■ Interagency Ecological Program for the San Francisco Estuary ■

IEP NEWSLETTER

VOLUME 18, NUMBER 3, FALL 2005

Of Interest to Managers

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This issue's Quarterly Highlights section includes a report from Jason Hanni (USFWS) on the Delta Juvenile Fishes Monitoring Program (DJFMP) catch for 2005 (along with an analysis of qualitative trends of fish assemblage stability across the Delta) and an update on the status of the Delta Smelt Culture Facility from Theresa Rettinghouse (UC Davis).

Jason Hanni's report on the DJFMP total fishery catch and his subsequent examination of fish assemblage stability across six regions from 1995 through 2005 (for the four month period from May through August) is a first-rate example of the collection and analysis IEP data. Jason's analysis shows moderate stability within the fish assemblage for each region or location. He also found that if the most dominant species are removed from the total catch, assemblage stability would greatly decrease. The combination of moderate assemblage stability and slight decreases in diversity over time warrant further investigation to determine if declining trends in near shore communities are valid and if these trends are also expressed as a lower assemblage stability.

Theresa Rettinghouse's report notes that the Fish Conservation and Culture Laboratory formerly established as the Delta Smelt Culture Facility has been substantially upgraded and expanded over the past two years. The facility is now designed to rear each life stage in separate labs, each with their own recirculation systems and the appropriate tank size for each life stage. She also notes that production of delta smelt has continued to increase with each season.

This issue's Contributed Papers section consists of a timely submission by Cassandra Enos, Jess Sutherland and Matt Nobriga (all DWR) who present an analysis of the first season's data for a two year study of fish entrainment in Suisun Marsh. Suisun Marsh has long been known as a significant nursery area for many fish species. Unfortunately, long-term fish sampling has shown overall declines in juveniles and adults of most fishes in Suisun - similar to trends observed in the Delta. They point out that one possible cause of these observed declines may be water diversions within the marsh. Diversions are generally assumed to kill great numbers of fish and there are 366 known water diversions distributed throughout Suisun Marsh - of which only 2% are screened to exclude fish! Their study compared entrainment losses of fishes at the Morrow Island Distribution System (MIDS) intakes over several months under various operational configurations to provide data on the site specific impact of the MIDS diversion on fishery resources. Results appear to indicate that existing MIDS operations actually provide some protective measures against entrainment of spring-spawning fish, particularly open-water fish like delta smelt that do not aggregate near in-stream structures such as diversions.

Ted Sommer (DWR), in his annual accounting of peer-reviewed publications, presents a bibliography of forty-three recent publications dealing with the San Francisco Estuary.

Finally, Kate Le (DWR) provides Water-Year 2005 outflow and export information through September. Compared to the previous year, flows in both the Sacramento and San Joaquin river's were improved to such an extent that outflow index levels were maintained and no standards were triggered. Kate also notes that exports were more stable than the previous year due to the fact that no export standards had to be met.

IEP QUARTERLY HIGHLIGHTS

USFWS Seasonal Fishery Catch and a Follow Up Investigation of Fish Fauna Assemblages in the Sacramento-San Joaquin River Delta and Bays.

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Background

Historically, the Stockton Fish and Wildlife Office, Delta Juvenile Fishes Monitoring Program has used beach seines, Kodiak (KDTR) and Mid-water (MWTR) trawls to investigate qualitative trends of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) and other juvenile fishes in the Sacramento-San Joaquin River Delta and Estuary. This article reports the total fishery catch for the reporting period of 1 May 2005 through 31 August 2005. Additionally, this article follows up on the results of Wichman and Hanni (2005) by examining fish assemblage stability across regions over a four month period, May through August, during 1995 through 2005. Fish data were examined to identify differences in fish assemblage stability using catch per unit effort (CPUE) within beach seine regions and trawl locations over time. Beach seine and trawl location total species count data also were used to determine diversity trends for this time period over the previous 11 years.

Methods

The historical beach seine and trawl locations sampled are the same as in Wichman and Hanni (2005). The Sacramento-San Joaquin Delta and Bays are divided into 6 different regions: region 1 - Lower Sacramento River, region 2 - North Delta, region 3 - Central Delta, region 4 - South Delta, region 5 - San Joaquin River, and region 6 - San Francisco and San Pablo Bays. The trawling locations are located at Chipps Island, Sherwood Harbor, and Mossdale. Mossdale sampling was conducted by the California Dept. of Fish and Game (DFG)from 1 April through 30 June, and we continued trawling July 1-August 31.

Fish sampling, data calculation and analysis follows Wichman and Hanni (2005) with these exceptions: the total number of years was increased from 6 years to 11 years (1995-2005) to investigate longer term assemblage stability, and Simpson's Index of Diversity (Krebs 1999) was calculated for each beach seine region and trawl location. The calculations for the variance of Simpson's Index of Diversity were computed from (Grundmann et al. 2001) as follows.

$$D = \sum p_i^2$$

where D = Simpson's Index

p_i= Proportion of species *i* in the community

The variance (σ^2) of D is defined as:

$$\sigma^2 = \frac{4}{n}\left[\sum (p_i)^3 - (p_i)^2\right]$$

where n = # of individuals

The 95% confidence interval (CI) is defined as:

$$CI = \left[D - 2\sqrt{\sigma^2}, D + 2\sqrt{\sigma^2}\right]$$

Simpson's Indices of Diversity were plotted on a graph with trend lines and p-values calculated from a regression analysis (Figure 1).

Results

Chinook Salmon Summary (1 May - 31 August 2005)

For the reporting period, a total of 430 unmarked (assigned a race size class following Fisher, 1992) Chinook salmon (*Oncorhynchus tshawytscha*) were captured in beach seine samples. The majority of these salmon (92.5%) (Table 1) were fall run size captured in region 1, region 2 and region 3. Region 6 yielded one unmarked fall run size Chinook salmon during the reporting period. Regions 2, 3, 4, and 5 recovered a total of 54 marked salmon.

Our trawls captured 17,024 unmarked juvenile and adult Chinook salmon at the following locations: 15,595 Chinook were captured at Chipps Island; 1,067 at Sherwood Harbor MWTR and 2 in the San Joaquin River at Mossdale (Table 2). The majority of marked fish were recovered from Mossdale (Table 2; n = 1,122) in early May and are likely from fish releases conducted by DFG and for the San Joaquin River Group Authority for the Vernalis Adaptive Management Plan.

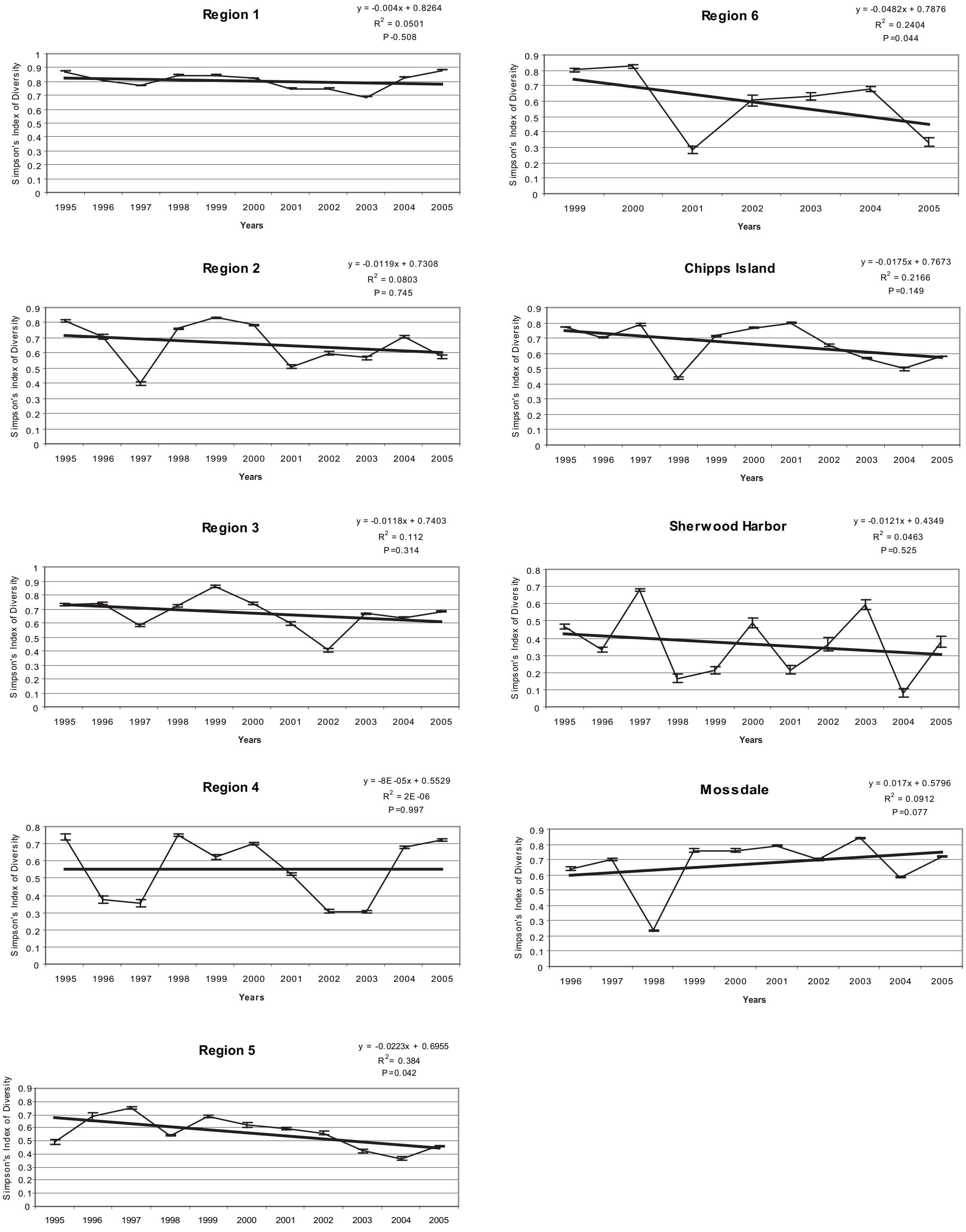

Figure 1 Graphs of Simpson's Index of Diversity over the previous 11 years for each beach seine and trawl location during the reporting period of 1 May through 31 August.

Table 1. Regional catch and CPUE of unmarked and marked Chinook salmon captured from beach seining during 1 May - 30 August 2005.Only unmarked fish were assigned a race size class.

Region # and Name	*Volume (m^3)*	*Fall*	*CPUE*	*Late Fall*	*CPUE*	*Spring*	*CPUE*	*Winter*	*CPUE*	*Marked*	*CPUE*
1. Lower Sacramento River	3,115.1	43	0.01380373	14	0.00449424	0	0	0	0	0	0
2. North Delta	6,901.6	221	0.03202179	12	0.00173874	0	0	0	0	35	0.00507132
3. Central Delta	6,337.8	83	0.01309613	2	0.00031557	0	0	0	0	0	0
4. South Delta	7,968.6	0	0	0	0	0	0	0	0	9	0.00112944
5. San Joaquin River	3,024.5	0	0	0	0	0	0	0	0	10	0.00330639
6. San Francisco and San Pablo Bays	4,938.8	1	0.00020248	0	0	0	0	0	0	0	0
Total		**348**		**28**		**0**		**0**		**54**	

Table 2. Catch and CPUE of unmarked and marked Chinook salmon captured at each trawling location during 1 May - 31 August 2005. Only unmarked fish were assigned a race size class.

Location	*Volume (m^3)*	*Adult*	*CPUE*	*Fall*	*CPUE*	*Late Fall*	*CPUE*	*Spring*	*CPUE*	*Winter*	*CPUE*	*Marked*	*CPUE*
Chipps Island mid-water trawl	27,642,018	10	3.618E-07	15,669	0.0005669	7	2.53E-07	275	9.94862E-06	1	3.61768E-08	858	3.10397E-05
Mossdale Kodiak trawl	12,303,439	0	0	1	2.177E-05	0	0	1	8.12781E-08	0	0	1,122	9.1194E-05
Sherwood Harbor mid-water trawl	8,574,983	0	0	1,053	0.0001228	1	1.1662E-07	13	1.51604E-06	0	0	32	3.73179E-06
Totals		**10**		**16,723**		**8**		**289**		**1**		**2,012**	

Fish Assemblage

Beach Seine Samples

For the reporting period of 1 May through 31 August 2005, 51 fish species were captured for a total of 56,793 fish in 612 total beach seine samples (est. vol. = 32,286 m^3). A total of 5,193 fish and 31 species were captured from region 1 (Table 3). In region 2, a total of 8,298 fish comprising 37 species were captured. In region 3, a total of 15,076 fish and 28 species were captured. In region 4, a total of 8,304 fish from 25 species were captured. In region 5, a total of 18,241 fish and 19 species were captured. Fifteen species comprised of 1,681 individuals were captured in region 6.

The most abundant fish captured overall were non-indigenous: inland silversides (*Menidia beryllina*; n=15,435) and red shiners (*Cyprinella lutrensis*; n=15,088). Alternatively, the highest catch of native fish were Sacramento suckers (*Catostomus occidentalis*) (n=4,289) and Sacramento splittail (*Pogonichthys macrolepidotus*; n=1,252). Between May and August 2005, one to six species comprised a minimum of 75% of the fauna captured within a region (Table 3). Priority species captured were winter run Chinook salmon (n=0) and Delta smelt (*Hypomesus transpacificus*; n=10). The total catch from the ten previous years is not summari zed here but is available from the our office or on BDAT at http://www.iep.ca.gov/data.html.

Fish assemblage stability (W_c), measured as consistency in ranks of species CPUE between May and August from 1995-2005, was calculated for each region.(Wichman and Hanni 2005) Region 1 had the greatest stability within the fish assemblage (W_c= 0.79). Regions 2, 3, 4, and 6 all demonstrated moderate stability, W_c= 0.74, 0.68, 0.72, and 0.69, respectively. Region 5 had the lowest Wc value at W_c=0.59.

Fish diversity between May and August of 1995 through 2005 exhibited a declining trend for all beach seine locations, except region 4 (Figure 1). However, only region 5 and region 6 had a statistically significant decline in near shore fish diversity as detected by beach seines ($p< 0.05$).

Table 3. Species that comprise greater than 75% of the fishes captured within each beach seine region and trawl sample area during 1 May - 30 August 2005.

	Species	(n)	% of total fish captured	Total Fish Captured	Total Species
Beach Seine Region					
1. Lower Sacramento River (n = 7 sites)	**TOTAL**	**2,566**	**75%**	**5,193**	**31**
	Sacramento Sucker	1,282	25%		
	Golden Shiner	672	13%		
	Sacramento Pikeminnow	612	12%		
	Mosquitofish	486	9%		
	Inland Silverside	467	9%		
	Threadfin Shad	390	8%		
2. North Delta (n = 10 sites)	**TOTAL**	**5,898**	**78%**	**8,298**	**37**
	Inland Silverside	5,313	64%		
	Sacramento Splittail	585	7%		
	Sacramento Sucker	581	7%		
3. Central Delta (n = 9 sites)	**TOTAL**	**11,609**	**77%**	**15,076**	**28**
	Splittail	6,009	40%		
	Inland Silverside	5,600	37%		
4. South Delta (n = 8 sites)	**TOTAL**	**5,683**	**89%**	**8,304**	**25**
	Inland Silverside	2,880	35%		
	Theadfin Shad	2,803	34%		
	Red Shiner	1,695	20%		
5. San Joaquin River (n = 10 sites)	**TOTAL**	**13,171**	**81%**	**18,241**	**19**
	Red Shiner	13,171	72%		
	Sacramento Splittail	1,593	9%		
6. San Francisco and San Pablo Bays (n = 9 sites)	**TOTAL**	**1,365**	**81%**	**1,681**	**15**
	Topsmelt	1,365	81%		
Trawl Location					
Chipps Island	**TOTAL**	**26,696**	**90%**	**29,731**	**31**
	Chinook Salmon (fall)	15,669	53%		
	American Shad	11,027	37%		
Mossdale	**TOTAL**	**15,775**	**78%**	**20,388**	**25**
	Splittail	9,257	46%		
	Threadfin Shad	4,944	24%		
	Red Shiner	1,574	8%		
Sherwood Harbor (mid-water)	**TOTAL**	**1,053**	**78%**	**1,356**	**20**
	Chinook Salmon (fall)	1,053	78%		

Trawl Samples

We conducted 2,511 trawls (est. vol.= 48,520,440 m^3) between May and August 2005 and captured 39 different species for a total of 51,475 fish. Chipps Island trawls yielded 31 different species for a total of 29,731 fish (Table 3). At Mossdale, 25 different species were captured for a total of 20,388 fish. Sherwood Harbor trawls captured 20 different species for a total of 1,356 fish. Four species comprised at least 75% of the total fauna captured at all trawling sites (Table 3). The most abundant species captured overall were native fall run size Chinook salmon (n = 16,723) and non-native American shad (n = 11,275), of which 94% and 98 %, respectively, were captured at Chipps Island. Species of concern captured in trawling included Sacramento splittail (n = 9,257), Delta smelt (n = 43), winter run size Chinook salmon (n = 1), and unmarked steelhead (n = 29).

W_c was calculated to assess fish assemblage stability over time for each trawling site. All trawling locations had moderate stability between 1995 and 2005: Chipps Island $W_c = 0.71$; Mossdale $W_c = 0.68$; and Sherwood Harbor MWTR $W_c = 0.63$.

Using Simpson's Index of Diversity, diversity trends were graphed for each trawl location (Figure 1). Chipps Island ($p<0.149$) and Sherwood Harbor MWTR ($p<0.525$) trawl locations appear to have a declining trend in fish species diversity, while Mossdale has a slight increasing trend ($p<0.077$).

Discussion

Total catch was greater (22,111 individuals) between May through August 2005 sampling period than that reported for Jan through April 2005. If the most dominant species are removed from the total catch, assemblage stability would greatly decrease. Assemblage stability and diversity measurements are sensitive to dominant species numbers, further investigation of native versus non-native and abundant versus common species may give better estimations on true stability and diversity.

As discussed in the previous newsletter (Wichman and Hanni, 2005), CPUE rank consistency over time (Kendall's W_c) is a broad ecological approach and one way to preliminarily examine inter-annual fish assemblage stability. The relatively high Kendall's W_c values show that if a species CPUE for 2005 had a high rank (more abundant) then it is very likely that the same species had high relative abundance in each of the previous five years. The same is true for mid and low ranked species (ie., ranks for species within an assemblage are not changing greatly during the study period). From the months of May through August during 1995 and 2005, there is moderate stability within the fish assemblage for each region or location. Assemblage stability was lower from May through August 1995 - 2005 than Jan to April 1999 - 2005; however, this could be misleading since the same number of years weren't compared and may increase or decrease variation in stability. Although most regions and trawl locations show a declining trend in species diversity, variation was too great to make any definitive inferences. Since diversity was not statistically significant and was variable from year to year, examination of a larger data set (15-20 years) may be useful at describing longer term diversity trends.

Acknowledgements

I want to thank the DJFMP field crew for collecting thorough data for the IEP Monitoring Program. I would also like to thank Russ Bellmer, Kim Webb, Holly Blalock-Herod and Paul Cadrett for their helpful guidance and Rick Wilder for his valuable statistical skills.

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Delta Smelt Culture Facility Project Update

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The Fish Conservation and Culture Laboratory (FCCL) formerly established as the Delta Smelt Culture Facility has made substantial changes during the past two years. Production has increased and a significant expansion has been completed. New tanks have been added with funding provided by the Department of Water Resources (DWR). The expansion was done to increase our production capabilities and provide delta smelt (Table1) to the Department of Fish and Game for the Collection, Handling, Transportation and Release studies (CHTR).

The new FCCL has a water treatment plant, which supplies up to 80 gpm. The old system provided a clean water source for only 10 gpm. Our facility is now designed to rear each life stage in separate labs, each with their own recirculation systems and the appropriate tank size for each life stage.

Production of delta smelt has continued to increase with each season. Improvements over the last two year are largely attributed to improved spawning techniques and a new incubator design. We are currently holding over 10,000 adults, primarily for the CHTR studies.

Table 1 Total number of each life stage of delta smelt provided to different agencies and principal investigators(PI) during 2005

Project	*Agency - PI*	*Larvae (<20 mm)*	*Juveniles (20-49 mm)*	*Adults (>50 mm)*	*Total*
Tagging Study (Phototonic biobeads)	USBR – Sutphin	0	0	800	800
TFTF (Facility evaluation and screen design)	USBR	53,167	0	2,547	55,714
Marking Study (Calcein and Alizarin Red)	CDFG – Morinaka	0	71	0	71
CHTR (Acute Mortality, Stress tests, Predation)	CDFG – Morinaka, Afentoulis, Aasen	0	2,168	890	3,058
Toxicity test	UCD – Werner	0	619	0	619
Total		**53,167**	**2,858**	**4,237**	
Total for all projects					**60,262**

CONTRIBUTED PAPERS

First Season Summary of a Fish Entrainment Study at Morrow Island Distribution System in Suisun Marsh

Cassandra Enos (DWR), cenos@water.ca.gov, Jessica Sutherland (DWR), Matt Nobriga (DWR)

Introduction

Suisun Marsh is the largest contiguous brackish marsh on the West Coast of the United States. The marsh represents approximately 12% of California's remaining wetland habitat and is a significant nursery area for many fish species (Meng et al. 1994; Meng and Matern 2001; Matern et al. 2002). However, long-term fish sampling has shown overall declines in juveniles and adults of most fishes in Suisun (Matern et al. 2002; Matern and Moyle 1994; Meng and Matern 2001; Schroeter and Moyle 2004). Some native species have declined to the point that they are considered threatened or endangered, including: Chinook salmon *Oncorhynchus tshawytscha* (winter and spring runs), delta smelt *Hypomesus transpacificus*, and longfin smelt *Spirinchus thaleichthys*. Factors thought to contribute this decline include alteration of the estuarine hydrology, introduction of alien species, pollution, and water diversions. (Meng and Matern 2001; Matern et al. 2002). Diversions are generally assumed to kill great numbers of fish, including migratory fish such as salmon and steelhead (Moyle and Israel 2005). There are 366 known water diversions distributed throughout Suisun Marsh (Herren and Kawasaki 2001). Nearly 80% of these operate via floodgates; only 2% are screened to exclude fish.

Few data are available regarding fish entrainment dynamics in Suisun Marsh. Picard et al. (1982) studied abundance and size of fish at the Roaring River Slough intake. However, this structure, which consists of eight 1.5 m (60-inch) culverts, is much larger than the typical intakes throughout Suisun Marsh, which range in size from 0.9 to 1.2 m. The California Department of Fish and Game sampled eight diversions in Suisun Marsh periodically between April 1996 and May 1998. Although, no analysis of the data was conducted, initial results suggest that most diversions in the Marsh are likely not diverting large numbers of fish and are having a negligible impact on fish populations (Moyle and Israel 2005). Moyle and Israel (2005) questioned whether screening small diversions improves fish populations, even populations of listed species. They noted studies in the Central Valley and Sacramento-San Joaquin Delta have found that the principal species entrained in small diversions ($<1.1\ m^3/s$) are alien or abundant natives. They emphasized the need to consider alternatives to fish screens, such as adjusting the timing and volume of water diversions. Detailed understanding of the factors influencing short-term entrainment may be used to develop diversion strategies that reduce entrainment at unscreened diversions in Suisun Marsh.

In September 2004, we began a two-year fish entrainment study at the Morrow Island Distribution System (MIDS) in Suisun Marsh. We compared entrainment losses of fishes at the MIDS intakes over several months under various operational configurations to provide data on the site specific impact of the MIDS diversion on fishery resources. Our goal was to provide data that could improve future entrainment/particle tracking modeling and guide operational configurations intended to minimize fish entrainment. We also sampled fishes in Goodyear Slough near the diversion to compare the composition of entrained fishes to the composition potentially vulnerable to entrainment.

Methods

We sampled for fishes entrained at the MIDS facility on Goodyear Slough, California. The MIDS is located off of Goodyear Slough in western Suisun Marsh, approximately 5.5 miles northeast of the Solano-Contra Costa County lines at the Benicia-Martinez Bridge (Figure 1). Goodyear Slough is a 20-30 m wide, 2-3 m deep channel fringed with bulrushes *Scirpus* spp., cattails *Typha* spp., and common reed *Phragmites australis* (Culberson et al. 2004). The MIDS intake consists of three 1.2 m (48-inch) intakes located on the eastern bank of Goodyear Slough, approximately 1.6 km (1 mile) south from the mouth of the slough. MIDS is a gravity-flow system; differential water levels caused by tidal action in Goodyear Slough, Grizzly Bay, and within the system itself, in combination with different gate configurations, fill and drain the system. No pumps or any other mechanical devices are used to facilitate water movement through the system.

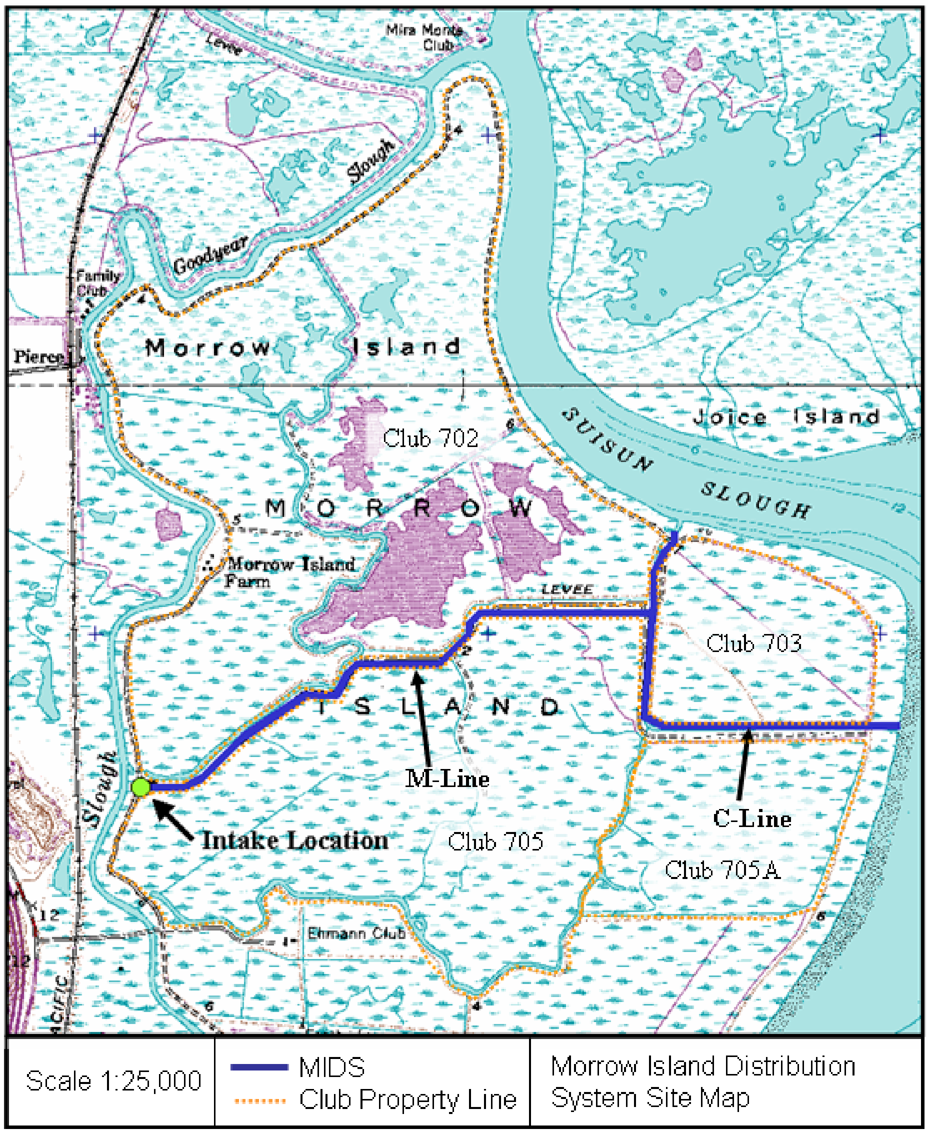

Figure 1. Morrow Island Distribution System site map

MIDS Intake Sampling

Samples were collected periodically from 23 September 2004 through 26 May 2005 following the schedule in Table 1. This sampling period was chosen to: (1) cover the operating season for MIDS and (2) cover the period when species of concern are present in Suisun Marsh. Samples were collected at the north and south intakes (approximately 2 m apart) of MIDS (referred to as "intake samples") and in Goodyear Slough. Fish were collected using two 1.6 mm-mesh hooped plankton nets. Only the two outer intakes were sampled because the inlet structure was not wide enough to accommodate three nets. Samples from the two intakes provided sufficient data to allow for estimation of total entrainment through the intake structure. The nets were attached to the intakes via coupling rings following a design employed by Matica and Nobriga (2005). When the rings were engaged, they sampled 100% of the diverted flow. Net contents were collected every two to three hours. At the end of each sampling interval, the nets were retrieved and samples were placed into separate, labeled containers. When possible, fish equal to or greater than 20 mm total length (TL) or fork length (FL) were identified to species on site. Up to 20 randomly selected individuals of each species from each sample were measured to TL or FL if the caudal fin was forked. When more than 20 individuals of a species were present in a sample, the remaining individuals were tallied, but not measured. Fish that could not be identified on site were preserved in 10% formalin and identified in the laboratory. Fish smaller than 20 mm were collected weekly from 21 April 2005 through 23 May 2005 and sent to the laboratory for identification. All samples not preserved for laboratory analysis were returned to the water.

Table 1. Sampling schedule for the 2004-05 season

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
GYS Sampling	1d/wk ⟷		1d/wk *	* *	⟵ 1d/wk		⟶	2d/wk ⟷	1d/wk ⟷			
Intake Sampling	3d/wk[1] ⟷		3d/wk *	* *	⟵ 3 day/wk event driven				⟶			
UC Davis	⟵ 1d/month											⟶

* Sampling occurred one week in November and two weeks in December.

1. Each sample "day" consisted of approximately six hours of sampling. The nets were attached to the intake when the water level in Goodyear Slough rose to the level where MIDS began to divert water. Sampling continued until the water level in Goodyear slough lowered to the point that inflow stopped. This period of inflow varied with the tide level and the operational status of MIDS.

Goodyear Slough Sampling

Fish were collected using a 30.5-m by 3.05-m purse seine with a stretched mesh size of 4.8 mm. Samples were collected coincidentally with the intake samples. All samples were collected within 100 m north or south of the intake channel (Figure 1). Usually, 8-12 seine hauls were conducted during each sampling period. All fish were identified and measured to TL or FL on site. When more than 20 individuals of a species were present in a sample, the remaining individuals were tallied, but not measured. Purse seine data were transformed to catch per unit effort (CPUE) as number of fish per 1,000 m^3 sampled. We calculated volume sampled using a range of potential purse seine volumes based on various seine deployment configurations. The average volume was taken as the CPUE and the maximum and minimum volumes were used as "error bars". We compared splittail CPUE between Goodyear slough and the MIDS intakes. Splittail was the only open water fish that we caught in sufficient numbers in both the intakes and Goodyear Slough to compare statistically.

We tested for differences in the CPUE, using randomization tests (Haddon 2001). The randomization tests compared observed mean differences in the response variable to distributions of mean differences derived from randomly shuffling the data 10,000 times. The *P*-values represent the proportion of times the randomized means equaled or exceeded the observed difference.

Water Quality Sampling

Water quality data, including water temperature (°C) and electrical conductivity (mS/cm) were taken from the DWR water quality monitoring station S-35, which is approximately 150 yards (140 m) upstream from the sample site. Water transparency (cm) was recorded with most samples.

Water level data were collected on the outside of the intake in Goodyear Slough and on the inside of the intake in Morrow ditch every 15 minutes. The water level data, in conjunction with gate operation data, were used to determine flow through the diversion. DWR staff developed a computer program to estimate flow through the north and south culverts during each sampling period. We used the program to estimate velocities, flow rates, and total sampling period volumes for our study periods.

Results and Discussion

We sampled the north and south intakes for a total of 299 and 296 hours, respectively (Table 2). The total volume of water diverted through the intakes was about 936,000 m^3, with the volume for the individual intakes ranging from 700 m^3 to 23,700 m^3 during each sampling period (Figure 2). Water temperatures ranged from 6.9 °C to 22.1 °C and mean daily electrical conductivity ranged from 1.48 mS/cm to 18.7 mS/cm (Figure 3). We collected 17 species from the diversion samples (Table 3). Threespine stickleback was by far the most abundant species entrained, accounting for 95% of the total. Prickly sculpin accounted for most of the remaining catch. We did not collect any delta smelt, Chinook salmon, or steelhead.

We sampled Goodyear Slough on 26 days, conducting a total of 227 purse seines, for a total sample volume of approximately 42,710 m^3 (Table 2). We collected 16 species in Goodyear Slough (Table 3). As with the intake sampling, threespine stickleback was by far the most abundant species caught, accounting for 74% of the total, and prickly sculpin was the second most abundant species. In contrast to the diversion samples, we collected 4 adult delta smelt using the purse seine during the sampling period.

The high numbers of threespine stickleback in the intakes and in Goodyear Slough are consistent with sampling results by U.C. Davis, who began fish sampling in Suisun Marsh in 1979. In an analysis of twenty-one years of data Matern et al. (2002) found Goodyear Slough had the highest catches of threespine stickleback in Suisun Marsh. Meng and Matern (2001) hypothesized that stickleback rear in the water on waterfowl clubs and are discharged into the sloughs when the clubs are drained.

Table 2. Summary of sampling effort for the 2004-05 sampling season

	North Intake	*South Intake*	*Goodyear Slough*
Number of samples	149	147	227
Volume sampled (m^3)	477,230	459,190	42,710±8542
Mean flow (m^3±SD)	0.034±0.025	0.033±0.023	N/A
Flow range (m^3/s)	0.003 – 0.136	0.003 – 0.136	N/A
Total sampling time (h)	299	296	N/A
Mean sample duration (min ±SD)	121±36	121±36	N/A

N/A=Not Available

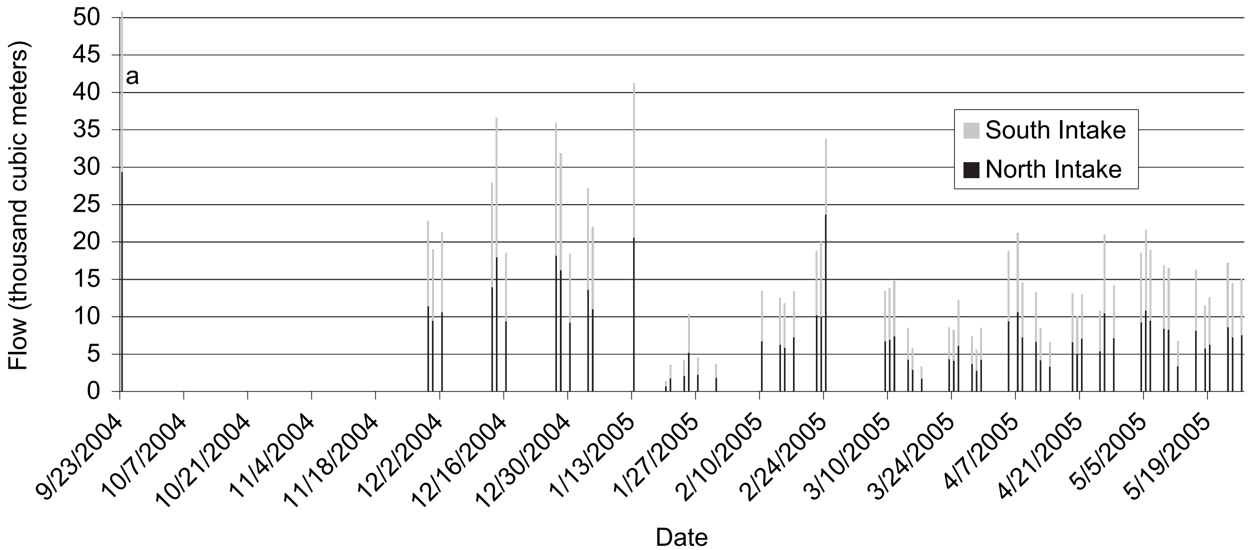

Figure 2. Flow through MIDS intakes during the 2004-05 sampling season. The "a"symbol indicates that on 23 September 2004 both high tides were sampled. This graph shows the combined flow for both sampling periods.

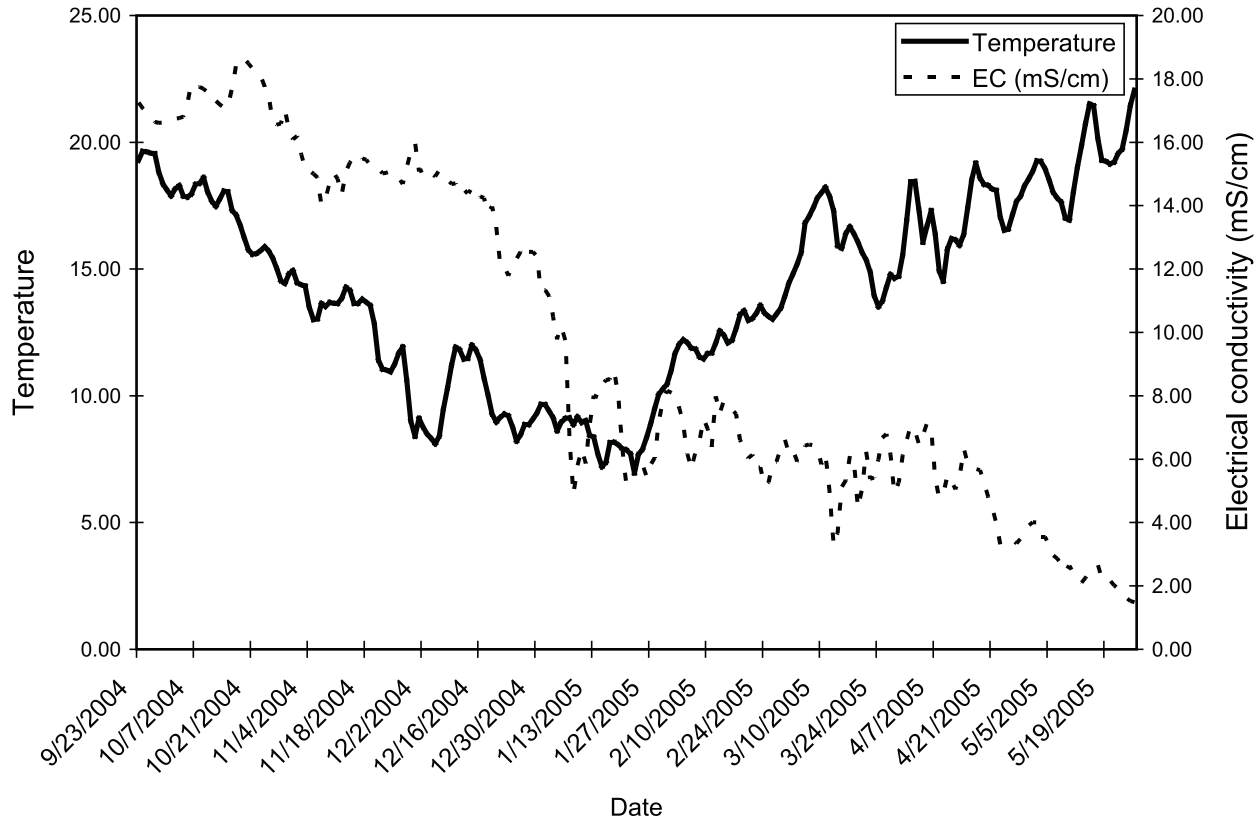

Figure 3. Goodyear Slough electrical conductivity and temperature during 2004-05 sampling season

Table 3. Number of fish collected and their length ranges for the 2004-05 sampling season

Latin name	Common Name	North Intake		South Intake		GYS Seine	
		Count	FL (mm)	Count	FL (mm)	Count	FL (mm)
Nearshore Species							
Cyprinus carpio	Carp	9	38-508	6	30-711	17	267-705
Gasterosteus aculeatus	Threespine stickleback	93,142	10-69	65,969	10-67	2,414	15-64
Hysterocarpus traski	Tule perch	5	25-37	9	31-130	9	33-185
Lepomis macrochirus	Bluegill	1	25	0		0	
Lucania parva	Rainwater killifish	284	18-43	402	18-44	28	23-43
Menidia beryllina	Inland silverside	57	12-92	20	22-87	119	33-101
Benthic Species							
Acanthogobius flavimanus	Yellowfin goby	24	15-152	33	12-137	16	50-155
Catostomus occidentalis	Sacramento sucker	2	51	0		21	356-514
Cottidae	Sculpin-unidentified juvenile	17	14-29	24	10-34	0	
Cottus asper	Prickily sculpin	3,896	15-137	2,645	17-118	345	18-112
Leptocottus armatus	Pacific staghorn sculpin	2	49-80	4	12-104	2	57-65
Tridentiger bifasciatus	Shimofuri goby	14	32-109	12	30-108	1	102
Openwater Species							
Alosa sapidissima	American shad	1	99	1	76	12	44-217
Dorosoma petenense	Threadfin shad	3	60-102	11	57-112	22	54-101
Hypomesus transpacificus	Delta smelt	0		0		4	56-68
Morone saxatilis	Striped bass	1	120	3	99-154	56	112-762
Oncorhyncus mykiss	Steelhead	0		0		0	
Oncorhyncus tschawytscha	Chinook salmon	0		0		0	
Pogonichthys macrolepidotus	Splittail	8	37-254	31	19-154	164	32-438
Spirinchus thaleichthys	Longfin smelt	19	30-81	99	9-115	14	55-102

Seasonal abundance and life stage distribution in Goodyear Slough

Monthly summary of catches in Goodyear Slough track known seasonal patterns of abundance. Sampling was conducted in Goodyear Slough in September 2004, and December 2004 through May 2005. The lowest catches were from December 2004 through February 2005 (Figure 4). This is consistent with patterns observed in Suisun Marsh by Matern et al. (2002). The highest catches were seen later in the sampling season, from mid-March through May 2005. This was mainly due to the increased abundance of young-of-year threespine stickleback (Figure 4) and prickly sculpin. Delta smelt were captured as adults in December and January. Longfin smelt were captured as adults during December. No young-of-year were captured for either longfin or delta smelt. This was most likely due to the mesh size of the purse seine, which is too large to capture longfin or delta smelt smaller than 35 mm FL. Splittail adults were captured in Goodyear Slough fairly consistently throughout the sampling season, but young-of-year were captured only in May.

Seasonal and life stage entrainment in MIDS

Monthly catches in the intakes reflected known seasonal patterns of abundance rather than particular operations (Figure 4). Densities of entrained fish (primarily threespine stickleback and prickly sculpin) increased abruptly during spring despite relatively small gate openings. This follows these fishes known springtime reproductive cycles, during which densities of young fishes increase dramatically in the sloughs (Meng and Matern 2001). The MIDS intake is capable of diverting water through three 1.2 m culverts, but it is rarely operated to full diversion capacity. The large water conveyance capacity is primarily utilized for drainage of MIDS not diversion from Goodyear Slough. The gate settings during flood-up months ranged from 41-61 cm (16-24 inches; always = 50% of capacity). During circulation the gates were open 5-20 cm (2-8 inches) in the winter and 18-20 cm (7-8 inches) in the spring. Comparison of the operational configuration with fish presence in Goodyear Slough shows that MIDS was set to greatest diversion capacity in the late fall and early winter, when the lowest densities of fish were in the slough. Although salmonids emigrate through Suisun Marsh during fall-winter (Matern et al. 2002), we did not collect any during our sampling. In the spring, when young fish numbers increased in the slough, MIDS was either closed, or operating at minimal diversion capacity. Therefore, it appears that the existing MIDS operations actually provide some protective measures against entrainment of spring-spawning fish, particularly open-water fish like delta smelt that do not aggregate near in-stream structures such as diversions.

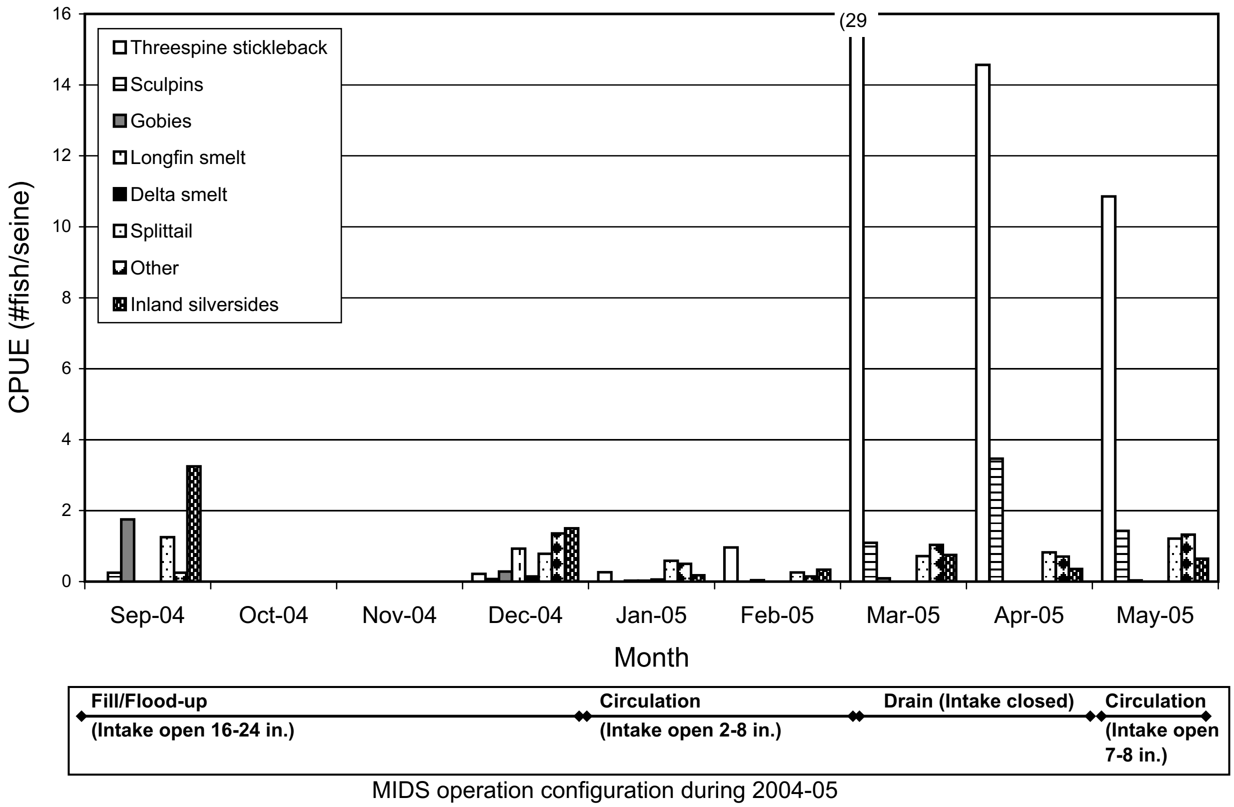

Figure 4. Seasonal presence of species in Goodyear Slough and MIDS operations for the 2004-05 sampling season

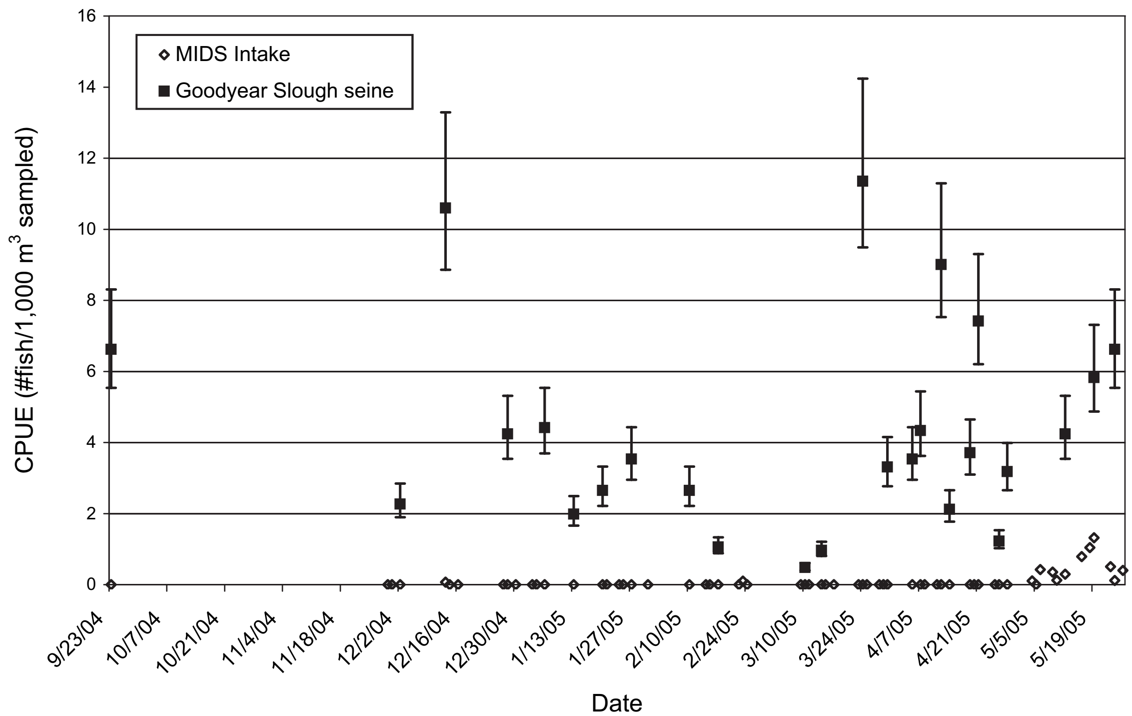

Figure 5. MIDS splittail CPUE for the 2004-05 sampling season

Comparison of CPUE between intake and Goodyear Slough samples

Splittail CPUE in Goodyear Slough was significantly higher ($P<0.0001$) than CPUE in the two intakes (adults and sub-adults combined; Figure 5). Therefore, the relatively low catch of splittail in the intakes was not due to equivalently low abundance in Goodyear Slough. It is likely the lower diversion densities were due to strong swimming ability and lack of physiologic stress response in the vicinity of water diversions (Danley et al. 2002). This hypothesis is supported by the consistent collection of age-1 and older splittail that comprised all of our Goodyear Slough catch, with little or no diversion catch from September 2004 through March 2005. Splittail entrainment only occurred consistently once young-of-year individuals had grown large enough to be retained in the intake nets (May 2005; Figure 5). Even then, Goodyear Slough purse seine densities of splittail were always higher than densities of entrained fish.

Next Phase

Sampling will continue for another season (October 2005 - May 2006). We plan to add a larval fish component to Goodyear Slough sampling to allow sampling of longfin and delta smelt smaller than 35 mm FL. Hopefully, this will result in collection of sufficient numbers of both young-of-year and adult fish to statistically compare differences in CPUE between the intake and Goodyear Slough. We anticipate that results from this study will provide DWR and private landowners with new information that can be used in the development of improved diversion strategies to minimize fisheries impacts.

Acknowledgments

This study was conducted with the support of the Interagency Ecological Program. We thank B. McDonnell, V. Pacheco, and T. Sommer who facilitated IEP support. We thank K. Clark, T. Gaines, S. Culberson, A. Garcia, P. Guidici, R. Smith, P. Quickert, J. Long, and L. Bermudez for their field support; and Z. Matica and R. Beckwith for assistance in equipment design. We gratefully acknowledge B. Tom for his assistance in intake flow modeling and purse seine volume calculation.

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Recent Research Published in the Open Literature

Compiled by Ted Sommer (DWR), tsommer@water.ca.gov

Journals

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Errata

IEP Newsletter, Spring 2005 (Volume 18, Number 2)

Pg. 19. The article should be entitled "Fishes in the San Francisco Estuary, 2004 Status and Trends" not Common Crabs of the San Francisco Estuary

Pg. 21. Figure 5e 2 Annual abundance of threadfin shad, FMWT, September-December should read Figure 2 Annual abundance of threadfin shad, FMWT, September-December.

Pg. 68. Article title should be Development and Evaluation of Bootstrapped Confidence Intervals for IEP Fish Abundance Indices.

DELTA WATER PROJECT OPERATIONS

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During the July through September 2005 period, San Joaquin River flow ranged between 56 and 202 cubic meters per second (1,966 cfs and 7,119 cfs), Sacramento flow ranged between 428 and 600 cubic meters per second (15,100 cfs to 21,200 cfs), and the Net Delta Outflow Index (NDOI) ranged between 97 and 324 cubic meters per second (3,416 cfs and 11,431 cfs) as shown in Figure 1. Compared to last year's flow levels, San Joaquin River, Sacramento River, and NDOI were higher during the July through September 2005 period. Generally, flow patterns after mid-August are contolled by either outflow or water quality standards. However, Sacramento, San Joaquin, and outflow index levels were maintained this year at a flow range that was sufficient enough not to trigger any standards.

Export actions during the July through September 2005 period at CVP and SWP were stable during this time period. CVP pumping was about 125 cubic meters per second, whereas SWP pumping was about 200 cubic meters per second. Last year pumping was more erratic due to meeting water quality or outflow standards during this time period. The minor dips in Figure 2 of SWP pumping occurred because tidal constraints did not allow full water allotment.

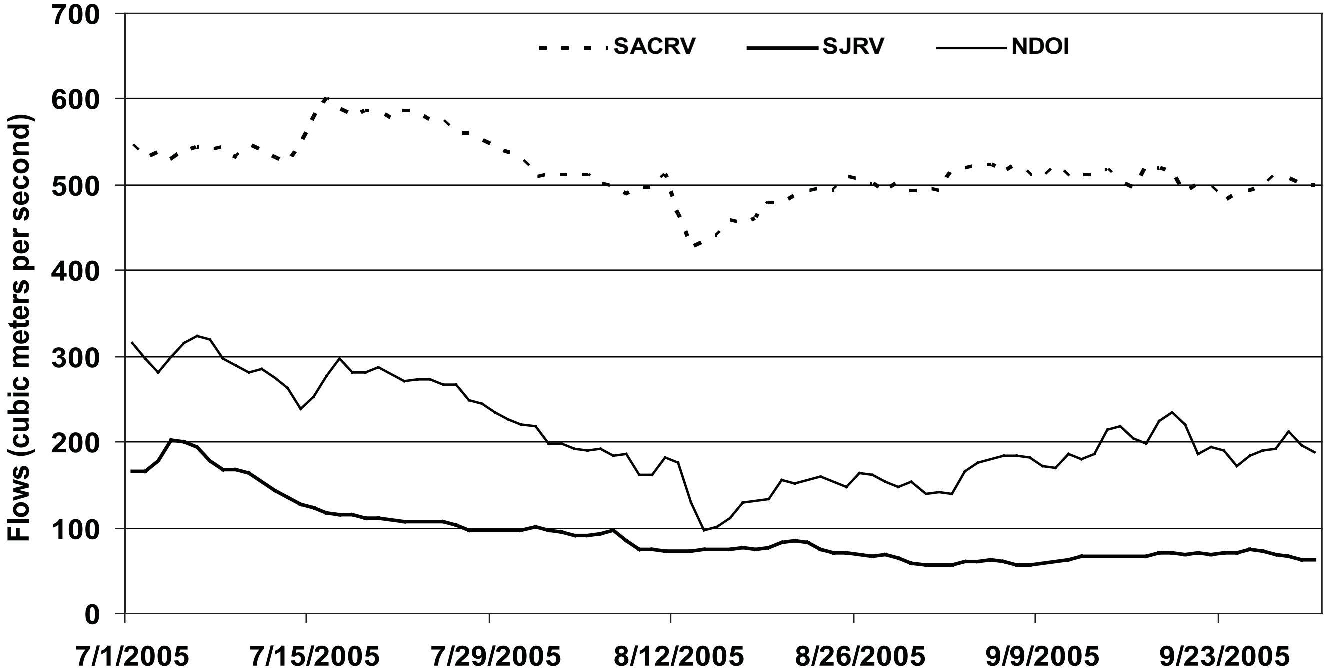

Figure 1. Sacramento River, San Joaquin River, and Net Delta Outflow Index, July through September 2005

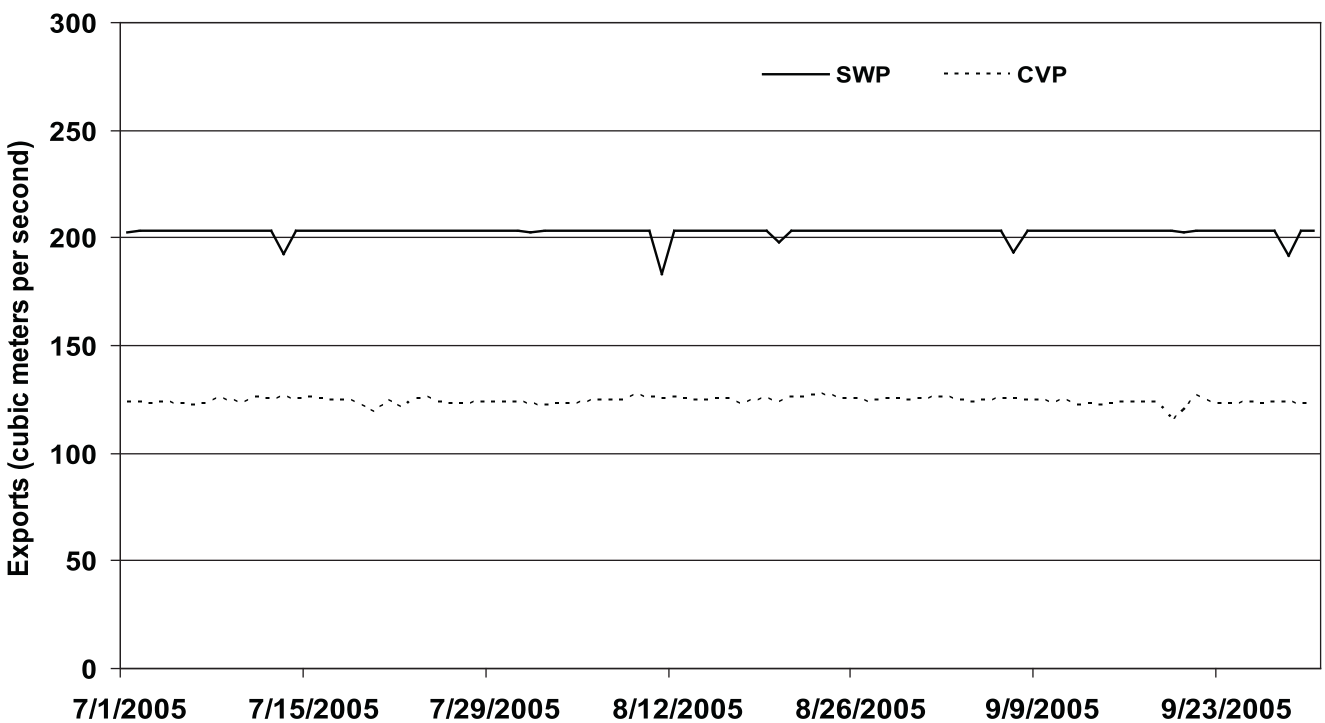

Figure 2. State Water Project and Central Valley Project Exports, July through September 2005

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