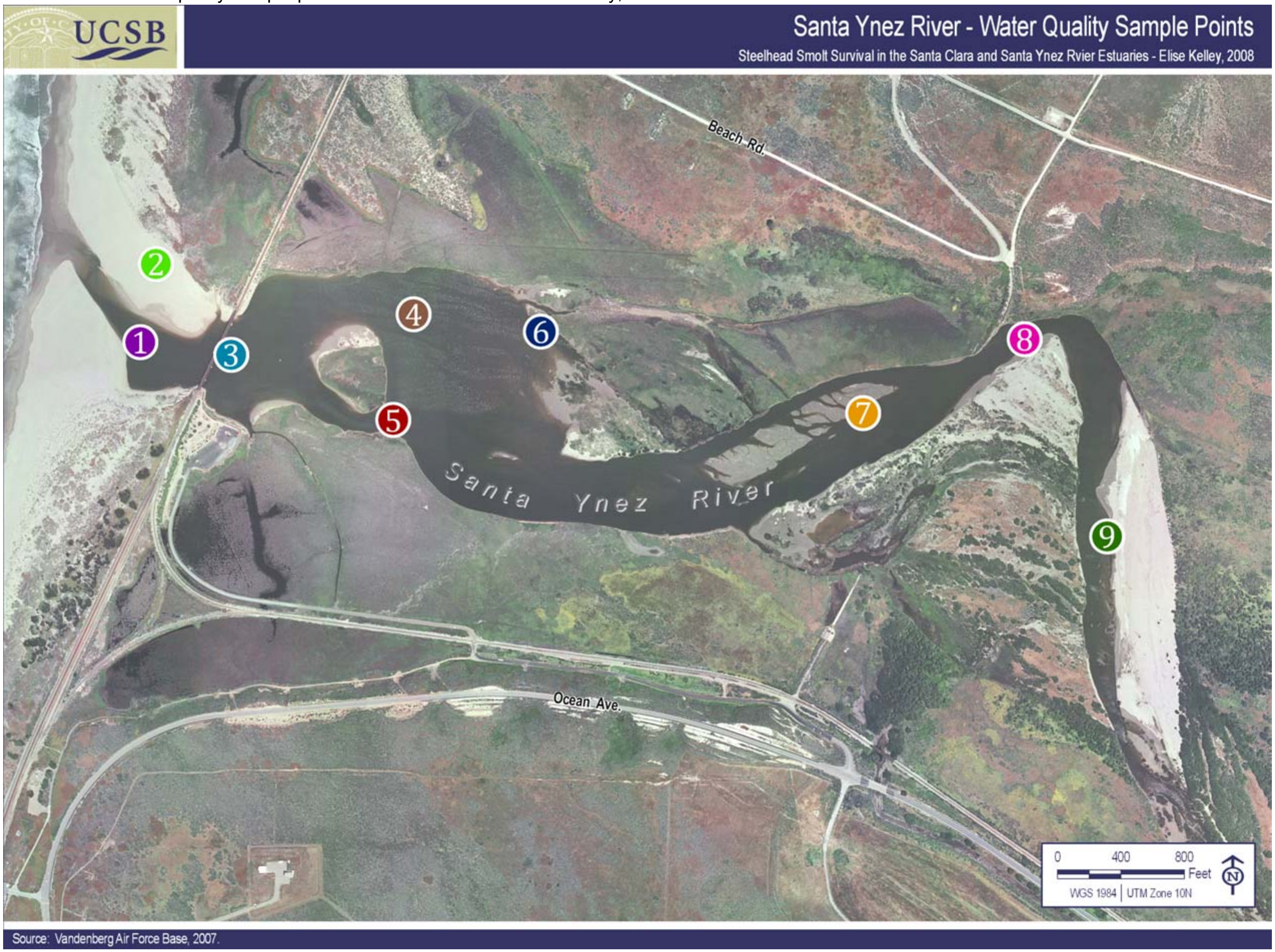


FIGURE 15. Water quality sample points in the Santa Ynez River estuary, 2008



gradient exists between the lower/mid and upper estuary in the SYRE with the lower estuary (Zones 1 and 2) being significantly more saline than the upper estuary (χ^2_1= 10.5, p<0.0012 for Zones 1 and 3, and χ^2_1= 11.29, p<0.0008 for Zones 2 and 3). On the SYRE salinity was significantly higher during high tide than between tides (χ^2_1= 24.8, p<0.0001). However there wasn't any significant difference in salinity between high and low tides. There was no significant difference in salinity associated with tides on the SCRE. Salinity did not vary by depth for either estuary. The impacts of salinity are discussed in the Synthesis and Implications section.

Dissolved Oxygen

There were not sufficient samples on the SYRE to compare DO by depth or zone. There were no differences found in DO by depth in the SCRE. The middle SCRE (Zone 2) has significantly higher DO levels than either the lower (χ^2_1= 9.39, p<0.0022) or upper estuary (χ^2_1= 5.72, p<0.0167). It was not possible to compare the levels of dissolved oxygen between the estuaries, however neither estuary appeared to be anoxic (i.e. lacking in oxygen).

Temperature

There were no temperature differences between the zones in the SCRE. The lowest depths in Zones 1 and 2 of the SYRE are colder than water closer to the surface but not significantly so. The lower estuary on the SYRE was also significantly colder than the upper estuary (χ^2_1= 31.14, p<0.0001). Overall, the SCRE is significantly warmer than the SYRE (χ^2_1= 132.17, p<0.0001).

pH

The pH in the upper estuary of the SYRE is significantly higher than that in either the lower (χ^2_1= 24.04, p<0.0001) or middle (χ^2_1= 24.87, p<0.0001) sections of the estuary. The opposite is true in the SCRE with the upper estuary having significantly lower pH than either the lower or middle estuary (χ^2_1= 17.38, p<0.0001 for Zone 1; χ^2_1= 31.47, p<0.0001 for Zone 2). The SCRE has significantly higher pH than the SYRE (χ^2_1= 52.86, p<0.0001). Overall both estuaries are basic rather than acidic.

Turbidity

In the SCRE upper estuary is significantly clearer and less turbid than the lower estuary (χ^2_1= 12.15, p<0.0005). Zone 1 is closest to the wastewater outfall and it is not surprising it would be more turbid. There were no differences in turbidity by zone on the SYRE, but overall the SYRE was significantly more turbid than the SCRE (χ^2_1= 4.09, p<0.0430).

Sampling after a breach

In general, estuary sampling occurred on days when the river mouths were closed (please see Breaching section). There was one day on each river when sampling occurred while the mouth was open.

On the SCRE, dissolved oxygen was lower (9.93 mg/L versus 12.79 mg/L), salinity was considerably higher (14.33 psu vs. 1.58 psu), and temperature was lower (17.18ºC versus 21.25º) in the lower estuary when the mouth was open. DO levels were extremely high in the SCRE when the mouth was closed which may be an artifact of the wastewater treatment process (Paul Fabbits, pers.comm.). pH was not affected. These data are consistent with measurements by the VWRF from 2000 – 2007 (City of Ventura, unpublished data).

For the SYRE dissolved oxygen and salinity were much higher with the mouth open and temperature was lower. At depths greater than 0.5 meters, water was both colder and more saline when the mouth was open indicating that the colder, saltier water of the ocean settled below that of the warmer freshwater. pH was not affected.

Prey base

We collected the first macro invertebrate samples in June 2007 for both the SCRE and SYRE. The second sampling was conducted in May 2008 for both estuaries. A total of 46 samples were collected and submitted to a UC Santa Barbara lab for identification in late May 2008. However only 11 samples had been processed by the time of this report. The samples were retrieved from the lab, and five 2008 benthic samples were submitted to Ecology Consultants, Inc. for identification. One of the 2008 benthic samples processed by the UCSB lab was used in the following analysis (Table 9).

TABLE 9. *O. mykiss* relative prey abundance and diversity on the Santa Clara and Santa Ynez Rivers, May 2008. All capital letters are used for taxonomic orders; Capital and small letters are used for taxonomic families.

Prey Items	Santa Clara River	Santa Ynez River
AMPHIPODA	0.0%	7.9%
Chironomidae (DIPTERA)	32.7%	4.0%
CLADOCERA	4.7%	0.0%
COPEPODA	33.4%	63.9%
Corixidae (HEMIPTERA)	21.7%	0.0%
Ephydridae (DIPTERA)	0.7%	0.0%
ISOPODA	0.0%	0.4%
Muscidae (DIPTERA)	0.6%	0.0%
MYSIDACEA	0.0%	2.6%
OLIGOCHAETA	3.2%	0.0%
OSTRACODA (Cyprididae)	0.0%	21.2%
Tipulidae (DIPTERA)	2.9%	0.0%

The invertebrate identification report from Jeff Brinkman at Ecology Consultants, Inc. stated the following:

> BMIs collected from the Santa Clara River and Santa Ynez River estuaries consisted of epibenthic crustaceans, insects, and oligochaete worms that live at the sediment/water interface. While the composition of BMIs from the two estuaries was somewhat different (more insects in the Santa Clara, more crustaceans in the Santa Ynez), overall diversity was similar, and similar to what has been found in other studies of estuaries in the region.
>
> BMIs collected from the Santa Ynez River estuary consisted mostly of crustaceans including Copepods, Ostracods, Chironomids, Amphipods, and Mysid shrimp. Chironomid midge larvae from the insect order Diptera comprised a significant portion of the sample near the upstream end of the estuary. The presence of a large proportion of Chironomids likely reflects lower salinity at this location compared to samples near the ocean outlet.
>
> Compared to the Santa Ynez, BMIs collected from the three sampling points in the Santa Clara River estuary consisted of greater proportion and diversity of insect taxa, and lesser proportion and diversity of crustaceans. Insects were comprised mostly of

Chironomid midge larvae. Other Diptera larvae included Tipulidae (crane flies), Ephydridae (shore flies), and Muscidae (house flies). Saltmarsh water boatmen (Corixidae), an insect from the order Hemiptera, were found in significant numbers. Crustaceans included Copepods and Cladocera. Oligochaete worms were found in the lower estuary. Based on the BMIs found, there did appear to be a gradient in the estuary at the time of the sampling, from higher salinity near the mouth to lower salinity at the upstream end. The sample located near the ocean outlet consisted mostly of small crustaceans with some Chironomids. The sample located more in the middle of the estuary was composed of approximately half small crustaceans and half insects including Chironomidae, Ephydridae, Tipulidae, and Corixidae. The sample from the upper estuary was entirely composed of insects including Chironomidae, Ephydridae, Tipulidae, and Corixidae.

Because most invertebrates are at least somewhat sensitive to salinity, the species occurring in these estuaries likely transition to some degree seasonally. Freshwater-oriented forms are likely to be more common in winter months when salinity is low due to substantial freshwater inputs, and nearer the upstream end of the estuaries where salinity is typically lower. Marine-oriented forms are probably more common in summer and fall months when freshwater inputs are lower and salinity is higher, and nearer to the ocean outlets. Forms that are fairly tolerant of fluctuations in salinity such as copepods, ostracods, amphipods, and saltmarsh water boatmen are probably fairly ubiquitous.

Many of the invertebrates found in the estuaries are prey for *O. mykiss* including amphipods, isopods, chironomids, copepods, and mysid shrimp (Shapovalov & Taft 1954, Bratovich & Kelley 1988, Salamunovich & Ridenhour 1990, Martin 1995, Quinn 2005). In addition to benthic samples, sampling was conducted at the surface and 1-meter depth though few of these were processed. Of the samples that were processed, the surface layer tended to be free of invertebrates, while the 1-meter depth samples had either few invertebrates or were dominated by Daphnia (planktonic crustaceans in the Order Cladocera).

Cover surveys

In both estuaries regardless of water level, fallen trees, overhanging vegetation, manmade objects (such as concrete block), and aquatic vegetation provide some amount of cover while turbidity provides most of the cover in open water (pers. obs. February 2008 – May 2008). Water levels in the estuaries changed during the smolt season and available cover altered with changing water levels. The cover surveys were undertaken as soon as possible after the smolt migration.

For the cover surveys, we sampled 19 locations along the shore on the SCRE and 20 on the SYRE. The locations were started from a random point along the shore and continued every 100 meters on the SCRE and every 150 meters on the SYRE. A minimum water depth of 20 cm was required to conduct a survey at a sample point. A 1.5 x 0.5 meter polyvinyl chloride (PVC) sampling frame was divided into quarters. Cover within the frame was visually estimated and could add up to greater than 100% (including overhead and instream cover). For sampling, the frame edge was placed on the shore at the waterline with the remainder of the frame upstream.

The percent cover within the PVC frame for the following categories was recorded:

- Algae/turbidity
- Algal mats
- Aquatic vegetation (emergent)
- Boulders
- Bubble curtain
- Cement chunks
- Hanging roots from bank
- Large Woody Debris (LWD) - large trees or parts of trees > 30 cm in dia., any length
- Manmade structures or debris
- Overhanging vegetation
- Rootwad
- Undercut bank (overhanging bank)
- Wrack - includes woody debris smaller than 30 cm dia., dead arundo or other dead veg.
- Other

Overhead vegetation and algae/turbidity on the SCRE provided the most amount of cover (Table 10). Wrack and aquatic vegetation provided additional cover. On the SYRE, algae/turbidity provided the most amount of cover, with overhead vegetation, wrack, algal mats, rootwads, and large woody debris providing the remaining observed cover. Overall, there isn't much cover along either estuary's shoreline for migrating smolts, and the percentages of cover in Table 10 are likely close to the highest that would have been available during the 2008 smolt season.

TABLE 10. Types and percentages of cover on the Santa Clara and Santa Ynez river estuaries, 2008.

	Santa Ynez River Estuary	Santa Clara River Estuary
Algae/turbidity	23.0%	22.4%
Aquatic vegetation	0.0%	7.7%
Large Woody Debris	1.3%	0.0%
Overhanging vegetation	5.8%	27.9%
Rootwad	1.5%	0.0%
Algal mats	3.8%	0.0%
Undercut bank	0.0%	1.1%
Wrack	5.3%	16.6%
Percent sample sites without cover	45.0%	26.3%

Breaching

The SCRE berm breached on January 25, 2007 and closed on April 20, 2007. It breached again on December 19, 2007 and stayed relatively open until May 6, 2008. This is a total of two breaches over an 11-month period. Compared to the historical data this is not typical. From 1999 – 2007 (VWRF data) the average number of breaches per year was four, and the average number of days the estuary was open was 229. In most years the estuary was open during the entire smolt run (Table 11). Historical data on the breaching of the SYRE are not readily available, and it is not clear who would maintain such a database. The SYRE did not breach at all in 2007. It breached on January 6, 2008 and was still open as of May 2008.

TABLE 11. Number of smolts that were migrating on the Santa Clara River when the river mouth is open or closed, by year.

Year	Number of smolts, mouth open	Number of smolts, mouth closed
1999	3	0
2000	839	0
2001	119	0
2002	0	3
2003	37	4
2004	2	0
2005	-	-
2006	13	0
2007	10	2
2008	92	41

In this year's smolt run just over 2/3 of the smolts were released when the mouth was open. This may mean that the phenomenon we saw this year of the mouth opening and closing during the run is relatively rare, however the endangered status of this steelhead run means that assuring emigration for all smolts is important. Further, during years when there has been no water in the estuary or the mouth has been closed, smolts have sometimes been directly released into the ocean or into the Ventura River estuary to complete their migration (Steve Howard pers. comm.). Studies on salmonid homing abilities (McCormick et al 1998) indicate this could reduce adult returns to the Santa Clara River. Recent hypotheses propose that salmon may imprint on their freshwater locations in a sequential manner, suggesting that smolts released into the Ventura River may return to the Ventura River, and then, unable to detect further olfactory cues leading to their rearing site, lose their stimulus for further migration (Dittman and Quinn 1996 *in* McCormick et al 1998). In light of this, it is likely important to steelhead recovery on these rivers to allow SYR and SCR smolts to complete their natural migration and to keep the river mouth open during the migration.

Synthesis and Implications

The two objectives of this project were to assess smolt survival on the Santa Clara and Santa Ynez Rivers and to assess the capacity of each river's estuary to support steelhead smolts. There are four stressors likely affecting smolt survival: predation, temperature, turbidity, and handling by humans. The levels of pH and dissolved oxygen within the estuaries do not appear to be a concern for smolts.

Salinity

The higher salinity of the SYRE likely has little effect on smolt acclimation to seawater since its levels are closer to freshwater (see Salinity in Estuarine Habitat). The lack of a saltwater lens in both estuaries is a positive habitat feature for smolts since warm salt water trapped at the bottom of an estuary can produce conditions of anoxia. Some salmonids use estuaries to prepare for sea entry (Thorpe 1994) and some move directly into the ocean (McCormick et al. 1998). The best means of evaluating the effects on SYR and SCR smolts short of physiological studies would be to measure post-smolt survival in the ocean, where their ability to perceive and avoid predators may be compromised by osmotic stress (Jarvi 1989).

Turbidity

The high levels of turbidity in both estuaries likely result from biosolids in the wastewater effluent. This was evident on the SCRE when the estuary mouth was open. The freshwater channel from upstream was clear to the bottom until it mixed with the outfall from the wastewater treatment plant, at which point it became obscure at a depth of 0.55 cm. The outfall channel's turbidity was higher at a Secchi depth of 0.15 cm. Based on our observations, the wastewater treatment plant effluent in the SCRE appears responsible for the opaque SCRE waters during non-storm flow. The SYRE's turbidity likely results from upstream secondary-treated effluent and ranching inputs. Anthropogenic inputs contribute to an unknown degree to the proliferation of biological organisms, which can increase turbidity. Bratovich and Kelley (1988) found that given the opportunity, smolts in Lagunitas Creek estuary would choose to wait in clearer, cooler waters rather than turbid ones prior to their exit to the ocean. Gregory (1993) noted that turbidity reduced juvenile chinooks' perception of danger from predators, perhaps reducing their stress levels but also making them more vulnerable to predation.

While turbid water may not be preferred smolt habitat, it could provide some protection from predators (Lloyd 1987). Working with juvenile chinook salmon, Gregory and Northcote (1993) indicated that moderately turbid conditions may enhance protection from predators. Understanding the composition of the turbidity (silt, sediment, algae, etc.) found in the SYRE and SCRE would help determine whether it is beneficial or detrimental to smolts. Turbidity levels of 0.4 – 3 g/L caused by ash, clay, and topsoil resulted in sublethal effects (including stress and susceptibility to disease) in yearling *O. mykiss* (Redding et al. 1987). In tests of clear versus turbid waters, Sigler et al. (1984) found that turbidity as low as 25 NTUs reduced growth in juvenile steelhead and coho. Noggle (1978) found that juvenile salmonids were more sensitive to sediment loads in the spring and summer indicating that smolting may reduce salmonid tolerance for turbidity. An investigation into the sources and composition of turbidity in each estuary would permit evaluation of its harm or benefit to steelhead smolts.

Temperature

Water temperatures present a potentially serious problem in the estuaries especially in the SCRE. On the day when the SCR mouth was open and we could clearly measure effluent and flow from upstream, the effluent temperature was 20.29ºC and the flow from upstream was 21.94ºC. During this project, SCR smolts were often released in the late afternoon and cooler evening hours but even so, water temperatures ranged as high as 24.2ºC. On April 13th, the daytime water temperature in the SCRE reached 28ºC. It is not unknown for southern *O. mykiss* to utilize habitat with temperatures of up to 28.9ºC when access to groundwater seeps and coldwater refugia is available (Matthews & Berg 1997). It has also been observed that *O. mykiss* in southern California streams can tolerate temperatures up to 32ºC (Spina 2007). This may be possible due to acclimatization and temperature cycling. Currie et al (2004) studied high temperature tolerance for *O. mykiss* exposed to temperature cycling (highs and lows). They found that fish acclimatized to thermal cycles had maximum temperature tolerances of 27.3ºC to 29.6ºC. However the length of exposure to high temperatures must be short, and smolts have a lower tolerance for such extremes than other lifestages. Richter and Kolmes (2005) note that high temperatures during the smolt phase can result in decreased survival in the marine environment or outright death. One sublethal effect includes desmolting (Duston 1991, McCormick 1996) which on both these rivers would likely result in mortality due to the lack of connection to rearing habitat in the tributaries. Schneider and Conner (1982) found that while juvenile rainbow trout swimming speeds were not affected at lower temperatures, above 25ºC swimming performance was significantly reduced. For smolts in these high temperature estuaries, compromised swimming ability could mean the difference between survival and being preyed upon. Much is often made of southern *O. mykiss* abilities to tolerate warm temperatures, and while this may be appropriate for other life stages it is not appropriate to assume that smolts possess the same temperature tolerance, or that high temperatures will not have sublethal effects that reduce smolts' ability to escape predation. Due to its depth the SYRE may provide thermal refugia unavailable to smolts in the SCRE.

Two changes could potentially help with the high temperatures and turbidity in both estuaries. One is maintenance of upstream flows during the smolt runs. In years when smolts are emigrating, UWCD and COMB should maintain flows to the estuaries. Maintaining these flows would provide water for the smolts to complete their migration, potentially cooler inputs into the estuaries, and sufficient water to keep the estuary open during the migration. In the Final Biological Opinion issued for the VFD by the National Marine Fisheries Service (NMFS 2008) the reasonable and prudent alternative includes the restoration of a smolt freshwater migration corridor below the diversion. An evaluation of smolt ocean survival would be appropriate since smolts trapped and released into the estuary may have lower survival rates in the ocean than those who complete a natural migration. Likewise a migration corridor for smolts should be maintained on the SYR for the duration of their run. The shutting down of flow on the SYR and prevention of smolt migration is detrimental to recovery of that steelhead run.

Another change that could help with both turbidity and temperature in the SCRE is a current proposal being considered by VWRF to direct their outfall into created wetlands. This would reduce the turbidity in the estuary and likely result in cooler water releasing into the estuary through the soil and groundwater. Zedler et al (1992) indicate that a twice-daily pulsed discharge rather than a constant outfall into a treatment wetlands is more effective at removing nutrients and heavy metals from the water.

On the SYR, the city of Lompoc is currently renovating their wastewater treatment plant to treat water to a tertiary level. This should reduce the amount of biosolids in the SYR, however the VWRF currently releases tertiary treated water into the SCRE and turbidity remains an issue there. It would be helpful to measure levels of turbidity and water temperature upstream and downstream of the Lompoc facility before and after the renovation.

Predation

The conditions found in the estuaries, especially the SCRE, may cause smolts to be particularly vulnerable to predation. For some smolts this may be the first time they have encountered predators such as cormorants and terns, and they could react slowly. High temperatures can also affect smolt responsiveness (discussed below). While smolts generally seemed fit post-surgery, the combination of surgery and transportation could have an impact on smolt survival (Welch et al. 2004). In addition, the lack of cover in both estuaries may make smolts more vulnerable to predation.

Predators may also have cued into the SCRE release site, resulting in higher mortality numbers (David Welch pers. comm.). However the choices for release sites on the SCRE when the mouth is open are limited. Without input from upstream, smolts must be released in the impounded (and highly bird populated) area toward the bottom of the estuary. Most predatory bird species tend to be in the lower and middle sections of the estuaries. Greater flow from upstream on the SCR might provide smolts with deeper water for migration from the upper estuary to the exit and a holding area in the upper estuary where predatory birds do not tend to congregate. Larger flows would also likely reduce predation by allowing smolts to enter the estuary during times and conditions of their choosing.

Other considerations

Smolts are not adult steelhead nor are they juveniles, but are physiologically different from other lifestages of this species. Overall *O. mykiss* is a hardy species, but smolts have particular vulnerabilities to environmental disturbances that can impact their survival including: altered flows and temperature regimes, reduced water quality, exposure to pollution, dams and impoundments, and altered estuarine habitat (McCormick et al 1998). Smolts are also more sensitive than other life stages to a variety of contaminants (Digiulio and Tillitt 1999), including endocrine disruptors (Kime 1998), which are known to occur in wastewater.

It isn't possible to determine from this one year of data whether smolts do not spend time in the estuaries because they are inhospitable or because it is in their nature to emigrate to sea as soon as possible. The larger size of the smolts in both these rivers suggests that they are less likely to over-summer in an estuary (Bond 2006), but this cannot be concluded based on one season of data.

While resident *O. mykiss* populations in the Santa Clara River are often considered to be the major contributors to the smolt run, there is evidence that ocean-going progeny of resident trout have a lower survival rate than those arising from anadromous parents, and that even one generation of close inbreeding can reduce marine survival (Hard et al. 2002). Consequently, while resident *O. mykiss* may contribute to the steelhead run, ocean-run adults are needed for recovery of these runs. Donohue et al (2008) found that anadromous *O. mykiss* females were the predominate progenitors of anadromous adults (compared to resident females) and are therefore more likely to give rise to the numbers of ocean-going juveniles that could help recover southern steelhead runs.

The small smolt runs on both these rivers indicate that there is insufficient production or that too few juveniles undergo smolting. This may mean that a focus on habitat improvements to increase production would make sense, or that greater amounts of spawning and rearing habitat are needed to increase production. The lack of anadromous males in a salmon run may increase the importance of male parr (Valiente et al. 2005) in spawning and production. Male parr have been shown to increase population sizes in small populations lacking sufficient numbers of anadromous males. Parr maturation can be chemically induced and environmental determination of parr maturation argues for conservation and promotion of environmental features that increase maturation rates and enhanced spawning opportunities.

Lastly, the varied life history expressed in steelhead likely represents an evolutionary strategy that allows *O. mykiss* to adapt to environmental variation (McPhee et al. 2007), an especially important consideration for southern California. The separation of *O. mykiss* into Distinct Population Segments that protects only the anadromous life form may hinder recovery, and efforts should be made to include *O. mykiss* located above dams in steelhead population planning and recovery (McPhee et al. 2007) . Additionally, the life form plasticity expressed by *O. mykiss* suggests that restoration should focus on habitat features that promote the expression of life-history diversity (McPhee et al 2007).

Conclusion

There are too few smolts surviving the migration on the Santa Clara and Santa Ynez Rivers to produce sustainable adult runs or to meet the criteria for recovery (NMFS 2007). Larger smolt runs and greater smolt survival is needed if these stocks are to be recovered.

Recommendations

Recommendations for improving steelhead smolt management and knowledge about the smolt life stage are made below. They are not necessarily in order of priority.

Category A: Management Actions

1. Negotiate a permit with the Army Corps of Engineers (ACOE), U.S. Fish and Wildlife Service (USFWS), and the California Department of Fish and Game (DFG) to allow small, environmental breaches if an estuary mouth closes during the smolt run.

   Importance: This action would allow smolts from the SCR and SYR to exit the estuaries and complete their natural run.

   Management Implications: Allowing smolts to emigrate quickly from their rivers may increase survival and adult returns. There are potential impacts on the tidewater goby, although if the breaching occurs before the berm has built up, the breach is minor, and it occurs prior to their main breeding season, the impacts are likely to be negligible. Further consultation with a tidewater goby expert to set parameters is recommended. Given that the environmental breaches will occur near the ocean and in the same general location as the initial breach this is not expected to have any impacts on least terns or snowy plovers.

2. Investigate options for housing remote PIT tag recorders and frames within a mile of each estuary in the mainstem of the rivers.

   Importance: Remote recorders would provide data on returning adults. Multiple PIT tag recorder locations would provide information on swim speed, adult migration survival, and adults' ability to negotiate barriers to migration.

   Management Implications: Data on the in-river migration for adults may provide information on adult steelhead's ability to successfully negotiate man-made barriers such as the ladders on the Vern Freeman Diversion and the Harvey Dam on Santa Paula Creek. Speed of migration may indicate areas to focus on restoration in the rivers. Data on adult return rates is of special importance for population recovery.

3. Talk with Lompoc Regional Wastewater Reclamation Plant (on the SYR) about the monitoring that will take place after their plant renovation is complete. Suggest inclusion of steelhead habitat monitoring, measuring parameters such as temperature and turbidity, if they are not already being considered. Monitoring would include samples upstream of the wastewater outfall.

   Importance: This will provide monitoring data on turbidity, temperature, and other parameters that may affect steelhead.

   Management Implications: The data should provide some basic information on the sources of turbidity in the river, and eventually on whether restoration efforts to reduce turbidity and temperature are warranted and where they should take place.

4. Consult with avian biologists about the likelihood of observing fishing success among cormorants, terns, herons, and other smolt predators in both estuaries.
   Importance: If feasible, the observations will provide a low-cost estimate of smolt predation.
   Management Implications: If birds are preying heavily upon smolts, then options for protecting smolts from predation (such as providing additional cover, etc.) could be investigated.

Category B: Adaptive Management and Monitoring

1. Increase flows from upstream into both estuaries during the smolt runs. Evaluate smolt survival, water temperatures, predation rates, available cover, and the timing of the opening and closing of the estuary mouth during these flows.
   Importance: Increased flows have several potential ways to increase smolt survival including providing a natural migration corridor, reducing the stress of transportation/trapping, providing a holding area with fewer predatory birds, allowing a more gradual acclimation to the estuarine habitat, maintaining an open river mouth, and providing thermal refugia.
   Management Implications: This may improve smolt survival rates, and indicate areas for potential habitat restoration on the river or estuary.
2. Continue to conduct tagging while concurrently monitoring estuary conditions, bird predation, and smolt migration.
   Importance: This is likely to be especially helpful on the SYRE where much less data is collected than on the SCRE. The factors that might influence how long smolts remain in the estuary include: life-history, clarity of water, temperature of water, degree of predation, and force of water flow. The effects of these factors on smolt emigration cannot be determined from one year of data.
   Management Implications: Further data will help with management decisions regarding flow, estuary habitat, and predation management.
3. Continue tagging effort and purchase an acoustic mobile hydrophone to track smolt presence and location in each estuary.
   Importance/Management Implications: This will provide information on where smolts are spending their time in the estuary and where best to focus restoration.
4. On the SCR, if insufficient water is provided for the smolts to complete their run, then the VFD downstream trap should be redesigned to reduce smolt stress.
   Importance: There are several stressors associated with this trap including crowding, noise, loss of water as the trap is lifted from the water, and the mechanical movement of the trap.
   Management Implications: This may increase smolt survival since smolts are particularly susceptible to stress, and since the stress of the trap is compounded by smolts being trucked to the estuary and released into a warm, unfamiliar environment.

Category C: Filling Life History Knowledge Gaps

1. Conduct surveys for *O. mykiss* prior to and during the smolt season above the dams on the SCR and SYR to assess smolt production.
   Importance: We don't know the carrying capacity of either watershed or whether *O. mykiss* above dams are smolting and could contribute to recovery.

Management Implications: Assessing production on both rivers is important in understanding factors affecting steelhead recovery.

2. Evaluate components of *O. mykiss* habitat and how these interact to influence male parr maturation.

   Importance: Recovery of southern steelhead may depend upon promoting features within the environment that encourages life form diversity and early maturation of male parr.

   Management Implications: Identification of environmental features that promote production can determine appropriate management actions and restoration projects.

3. Evaluate the smolt life cycle on the SYR and SCR including the environmental conditions that may trigger smolting and migration. Important factors to consider include: temperature, photoperiod, rainfall, and density of each age class.

   Importance: In general environmental triggers that promote smolting are not well understood and may differ in southern populations.

   Management Implications: Understanding the smolt life cycle and potential environmental triggers may permit managers to better predict smolt run size and to manage habitat and migration corridors to increase smolt numbers and survival.

4. Conduct long-term monitoring of instream conditions, juvenile production, and smolt production in the tributaries of the SYR and SCR.

   Importance: Provides baseline data to predict smolt population size and capacity of the tributaries to produce smolts.

   Management Implications: Predicting smolt population sizes and the percentage of smolts that arise from the juvenile population can provide data for preserving and restoring rearing habitat.

5. Collect genetic samples from resident *O. mykiss* to determine whether they are of anadromous ancestry, and how much resident individuals are contributing to the smolt populations on both rivers.

   Importance: Plasticity between life forms of *O. mykiss* is not well understood especially in southern California.

   Management Implications: If resident *O. mykiss* are giving rise to successful migrants at greater rates in southern California, this could make a difference in recovery planning.

6. Continue tagging effort but move operations upstream on the SCR and monitor migration times to the VFD.

   Importance: This will provide migration times for the smolts, as well as allowing them the opportunity to recover from the stress of trapping and surgery prior to their encounter with either the diversion or the estuary.

   Management Implications: This could become a non-issue if the UWCD supplies enough flow for smolts to complete their migration naturally.

7. Evaluate ocean survival by gradually increasing the acoustic receiver array and evaluating swimming direction. Join the Pacific Ocean Salmon Tracking (POST) project and gain access to their acoustic listening stations.

   Importance: This would constitute the first ocean movement data on southern *O. mykiss*. Becoming members of POST might provide further information on southern steelhead ocean feeding grounds.

   Management Implications: Provides additional information for recovery planning and for understanding the species' life history.

Category D: Other Investigations

1. Explore the sources of water coming into each estuary, and conduct in-depth water quality assessments to evaluate each source's cleanliness and temperature. Measure pollutants from all sources including: nitrates, nitrites, biosolids, heavy metals, silt/sediment, estrogen, and estrogen mimickers. Assess effects of these pollutants (proliferation of biological organisms, turbidity levels, etc.) on smolts. If appropriate, consider planting native flora to cleanse and cool water. Evaluate whether a treatment wetland would be beneficial on the SYR.

    Importance: Improving the estuary environment may increase smolt residence times and increase survival.

    Management Implications: Information could direct restoration and management of the SYR and SCR estuaries. May also provide information for constructively managing other southern California estuaries used by steelhead smolts.

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Appendix I

Special status species lists

Special status species that occur on the Santa Clara and Santa Ynez river estuaries

Common Name	Scientific Name	Status	Source	Occurs SCRE?	Source	Occurs SYRE?	Source
Arroyo chub	*Gila orcutti*	State Special Concern	ESA 2003	Y	ESA 2003; Court et al. (2000)	Y	U.S. Bureau of Reclamation, Cachuma Project Authority and Santa Barbara County Water Agency 1995
Bald Eagle	*Haliaeetus leucocephalus*	Threatened	United States Department of the Interior Fish and Wildlife Service 2008			Y	U.S. Bureau of Reclamation, Cachuma Project Authority and Santa Barbara County Water Agency 1995
Beldings savannah sparrow	*Passerculus sandwichensis beldingi*	State Endangered	ESA 2003	Y	ESA 2003; Court et al. (2000)	nonendangered subspecies	Mahrdt et al. (1976)
Brown pelican	*Pelecanus occidentalis*	Federal species of concern	Environmental Science Associates 2003	Y	ESA 2003	Y	Collins et al. (1999); Dames and Moore (1984)
California least tern	*Sterna antillarum browni*	Federal Endangered, State Fully Protected	ESA 2003	Y	ESA 2003; Court et al. (2000)	Y	U.S. Bureau of Reclamation, Cachuma Project Authority and Santa Barbara County Water Agency 1995; Dames and Moore (1984)
California red-legged frog	*Rana aurora draytonii*	Federal Threatened, State Special Concern	ESA 2003	Y	ESA 2003; Court et al. (2000)	Y	Dames & Moore (1984)
Least bell's vireo	*Vireo bellii pusillus*	Federal Endangered, Critical Habitat	ESA 2003, Santa Clara River Project Steering Committee 1996,	Y	ESA 2003; Court et al. (2000)		
Light-footed clapper rail	*Rallus longirostris levipes*	Federal Endangered, State Endangered and Fully Protected	ESA 2003	Y	ESA 2003		
Long-billed curlew	*Numenius americanus*	State Special Concern	ESA 2003	Y	ESA 2003; Court et al. (2000)		
Northern Harrier	*Circus cyaneus*	State Special Concern	ESA 2003	Y	ESA 2003; Court et al. (2000)	Y	U.S. Bureau of Reclamation, Cachuma Project Authority and Santa Barbara County Water Agency 1995; Collins et al. (1999); Dames and Moore (1984)
Osprey	*Pandion haliaetus*	State Special Concern	ESA 2003	Y	ESA 2003	Y	Collins et al. (1999); Dames and Moore (1984)
Salt Marsh Bird's-Beak	*Cordylanthus maritimus maritimus*	Endangered	United States Department of the Interior Fish and Wildlife Service 2008	Y	Court et al. (2000)		
San Diego horned lizard	*Phrynosoma coronatum blainvillei*	State Special Concern	ESA 2003	Y	ESA 2003; Court et al. (2000)	Y	Dames & Moore (1984)
Silvery Legless Lizard	*Anniella pulchra pulchra*	State Special Concern	ESA 2003	Y	ESA 2003; Court et al. (2000)		
South coast garter snake	*Thamnophis sirtallis spp.*	State Special Concern	ESA 2003	Y	ESA 2003	Y	Dames & Moore (1984)

Common Name	Scientific Name	Status	Source	Occurs SCRE?	Source	Occurs SYRE?	Source
Southern Steelhead	*Oncorhynchus mykiss*	Federal Endangered	United States Department of the Interior Fish and Wildlife Service 2008	Y	Court et al. (2000)	Y	SYR Draft (2007)
Southwestern pond turtle	*Clemmys marmorata pallida*	State Special Concern	ESA 2003	Y	ESA 2003		
Southwestern willow flycatcher	*Empidonax trallii extimus*	Endangered	United States Department of the Interior Fish and Wildlife Service 2008	Y	Santa Clara River Project Steering Committee 1996; Court et al. (2000)	Y	Farmer et al. (2003)
Tidewater goby	*Eucyclogobius newberryi*	Federal endangered	ESA 2003	Y	ESA 2003; Court et al. (2000)	Y	U.S. Bureau of Reclamation, Cachuma Project Authority and Santa Barbara County Water Agency 1995, Mahrdt et al. (1976); Dames and Moore (1984)
Townsend's (western) big-eared bat	*Corynorhinus townsendii*	State Special Concern	ESA 2003	Y	ESA 2003		
Two-striped garter snake	*Thamnophis hammondii*	State Special Concern	ESA 2003	Y	ESA 2003; Court et al. (2000)	Y	Dames & Moore (1984)
Unarmored threespine stickleback	*Gasterosteus aculeatus williamsoni*	Endangered	United States Department of the Interior Fish and Wildlife Service 2008	Y	Court et al. (2000)	only nonend. armored stickleback	U.S. Bureau of Reclamation, Cachuma Project Authority and Santa Barbara County Water Agency 1995; Dames & Moore (1984)
Ventura marsh milkvetch	*Astragalus pycnostachyus lanosissimus*	Threatened	Court et al. (2000)	Y	Court et al. (2000)		
Western least bittern	*Ixobrychus exilis*	State special concern	ESA 2003	Y	ESA 2003; Court et al. (2000)		
Western snowy plover	*Charadrius alexandrinus nivosus*	Federal Threatened, Critical Habitat, State Special Concern	ESA 2003	Y	ESA 2003; Court et al. (2000)	Y	U.S. Bureau of Reclamation, Cachuma Project Authority and Santa Barbara County Water Agency 1995, Mahrdt et al. (1976); Dames and Moore (1984)
Yellow warbler	*Dendoica petechia*	State Special Concern	ESA 2003	Y	ESA 2003; Court et al. (2000)		
Yellow-breasted chat	*Icteria virens*	State Special Concern	ESA 2003	Y	ESA 2003; Court et al. (2000)		

Appendix II

Plant Lists

General habitat categories are described below and followed by plant community lists for each estuary.

Dunes: characterized by sparse to moderate cover and low-lying vegetation occurring on beach dunes.
Marsh and Wetlands: frequently inundated by fresh water.
Riparian Scrub and Woodland: mid-succession, riparian woodland
Riverwash: may at times be in the active channel
Other: additional habitats

Santa Clara River Estuary

Plant species and habitats for the SCRE (Tables A –D) come from recent vegetation surveys conducted by Nautilus Environmental (2005), and Stillwater Sciences and URS Corporation (2007).

TABLE A. DUNE VEGETATION

Common Name	Scientific Name
Beach primrose	*Camissonia cheiranthifolia*
Beach-bur	*Ambrosia chamissonis*
Coast buckwheat	*Eriogonum parvifolium*
Giant reed	*Arundo donax*
Hottentot fig	*Calistygia macrostegia*
Iceplant	*Carpobrotus spp.*
Lotus	*Lotus junceus*
Pink sand verbena	*Abronia umbellate*
Salt grass	*Distichlis spicata*
Sand verbena	*Abronia maritima*
Sea rocket	*Cakile maritima*
Silver burweed	*Ambrosia chamissonsis*

Sources: Greenwald et al 1999, Nautilus 2005, Stillwater/URS 2007

TABLE B. MARSH AND WETLANDS VEGETATION

Common Name	Scientific Name
Bristly ox tongue	*Picris echioides*
Broadleaved cattail	*Typha latifolia*
Bulrushes	*Scirpus sp.*
Cocklebur	*Xanthium stumarium*
Creeping wild rye	*Leymus triticoides*
Curly dock	*Rumex crispus*
Dwarf and hoary nettle	*Urtica urens; U. diocia ssp. holosericea*
Fleshy jaumea	*Jaumea carnosa*
Narrow-leaved cattail	*Typha angustifolia*
Pacific silverweed	*Potentilla anserina ssp. pacifica*
Pickleweed	*Salicornia bigelovii*
Rabbit's foot grass	*Polypogon monspeliensis*
Rushes	*Juncus sp.*
Salt grass	*Distichlis spicata*
Sedges	*Carex sp.*
Western ragweed	*Ambrosia psilostachya*
Yerba mansa	*Anemopsis californica*

Sources: Greenwald et al 1999, Nautilus 2005, Stillwater/URS 2007

C. Riparian Scrub and Woodland

Common Name	Scientific Name
Arroyo willow	*Salix lasiolepis*
Black cottonwood	*Populus balsamifera* ssp. *trichocarpa*
Fremont cottonwood	*Populus fremontii*
Giant reed	*Arundo donax*
Mulefat	*Baccharis salicifolia*
Narrow-leaved willow	*Salix exigua*
Ngaio Tree	*Myoporum laetum*
Poison oak	*Toxicodendron diversilobum*
Red willow	*Salix laevigata*
Tamarisk	*Tamarix* sp.
Western sycamore	*Platanus racemosa*

Sources: Greenwald et al 1999, Nautilus 2005, Stillwater/URS 2007

D. Riverwash

Common Name	Scientific Name
Annual rabbitsfoot grass	*Polypogon monspeliensis*
Barnyard grass	*Echinochloa crus-galli*
Fremont cottonwood	*Populus fremontii*
Giant reed	*Arundo donax*
Knotweed	*Polygonum* spp
Mulefat	*Baccharis salicifolia*
Sprangletop	*Leptochloa uninervia*
Water speedwell	*Veronica anagallis-aquatica*
Watercress	*Rorippa nasturtium-aquaticum*
White sweetclover	*Melilotus alba*
Willows	*Salix exigua, S. laevigata, S. lucida* ssp. *lasiandra,* and *S. lasiolepis*

Sources: Greenwald et al 1999, Nautilus 2005, Stillwater/URS 2007

Santa Ynez River Estuary

The SYRE has had fewer complete plant surveys than the SCRE. The species listed from these surveys have been placed into the habitat categories (Tables AA-CC) where such could be determined. If a habitat is generic or unknown the species was placed in an "Other" category (Table DD).

AA. Dune Vegetation

Common Name	Scientific Name
Beach-burr	*Ambrosia chamissonis*
Crystal iceplant	*Gasoul crystallium*
Hottentot fig	*Mesembryanthemum edulis*
Salt grass	*Distichlis spicata*
Sea rocket	*Cakile maritime*

Sources: Mahrdt et al 1976, Moore 1984, Santa Barbara County 1988, California Polytechnic State University San Luis Obispo 1995, Paterson 1995.

BB. Marsh and Wetlands Vegetation

Common Name	Scientific Name
Alkali heath	*Frankenia salina*
Australian saltbrush	*Atriplex semibaccata*
Bristly ox tongue	*Picris echioides*
Bulrushes	*Scirpus sp.*
California sealavender	*Limonium californicum*
Cattails	*Typha spp.*
Cocklebur	*Xanthium stumarium*
Common brassbuttons	*Cotula coronopifolia*
Creeping wild rye	*Leymus triticoides*

Curly dock	*Rumex crispus*
Fleshy jaumea	*Jaumea carnosa*
Heliotrope	*Heliotropium curassavicum*
Hen bit	*Atriplex patula*
Italian wild rye	*Lolium multiflorum*
Menzies' goldenbush	*Isocoma mensiezii*
New Zealand spinach	*Tetragonia tetragonioides*
Pacific silverweed	*Potentilla anserina ssp. pacifica*
Pickleweed	*Salicornia bigelovii*
Rabbit's foot grass	*Polypogon monspeliensis*
Rushes	*Juncus sp.*
Salt grass	*Distichlis spicata*
Salt marsh baccharis	*Baccharis douglasi*
Salt marsh pickleweed	*Salicornia virginica*
Salt marsh sand-spurrey	*Spergularia marina*
Salt marsh dodder	*Cuscuta salina*
Sickle grass	*Parapholis incurve*
Silverweed	*Potentilla egedii*
Watercress	*Rorippa nasturtium-aquaticum*
Western ragweed	*Ambrosia psilostachya*
Yerba mansa	*Anemopsis californica*

Sources: Mahrdt et al 1976, Moore 1984, Santa Barbara County 1988, California Polytechnic State University San Luis Obispo 1995, Paterson 1995.

CC. RIPARIAN SCRUB AND WOODLAND

Common Name	Scientific Name
Cottonwoods	*Populus* ssp.
Ngaio Tree	*Myoporum laetum*
Tamarisk	*Tamarix* sp.
Willows	*Salix spp.*

Sources: Mahrdt et al 1976, Moore 1984, Santa Barbara County 1988, California Polytechnic State University San Luis Obispo 1995, Paterson 1995,

DD. Other

Common Names	Scientific Name	Habitat
Alkali wild rye	*Elymus triticoides*	Not given
Black mustard	*Brassica nigra*	Not given
Brass buttons	*Cotula australis*	Disturbed
Coastal isocoma	*Haplopappus venetus*	Valley grassland
Common iceplant	*Mesembryanthemum crystalinum*	Coastal
Common sow thistle	*Sonchus oleraceus*	Disturbed
Coulter's conyza	*Conyza coulteri*	Valley grassland
Coyote brush	*Baccharis pilularis*	Coastal
English rye grass	*Lolium perenne*	Wetlands, non-wetlands
Everlasting Cudweed	*Gnaphalium luteo-album*	Not given
Fat Hen	*Atriplex triangularis*	Not given
Fennel	*Foeniculum vulgare*	Disturbed
Foxtail barley	*Hordeum leporinum*	Disturbed
Mediterranean Hoary Mustard	*Hirschfeldia incana*	Non-wetlands
Mock parsley	*Apiastrum angustifolium*	Slopes
Poison hemlock	*Conium maculatum*	Disturbed
Ripgut brome	*Bromus diandrus*	Disturbed
Russian thistle	*Salsola kali*	Disturbed, poss. dunes
Slender wild oats	*Avena barbata*	Disturbed
Soft Brome	*Bromus hordeaceus*	Disturbed
Spiny sowthistle	*Sonchus asper*	Disturbed
Summer mustard	*Brassica geniculata*	Disturbed, wetlands
Tocolote	*Centaurea melitensis*	Disturbed
White sweetclover	*Melilotus alba*	Not given
Yellow sweet-clover	*Melilotus indicus*	Not given

Sources: (Paterson 1995)California Polytechnic State University San Luis Obispo 1995, Paterson 1995, CalFlora 2008

Appendix III

<u>Grant Budgets and Location Maps</u>

Estimated Total Project Budget and Expenditures
Department of Fish and Game

	Budget	Expended	Remaining
PERSONNEL			
Project Manager	$110,864.00	$103,903.44	$6,960.56
Staff Benefits @ 23.99967%	$26,607.00	$19,248.09	$7,358.91
Field Tech.	$20,251.00	$18,784.60	$1,466.40
Staff Benefits @ 7.21939%	$1,462.00	$1,056.16	$405.84
Subtotal Personnel	$159,184.00	$142,992.29	$16,191.71
OPERATING EXPENSES			
Subcontractors			
Fish Surgeon*	$4,680.00	$5,600.00	-$920.00
GIS Tech. & Invertebrate Tech. (lump sum)	$4,000.00	$4,000.00	$0.00
Subtotal Subcontractors	$8,680.00	$9,600.00	-$920.00
Anchoring	$17,360.00	$19,200.00	-$1,840.00
Subsurface buoys (6 ea. @ $6/ea.)	$36.00	$36.00	$0.00
Modified Earth Auger Anchors	$2,940.00	$2,925.75	$14.25
Leadline	$200.00	$200.00	$0.00
Anti-fouling paint	$187.00	$173.98	$13.02
Anchoring Subtotal	$3,363.00	$3,335.73	$27.27
Surgical Supplies (tables,fish measur. bd.,etc.)	$8,057.00	$8,104.67	-$47.67
Estuary Supplies			
Waders	$180.00	$172.56	$7.44
Transducer	$1,200.00	$1,200.00	$0.00
Salinity, Temp. & D.O. meter (lump sum)	$3,000.00	$2,967.64	$32.36
Boat Rental	$2,700.00	$2,700.00	$0.00
Estuarine survey supplies	$531.00	$747.32	-$216.32
Subtotal Estuary Supplies	$7,611.00	$7,787.52	-$176.52
Other Operating Expenses			
Laptop Computer Rental	$3,749.00	$3,730.94	$18.06
V8 Acoustic Tags	$59,205.00	$59,205.00	$0.00
PC Interface	$165.00	$165.00	$0.00
Vemco Shipping	$250.00	$250.00	$0.00
Pit Tags	$1,650.00	$1,650.00	$0.00
Travel			
Mileage	$5,610.00	$5,104.90	$505.10
Fish Surgeon Travel	$680.00	$0.00	$680.00
Fish Surgeon Hotel	$420.00	$0.00	$420.00
Per Diem	$200.00	$0.00	$200.00
Supplies, printing, copying, telecomm.,	$2,000.00	$1,766.81	$233.19
Field camera	$250.00	$250.00	$0.00
Final report production	$550.00	$550.00	$0.00
Subtotal Other Operating Expenses	$74,729.00	$72,672.65	$2,056.35
Tagging Equipment & Supplies			
VR2 Acoustic Receivers	$21,150.00	$21,150.00	$0.00
PIT Readers and software	$5,020.00	$5,001.39	$18.61
Dummy tags	$600.00	$600.00	$0.00
Acoustic range tags	$580.00	$580.00	$0.00
Subtotal Tagging Equipment & Supplies	$27,350.00	$27,331.39	$18.61
Overhead	$43,346.00	$41,330.07	$2,015.93
Total	$332,320.00	$313,154.32	$19,165.68

*The complete budget for the Fish Surgeon includes line items under travel, but expenditure was entered as one sum on this line.

California Department of Fish and Game Grant Information

Grant Number: P0550008 00
Geographic Area: Santa Clara and Santa Ynez Rivers
Location of Work: See Figures 1, 4, 5, and Appendix VII

Geospatial Reference (in decimal degrees):

Location	Latitude	Longitude
Santa Clara River Estuary	34.23392	-119.25834
Vern Freeman Diversion	34.299695	-119.10905
Santa Ynez River Estuary	34.692783	-120.59841
Salsipuedes Creek	34.596865	-120.41031

Project Start/End Dates: September 1, 2006 – August 31, 2008
Number of person hours expended: 6304
Total of DFG Fund Source: $332,320.00
Total of TNC and Santa Clara River Trustee Council Fund Source: $3155.00

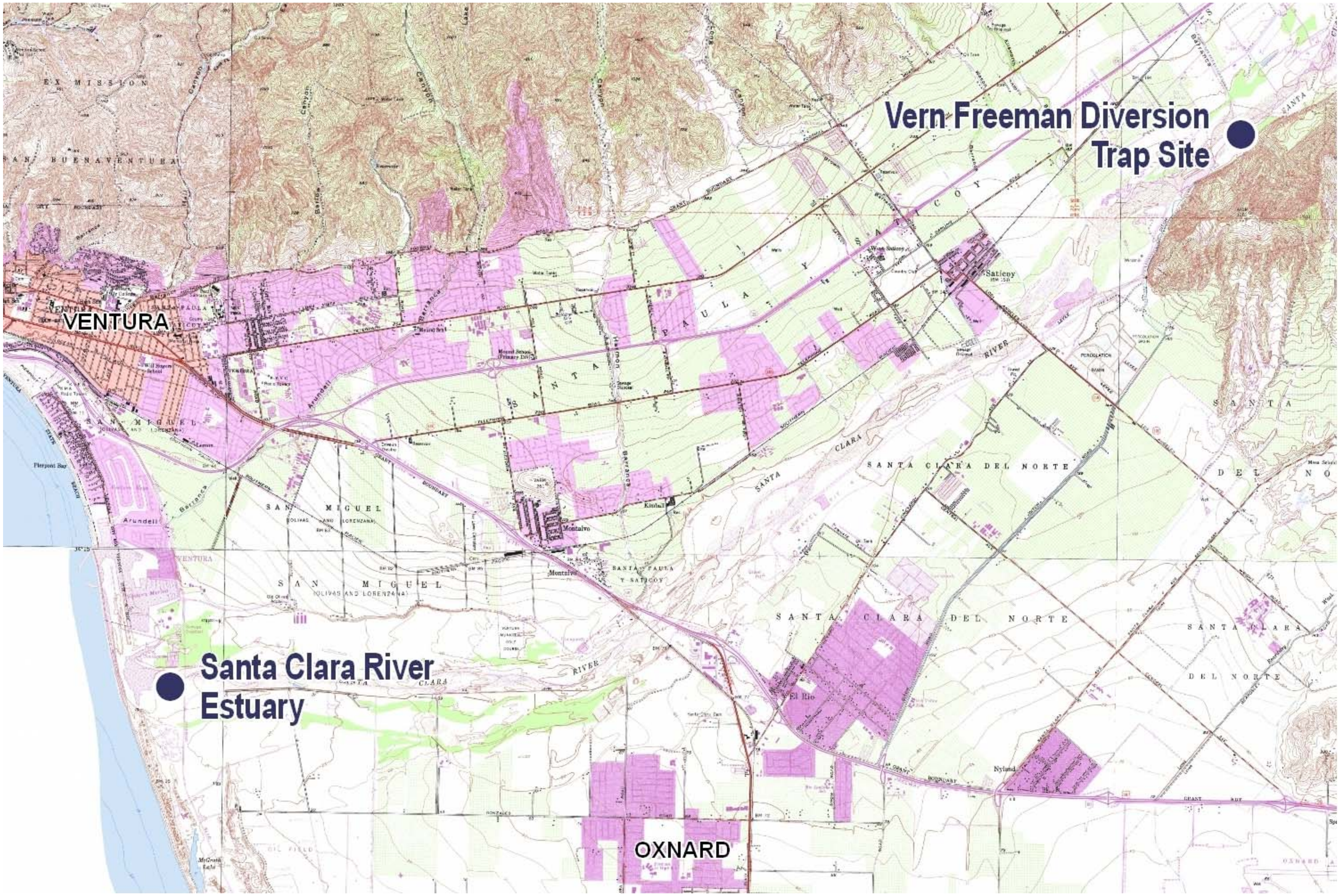
Organizations cooperating on the project include: Cachuma Conservation and Release Board, California State Parks, City of San Buenaventura, NOAA Fisheries, Santa Barbara County Parks, The Nature Conservancy, United Water Conservation District, U. S. Fish and Wildlife Service, and Vandenberg Air Force Base.

Stream length assessed each year:
Santa Clara River – 0.06 miles (Santa Clara River Estuary)
Santa Ynez River – 1.50 miles (Santa Ynez River Estuary)

Funding from:
The Nature Conservancy and The Santa Clara River Trustee Council
Budget and Expenditures

	Budget	Expended	Remaining
Technician Salary	$2,163.00	$2,723.87	-$560.87
Technician Benefits	$705.00	$138.56	$566.44
TOTAL DIRECT COSTS:	$2,868.00	$2,862.43	$5.57
TOTAL INDIRECT COSTS @ 10% on TDC:	$287.00	$286.25	$0.75
TOTAL FUNDING:	**$3,155.00**	**$3,148.68**	**$6.32**

Santa Clara River estuary and trapping site



Santa Ynez River estuary and trapping site