4 Head of Old River Barrier

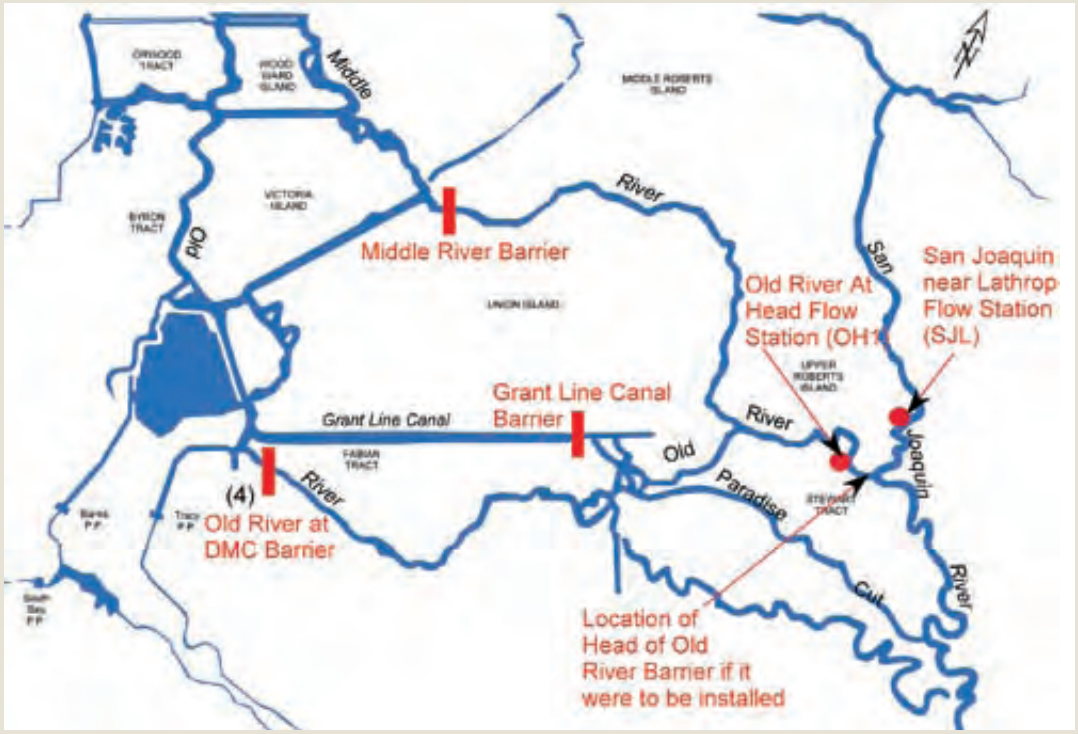
Installation of the spring temporary Head of Old River Barrier (HORB) was not performed in 2005 due to high flows in the San Joaquin River, nonetheless, the spring HORB is a component of the south delta Temporary Barriers Project (TBP). The TBP mitigates for low water levels in the south delta and improves water circulation and quality for agricultural purposes.

BACKGROUND

The spring HORB was first constructed in 1992. Since then, the barrier has been installed in 1994, 1996, 1997 (w/two culverts), and between 2000 and 2004. In 2000-2004 the barrier was installed with six culverts. The HORB was not installed in 1993, 1995, 1998, and 2005 due to high San Joaquin River flows. The HORB was not installed in 1999 due to landowner access problems. The HORB, a key component of VAMP, is intended to increase San Joaquin River Chinook salmon smolt survival by preventing them from entering Old River.

Although the HORB was not installed in 2005, the three agricultural barriers (the Grant Line Canal barrier, the Old River near Tracy barrier, and the Middle River barrier) were installed in mid-April and were removed at end of November 2005. Figure 4-1 shows the locations of the three agricultural barriers and the location of the HORB, if it were to be installed.

Figure 4-1
South Delta Temporary Barriers



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FLOW MEASUREMENTS AT AND AROUND THE HEAD OF OLD RIVER

DWR operates two Acoustic Doppler Current Meters (ADCM) in the vicinity of the head of Old River, one in the San Joaquin River 1,500 feet downstream of Old River (San Joaquin River below Old River near Lathrop, SJL) and one in Old River 840 feet downstream of the head of Old River (Old River at Head, OH1) (Figure 4-1). The ADCMs record velocity measurements at a 15 minute interval from which flow values can be determined. Table 4-1 lists the daily minimum, maximum and mean flows for the April 8, 2005 through June 30, 2005 period for the two ADCMs, along with the percentage of the total San Joaquin River flow at each ADCM. Figures 4-2 and 4-3 show plots of the daily minimum, maximum and mean flows for the two ADCMs. The San Joaquin River below Old River near Lathrop ADCM suffered from a technical glitch with the Handar data logger program resulting in a period of missing data from April 27, 2005 at 12:45 p.m. through April 29, 2005 at 1:45 p.m.

A comparison of the mean daily flow near Vernalis and the mean daily flow at Old River is presented in Table 4-2 and in Figure 4-4.

DWR at the end of each year conducts a Delta Simulation Model 2 (DSM2) modeling run to be included in the yearly published South Delta Temporary Barriers Monitoring Report. Data collected from the two ADCMs will be used to verify the flow split of the San Joaquin River and Old River at the confluence against that estimated using the model.

Seepage Monitoring

A seepage-monitoring program was initiated in April 2000, to evaluate the effects of HORB operations on seepage and groundwater on Upper Roberts Island. Although the HORB was not installed this year, DWR continued monitoring for seepage. In 2005 no seepage was observed at any of the monitoring sites despite the high flows in the San Joaquin River. Currently, DWR is in the process of completing the (2004-2005) seepage report.

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Table 4-1
Flows in Old River at Head and San Joaquin River below Old River

Date	Old River at Head (OH1)			San Joaquin River below Old River (SJL)			Flow Split (% of Total Flow)	
	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Flow (cfs)	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Flow (cfs)	OH1	SJL
4/1/2005								
4/2/2005								
4/3/2005								
4/4/2005								
4/5/2005								
4/6/2005								
4/7/2005								
4/8/2005	5,538	6,339	5,946	4,753	5,830	5,383	52.5%	47.5%
4/9/2005	5,279	5,822	5,558	4,593	5,525	5,151	51.9%	48.1%
4/10/2005	5,012	5,603	5,295	4,446	5,344	4,908	51.9%	48.1%
4/11/2005	4,732	5,315	5,056	4,119	5,020	4,693	51.9%	48.1%
4/12/2005	4,616	5,212	4,968	4,085	4,931	4,611	51.9%	48.1%
4/13/2005	4,794	5,335	5,119	4,219	5,187	4,766	51.8%	48.2%
4/14/2005	4,570	5,308	4,889	4,213	4,891	4,636	51.3%	48.7%
4/15/2005	4,208	4,828	4,563	3,896	4,579	4,290	51.5%	48.5%
4/16/2005	4,201	4,637	4,446	3,772	4,472	4,127	51.9%	48.1%
4/17/2005	4,044	4,557	4,327	3,617	4,428	4,043	51.7%	48.3%
4/18/2005	3,984	4,518	4,229	3,559	4,340	4,013	51.3%	48.7%
4/19/2005	3,878	4,355	4,146	3,519	4,258	3,918	51.4%	48.6%
4/20/2005	3,809	4,415	4,143	3,333	4,154	3,785	52.3%	47.7%
4/21/2005	3,677	4,311	4,020	3,154	4,105	3,685	52.2%	47.8%
4/22/2005	3,477	4,114	3,882	2,986	4,023	3,557	52.2%	47.8%
4/23/2005	3,287	4,128	3,719	2,763	3,848	3,451	51.9%	48.1%
4/24/2005	3,163	4,083	3,644	2,668	3,806	3,384	51.9%	48.1%
4/25/2005	3,079	4,010	3,550	2,523	3,770	3,300	51.8%	48.2%
4/26/2005	2,838	3,723	3,348	2,229	3,595	3,110	51.8%	48.2%
4/27/2005	2,527	3,623	3,193					
4/28/2005	2,570	3,645	3,199					
4/29/2005	2,870	3,703	3,359					
4/30/2005	2,862	3,702	3,378	2,532	3,781	3,284	50.7%	49.3%
5/1/2005	3,135	3,898	3,517	2,826	3,969	3,434	50.6%	49.4%
5/2/2005	3,352	3,970	3,716	3,156	4,087	3,631	50.6%	49.4%
5/3/2005	3,513	4,075	3,821	3,195	4,092	3,727	50.6%	49.4%
5/4/2005	3,466	4,096	3,768	3,155	4,092	3,712	50.4%	49.6%
5/5/2005	3,259	3,946	3,642	3,041	4,003	3,552	50.6%	49.4%
5/6/2005	3,293	4,047	3,713	2,864	4,043	3,589	50.9%	49.1%
5/7/2005	3,352	4,219	3,838	2,967	4,178	3,713	50.8%	49.2%
5/8/2005	3,442	4,322	3,935	3,115	4,260	3,809	50.8%	49.2%
5/9/2005	3,473	4,381	4,029	3,003	4,421	3,823	51.3%	48.7%
5/10/2005	3,663	4,509	4,165	3,372	4,473	4,008	51.0%	49.0%
5/11/2005	3,761	4,524	4,204	3,535	4,498	4,080	50.7%	49.3%
5/12/2005	3,850	4,523	4,207	3,613	4,549	4,096	50.7%	49.3%
5/13/2005	3,945	4,523	4,252	3,642	4,554	4,125	50.8%	49.2%
5/14/2005	4,038	4,502	4,282	3,735	4,489	4,133	50.9%	49.1%
5/15/2005	4,070	4,442	4,258	3,677	4,476	4,097	51.0%	49.0%
5/16/2005	4,022	4,426	4,237	3,643	4,392	4,097	50.8%	49.2%
5/17/2005	3,928	4,387	4,158	3,535	4,348	4,040	50.7%	49.3%
5/18/2005	3,726	4,289	4,066	3,422	4,314	3,960	50.7%	49.3%
5/19/2005	3,806	4,410	4,220	3,380	4,485	4,084	50.8%	49.2%
5/20/2005	4,220	4,837	4,540	3,652	4,738	4,335	51.2%	48.8%
5/21/2005	4,638	5,387	5,079	4,050	5,192	4,751	51.7%	48.3%
5/22/2005	5,175	5,808	5,528	4,460	5,489	5,096	52.0%	48.0%
5/23/2005	5,421	6,058	5,802	4,739	5,696	5,315	52.2%	47.8%
5/24/2005	5,557	6,231	5,966	4,742	5,800	5,433	52.3%	47.7%
5/25/2005	5,705	6,370	6,086	4,852	5,932	5,570	52.2%	47.8%
5/26/2005	5,770	6,580	6,265	5,009	6,090	5,639	52.6%	47.4%
5/27/2005	6,045	6,549	6,358	5,080	6,101	5,719	52.6%	47.4%
5/28/2005	6,124	6,654	6,401	5,356	6,268	5,865	52.2%	47.8%
5/29/2005	6,345	6,788	6,577	5,619	6,381	5,965	52.4%	47.6%
5/30/2005	6,498	7,027	6,786	5,846	6,420	6,141	52.5%	47.5%
5/31/2005	6,788	7,110	6,931	5,806	6,469	6,204	52.8%	47.2%
6/1/2005	6,755	7,126	6,948	5,830	6,504	6,238	52.7%	47.3%
6/2/2005	6,822	7,198	7,023	5,917	6,611	6,270	52.8%	47.2%
6/3/2005	7,005	7,276	7,160	5,906	6,635	6,297	53.2%	46.8%
6/4/2005	7,076	7,417	7,214	5,944	6,773	6,406	53.0%	47.0%
6/5/2005	7,091	7,427	7,261	5,922	6,969	6,476	52.9%	47.1%
6/6/2005	7,062	7,472	7,255	5,996	6,849	6,469	52.9%	47.1%
6/7/2005	6,812	7,400	7,056	6,092	6,738	6,409	52.4%	47.6%
6/8/2005	6,415	6,961	6,691	5,898	6,583	6,207	51.9%	48.1%
6/9/2005	6,200	6,676	6,399	5,561	6,232	5,931	51.9%	48.1%
6/10/2005	5,777	6,324	5,983	5,222	5,876	5,642	51.5%	48.5%
6/11/2005	5,332	5,897	5,597	4,933	5,581	5,314	51.3%	48.7%
6/12/2005	4,844	5,375	5,105	4,762	5,359	5,050	50.3%	49.7%
6/13/2005	4,689	5,143	4,872	4,566	5,147	4,829	50.2%	49.8%
6/14/2005	4,460	4,898	4,663	4,322	4,899	4,609	50.3%	49.7%
6/15/2005	4,293	4,764	4,520	4,035	4,686	4,445	50.4%	49.6%
6/16/2005	3,877	4,497	4,192	3,727	4,470	4,145	50.3%	49.7%
6/17/2005	3,669	4,290	3,890	3,251	4,269	3,831	50.4%	49.6%
6/18/2005	3,389	4,007	3,704	2,925	4,128	3,616	50.6%	49.4%
6/19/2005	3,196	3,897	3,623	2,607	4,048	3,504	50.8%	49.2%
6/20/2005	3,163	4,024	3,577	2,494	4,029	3,419	51.1%	48.9%
6/21/2005	2,794	3,843	3,294	2,085	3,915	3,241	50.4%	49.6%
6/22/2005	2,617	3,473	3,154	2,054	3,850	3,172	49.9%	50.1%
6/23/2005	2,637	3,616	3,262	1,922	3,791	3,111	51.2%	48.8%
6/24/2005	2,794	3,902	3,299	1,665	3,710	3,001	52.4%	47.6%
6/25/2005	2,499	3,773	3,083	1,587	3,505	2,880	51.7%	48.3%
6/26/2005	2,511	3,518	2,936	1,574	3,377	2,768	51.5%	48.5%
6/27/2005	2,392	3,200	2,804	1,815	3,260	2,688	51.1%	48.9%
6/28/2005	2,371	3,300	2,792	1,443	3,179	2,575	52.0%	48.0%
6/29/2005	2,596	3,296	2,820	1,097	3,114	2,512	52.9%	47.1%
6/30/2005	2,319	3,153	2,790	1,237	3,219	2,559	52.2%	47.8%

Missing Data

Figure 4-2
Daily Flow Range - Old River at Head Gage

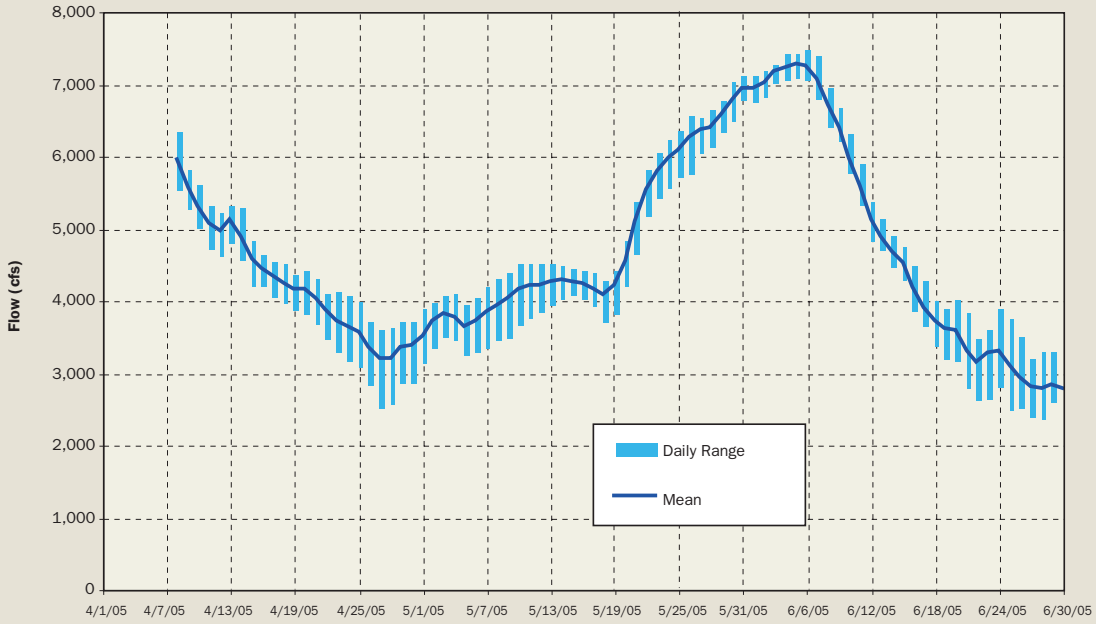


Figure 4-3
Daily Flow Range - San Joaquin River below Old River Gage

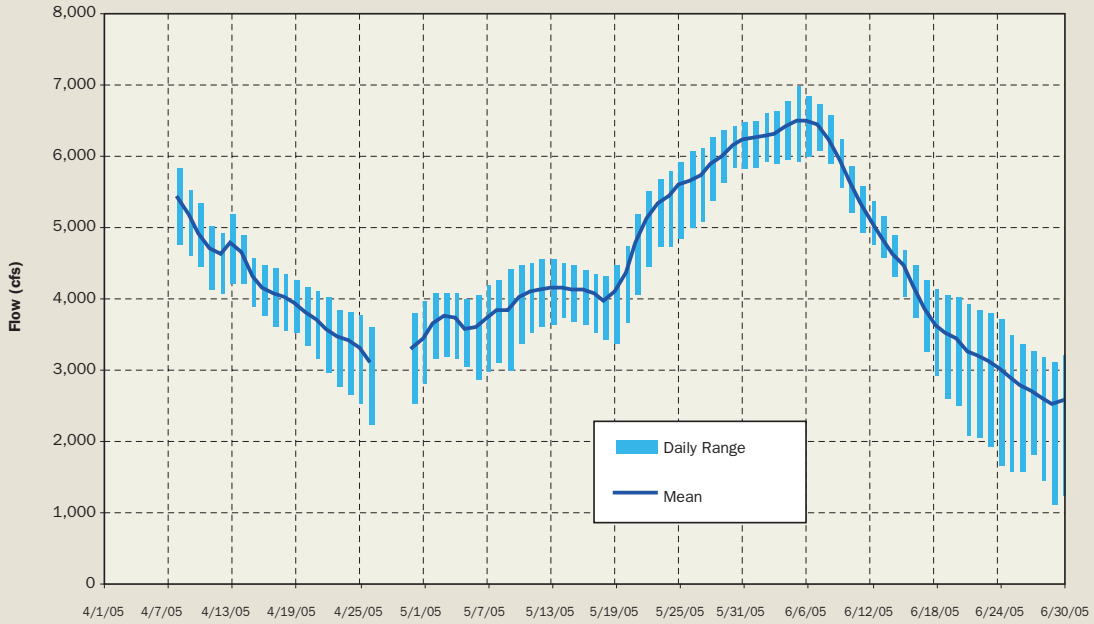


Table 4-2
San Joaquin River and Old River Mean Daily Flows

Date	Mean Daily Flow (cfs)			
	Old River at Head [A]	San Joaquin River below Old River [B]	San Joaquin River at Old River [C]=[A]+[B]	San Joaquin River near Vernalis [D]
4/8/2005	5,946	5,383	11,329	12,000
4/9/2005	5,558	5,151	10,709	11,400
4/10/2005	5,295	4,908	10,203	10,600
4/11/2005	5,056	4,693	9,749	10,200
4/12/2005	4,968	4,611	9,579	10,200
4/13/2005	5,119	4,766	9,886	10,600
4/14/2005	4,889	4,636	9,524	9,690
4/15/2005	4,563	4,290	8,853	9,090
4/16/2005	4,446	4,127	8,573	8,840
4/17/2005	4,327	4,043	8,370	8,740
4/18/2005	4,229	4,013	8,242	8,530
4/19/2005	4,146	3,918	8,064	8,450
4/20/2005	4,143	3,785	7,928	8,360
4/21/2005	4,020	3,685	7,705	8,160
4/22/2005	3,882	3,557	7,439	7,840
4/23/2005	3,719	3,451	7,170	7,620
4/24/2005	3,644	3,384	7,028	7,420
4/25/2005	3,550	3,300	6,850	7,160
4/26/2005	3,348	3,110	6,458	6,730
4/27/2005	3,193			6,500
4/28/2005	3,199			6,800
4/29/2005	3,359			7,090
4/30/2005	3,378	3,284	6,662	7,200
5/1/2005	3,517	3,434	6,951	7,720
5/2/2005	3,716	3,631	7,347	8,180
5/3/2005	3,821	3,727	7,549	8,320
5/4/2005	3,768	3,712	7,480	8,070
5/5/2005	3,642	3,552	7,194	7,890
5/6/2005	3,713	3,589	7,302	8,130
5/7/2005	3,838	3,713	7,551	8,400
5/8/2005	3,935	3,809	7,744	8,610
5/9/2005	4,029	3,823	7,852	8,820
5/10/2005	4,165	4,008	8,173	9,060
5/11/2005	4,204	4,080	8,284	9,110
5/12/2005	4,207	4,096	8,303	9,070
5/13/2005	4,252	4,125	8,377	9,130
5/14/2005	4,282	4,133	8,414	9,220
5/15/2005	4,258	4,097	8,355	9,250
5/16/2005	4,237	4,097	8,334	9,120
5/17/2005	4,158	4,040	8,198	8,970
5/18/2005	4,066	3,960	8,026	8,940
5/19/2005	4,220	4,084	8,305	9,340
5/20/2005	4,540	4,335	8,875	10,200
5/21/2005	5,079	4,751	9,830	11,400
5/22/2005	5,528	5,096	10,624	12,100
5/23/2005	5,802	5,315	11,116	12,600
5/24/2005	5,966	5,433	11,400	13,000
5/25/2005	6,086	5,570	11,656	13,200
5/26/2005	6,265	5,639	11,904	13,500
5/27/2005	6,358	5,719	12,077	13,500
5/28/2005	6,401	5,865	12,267	13,800
5/29/2005	6,577	5,965	12,542	14,200
5/30/2005	6,786	6,141	12,926	14,700
5/31/2005	6,931	6,204	13,136	15,100
6/1/2005	6,948	6,238	13,186	15,000
6/2/2005	7,023	6,270	13,293	15,100
6/3/2005	7,160	6,297	13,458	15,200
6/4/2005	7,214	6,406	13,619	15,300
6/5/2005	7,261	6,476	13,737	15,400
6/6/2005	7,255	6,469	13,724	15,300
6/7/2005	7,056	6,409	13,466	14,700
6/8/2005	6,691	6,207	12,898	13,900
6/9/2005	6,399	5,931	12,330	13,200
6/10/2005	5,983	5,642	11,625	12,200
6/11/2005	5,597	5,314	10,911	11,300
6/12/2005	5,105	5,050	10,155	10,600
6/13/2005	4,872	4,829	9,701	10,100
6/14/2005	4,663	4,609	9,272	9,770
6/15/2005	4,520	4,445	8,964	9,350
6/16/2005	4,192	4,145	8,338	8,640
6/17/2005	3,890	3,831	7,720	8,020
6/18/2005	3,704	3,616	7,320	7,710
6/19/2005	3,623	3,504	7,127	7,540
6/20/2005	3,577	3,419	6,995	7,370
6/21/2005	3,294	3,241	6,535	6,920
6/22/2005	3,154	3,172	6,326	6,720
6/23/2005	3,262	3,111	6,373	6,800
6/24/2005	3,299	3,001	6,300	6,620
6/25/2005	3,083	2,880	5,963	6,270
6/26/2005	2,936	2,768	5,704	6,010
6/27/2005	2,804	2,688	5,492	5,740
6/28/2005	2,792	2,575	5,367	5,560
6/29/2005	2,820	2,512	5,333	5,650
6/30/2005	2,790	2,559	5,349	5,680

Missing data

OLD RIVER AND SAN JOAQUIN RIVER KODIAK TRAWLING

Since the spring HORB was not constructed this year, there was no fish entrainment monitoring at the HORB. As an alternative to the entrainment monitoring, the Department of Fish and Game (DFG) towed a Kodiak trawl in Old River during the VAMP test period. The Old River Kodiak Trawl (ORKT) was conducted in a similar manner to the Mossdale Kodiak Trawl (MKT) which is conducted year-round on the San Joaquin River. Both trawls sampled on a daily basis during the first three weeks of May. Comparison of salmon catch between the two trawls may provide insights into salmon migration from the San Joaquin River into Old River.

METHODS AND RESULTS

The ORKT and MKT used similar sampling gear and protocols. Fish were collected using a Kodiak trawl towed between two boats. Trawling took place in Old River, downstream of the head, and in the San Joaquin River, upstream of the head of Old River (Figure 4-5). The Kodiak trawl is 19.8 m long, made of variable mesh (ranging from 1.27 cm stretch mesh at the cod-end to 5.08 cm mesh at the mouth), and has a mouth opening of 1.83 m by 7.62 m. The effective sampling area of the net was estimated at 12.5 m^2 (USFWS 2003). All trawling occurred during daylight hours, starting around 0800 hrs. Typically, the MKT and ORKT started within a half hour of each other and ended within an hour of each other. The Kodiak trawl was towed against the current for 20 minutes. Although the boats and net faced upstream, the high flows carried the boats and net downstream. Typically, five tows were completed before the ORKT net was retrieved and reset upstream. A total of 15 tows per day, seven days a week, were attempted from May 2 through May 20. Boat troubles and a snagged net resulted in two days with fewer than 15 tows in Old River.

For the ORKT, all fish were counted and measured (fork length) to the nearest millimeter. All salmon were checked for a clipped adipose fin or spray dyed color-mark. Salmon with a clipped adipose fin were sacrificed for CWT reading. For this comparison of the MKT and ORKT salmon catch, CWT salmon refers to all salmon with a clipped adipose fin. The unmarked salmon catch represents both hatchery and naturally spawned salmon. A flow meter was used to estimate the volume of water sampled. All sample statistics are reported as the mean ± standard deviation unless otherwise noted. The average volume of water sampled per tow by the MKT (10,520 ± 2,216 m^3) was greater than the ORKT (7,224 ± 1,074 m^3). Catch-per-unit-effort (CPUE) for both trawling efforts was standardized to the number of salmon per 10,000 m^3. CPUE was calculated by dividing the catch by the volume (m^3) of water sampled and then multiplying the result by 10,000.

Figure 4-4
San Joaquin River Flow near Vernalis and at Old River

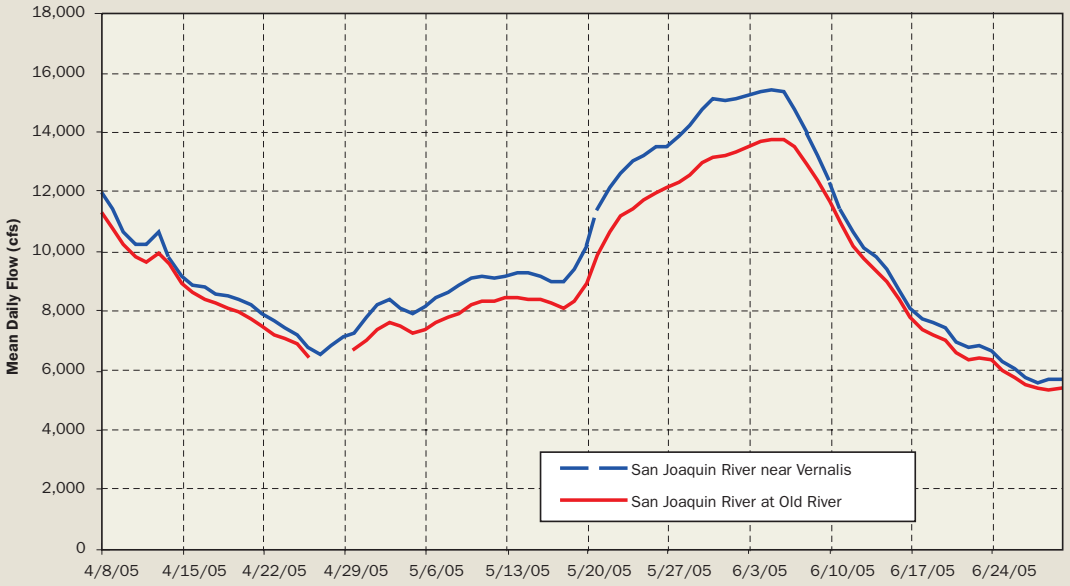
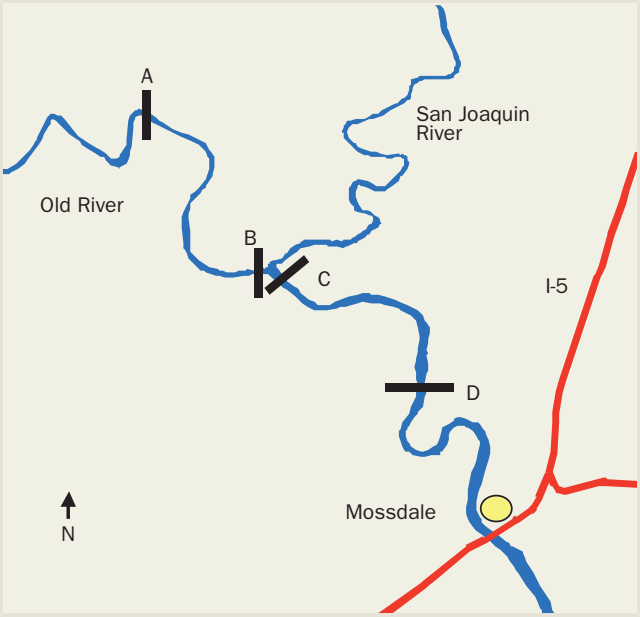


Figure 4-5
Map of the 2005 Kodiak trawl sample locations on Old and San Joaquin Rivers. The Old River Kodiak trawl sampled between letters A and B, and the Mossdale Kodiak trawl sampled between letters C and D.



The ORKT caught approximately 1,000 fish, representing 14 species, in 276 tows during the 19 day sampling period in Old River. The most abundant species was Chinook salmon followed by splittail (*Pogonichthys macrolepidotus*) (Table 4-3). Of the 709 salmon caught, 370 were unmarked, 318 were classified as CWT, and 21 had a color-mark. A two-tailed t-test (degrees of freedom (df) = 686, Probability (P) < 0.01, t statistic = 10.0) indicated fork lengths for unmarked salmon (95 ± 7.9 mm) were significantly larger than CWT salmon fork lengths (89 ± 6.9 mm).

The MKT caught approximately 4,500 fish, representing 17 species, in 285 tows during the same 19 day sampling period in the San Joaquin River. The most abundant species caught was splittail followed by Chinook salmon (Table 4-3).

Table 4-3
The raw abundance and composition of fishes caught in the Kodiak trawl in Old River (ORKT) and in the San Joaquin River (MKT) for trawls conducted May 2-20, 2005. Chinook salmon catch is divided into CWT salmon, unmarked salmon, and color-marked salmon.

Species	ORKT	MKT
Bigscale Logperch	1	
Black Crappie	1	1
Bluegill	6	1
Carp	11	2
Channel Catfish	2	1
Goldfish		7
Golden Shiner		6
Inland Silverside	1	9
Largemouth Bass		3
Redear Sunfish	2	2
Red Shiner		3
Sacramento Blackfish		2
Sacramento Pikeminnow	1	5
Sacramento Sucker	1	
Splittail	218	2,917
Steelhead	4	4
Striped Bass	3	
Threadfin shad	28	61
White Catfish	27	5
Chinook Salmon	**709**	**1,534**
CWT Salmon	318	466
Unmarked Salmon	370	812
Color-Marked Salmon	21	256
Total	**1,015**	**4,563**

Of the 1,534 salmon caught, 812 were unmarked, 466 were classified as CWT, and 256 had a color-mark. The mean length for unmarked salmon was 95 ± 9.8 mm for the 19 day sampling period. The mean unmarked salmon CPUEs in the MKT, from March through June, were highest during the VAMP period (Figure 4-6).

As part of the VAMP salmon survival studies, roughly 100,000 CWT salmon were released at Durham Ferry on two occasions. The effective number of CWT salmon released was estimated at 93,833 on May 2 and 91,563 on May 9. CWT salmon catch was the highest on May 3 in both Old River (Figure 4-7) and San Joaquin River (Figure 4-8). Overall, ORKT recaptured very few of the Durham Ferry released salmon. More salmon were recaptured from the May 2 release (77 salmon) than from the May 9 release (21 salmon).

To determine if CWT salmon were migrating similarly to unmarked salmon into the Old River, their daily ratios were compared between trawls. The daily ratio of CWT salmon to unmarked salmon was similar between the ORKT and MKT, although CWT salmon were proportionally higher in the ORKT during the VAMP salmon releases (Figure 4-9). The daily ratios of CWT to unmarked salmon were converted to percentages (percent of the combined CWT and unmarked catch) and arcsine transformed before testing whether there was a significant difference between the ORKT and MKT. A paired two-tailed t-test (df = 18, P = 0.13, t statistic = -1.60) indicates no significant difference in the daily percent of CWT salmon caught between the ORKT and MKT.

In order to compare salmon abundance between the San Joaquin River and Old River, salmon densities (calculated from the Kodiak trawls) were expanded by river flow and trawling duration. The following equation was used:

E = estimated number of salmon
D = fish density (fish/m^3)
F = river flow (m^3/s) during sampling
T = trawling time (s)
i = i^{th} tow
n = last tow with fish

$$E = \sum_{i=1}^{n} D_i * F_i * T_i$$

To determine how well this equation estimates salmon abundance in the San Joaquin River, abundance estimates for color-marked salmon were calculated and compared to the number of color-marked fish released. Eight groups of color-marked fish were released at Mossdale as part of DFG Region IV's MKT vulnerability study (see chapter 6). It was assumed all color-marked fish released upstream of the MKT, at Mossdale, passed the MKT while they were

Figure 4-6
The average daily densities of unmarked salmon caught in the Mossdale Kodiak trawl on the San Joaquin River.

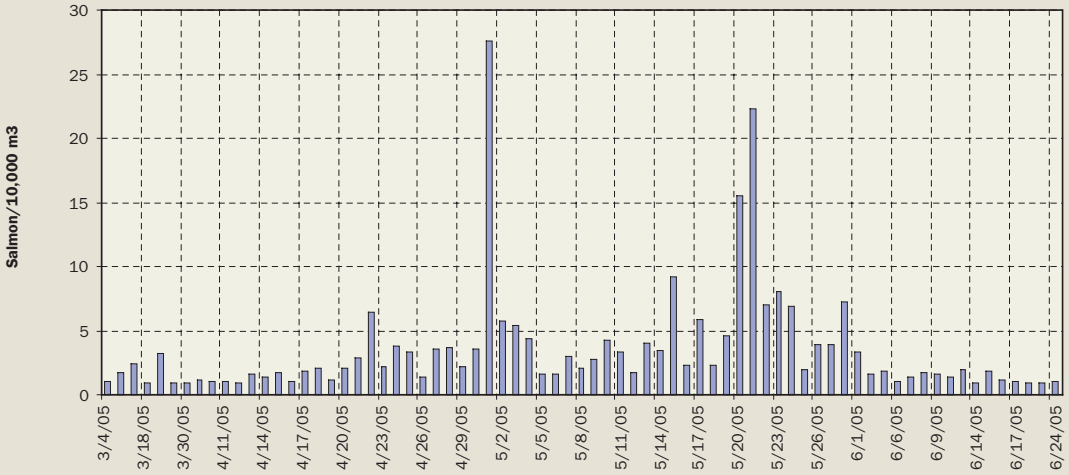


Figure 4-7
The total number of salmon by category (color-marked, coded wire tagged, and unmarked) caught in daily five hour Kodiak trawling sessions (150,000 m^3) in the San Joaquin River.

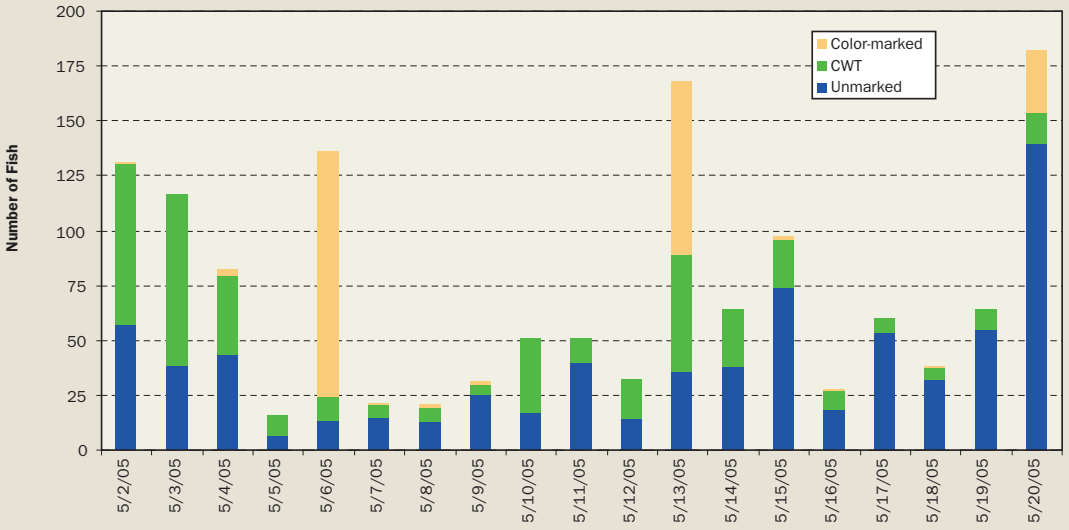


Figure 4-8
The total number of salmon by category (color-marked, coded wire tagged, and unmarked) caught in daily five hour Kodiak trawling sessions (150,000 m^3) in Old River.

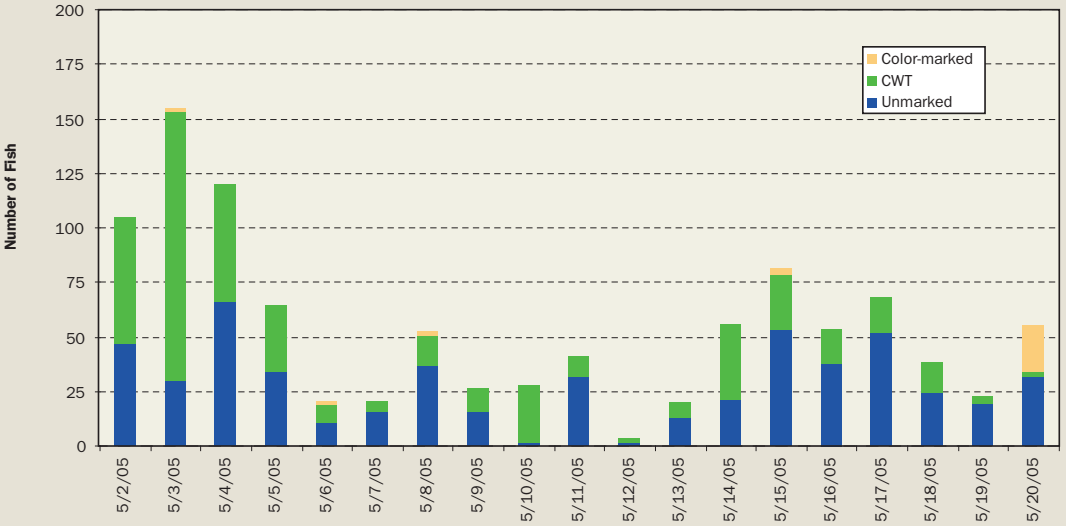
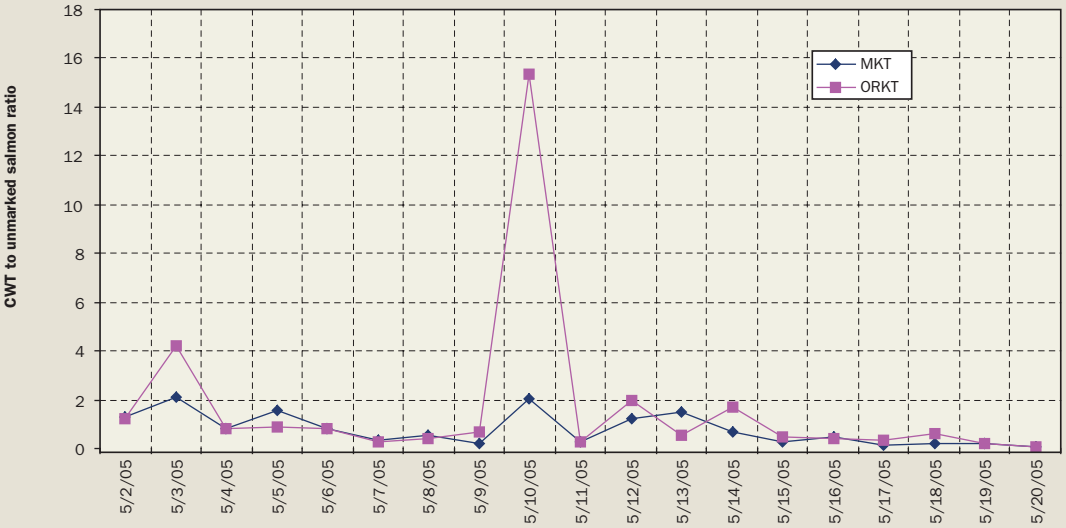


Figure 4-9
The ratio of CWT salmon to unmarked salmon caught in the Old River Kodiak trawl (ORKT) on Old River and the Mossdale Kodiak trawl (MKT) on the San Joaquin River.



trawling. Three of the color-mark groups were released when both MKT and ORKT were sampling. The estimated number of color-marked fish passing the MKT ranged from 6 % to 138 % of the color-marked salmon released upstream of the trawl, and averaged 50 % ± 38 % (Table 4-4). ORKT only caught color-marked salmon from the May 20 release (Table 4-5).

Flow data for the head of Old River (OH1) and San Joaquin River below Old River near Lathrop (SJL) was obtained from the California Data Exchange Center (http://cdec.water.ca.gov). Estimated flow on the San Joaquin River above Old River was calculated by summing flows from OH1 and SJL. The flow was split approximately equally between Old River and the San Joaquin River from May 2 through May 20 (Figure 4-10). The percent of water flowing down Old River ranged from 47 % (3,259 cfs) to 58 % (4,387 cfs), and averaged 51 % (4,060 cfs) ± 2 % (292 cfs).

As a general comparison of flows and fish between Old and San Joaquin Rivers, a daily five hour salmon abundance estimate was calculated for both CWT and unmarked salmon. The salmon abundance estimate was calculated using the previously mentioned equation; however, all daily 20 minute tows (n = 15) were used in the calculation. On a daily average, 55 ± 61 % of the unmarked salmon and 64 ± 43 % of the CWT salmon estimated in the San Joaquin River migrated down Old River (Table 4-6).

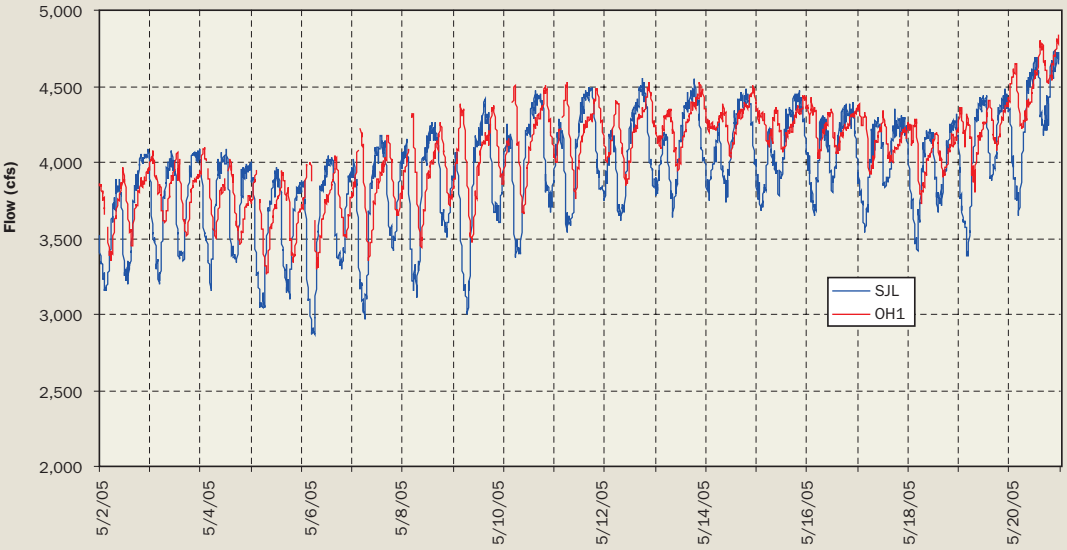
Table 4-4
The estimated number of color-marked salmon passing the Mossdale Kodiak trawl compared to the actual number of color-marked salmon released upstream of the trawl. Estimates based on salmon densities as calculated by the Mossdale Kodiak trawl multiplied by river flow (while trawling) and trawling duration. Percent is how close the estimated number is to the color-marked release number.

Date	Flow (cfs)	Density (salmon/m3)	Estimate	Released	Percent
4/6/05	12,800	0.000100	130	2,036	6%
4/15/05	8,518	0.000767	1,997	5,068	39%
4/22/05	7,077	0.001300	938	2,000	47%
4/29/05	6,337	0.000778	1,507	5,000	30%
5/6/05	7,301	0.003700	2,754	2,003	138%
5/13/05	7,882	0.001580	2,116	5,000	42%
5/20/05	8,910	0.000933	848	2,001	42%
5/27/05	11,576	0.000540	1,062	2,000	53%

Table 4-5
Total raw catch (first nine tows only) in the Mossdale and Old River Kodiak trawls, by tow and time, for three color-marked salmon releases on the San Joaquin River at Mossdale Landing. The asterisk in the Old River column indicates when the net was reset upstream.

	RedUC/Do (5/6/2005)		RedUC (5/13/2005)		RedLC (5/20/2005)	
Tow	Mossdale Catch Time	Old River Catch Time	Mossdale Catch Time	Old River Catch Time	Mossdale Catch Time	Old River Catch Time
1	0 (8:12)	0 (8:04)	0 (8:29)	0 (8:23)	0 (8:08)	0 (7:35)
2	72 (8:35)	0 (8:29)	6 (8:53)	0 (8:47)	0 (8:32)	0 (8:01)
3	59 (8:59)	0 (8:54)	19 (9:17)	0 (9:12)	25 (8:55)	0 (8:26)
4	3 (9:23)	0 (9:18)	53 (9:40)	0 (9:37)	2 (9:17)	0 (8:51)
5	0 (9:46)	0 (9:42)	1 (10:05)	0 (10:02)	2 (9:41)	0 (9:32)*
6	0 (10:10)	0 (10:06)	2 (10:41)	0 (10:55)*	0 (10:04)	12 (9:50)
7	0 (10:33)	0 (10:53)*	0 (11:04)	0 (11:20)	0 (10:28)	0 (10:15)
8	0 (10:57)	0 (11:17)	0 (11:28)	0 (11:45)	0 (10:51)	5 (10:46)
9	0 (11:20)	0 (11:42)	0 (11:51)	0 (12:10)	0 (11:26)	0 (11:26)*
Total catch	134	0	81	0	29	17

Figure 4-10
Flow at the head of Old River (OH1) and near Lathrop on the San Joaquin River (SJL) during the 2005 Kodiak trawl survey.



DISCUSSION

For the most part, trawling went well in Old River. Boat engine problems resulted in eight missed tows on the first day and a snagged net resulted in one missed tow on another day. MKT was able to complete all their tows during this time period.

Direct comparisons between ORKT and MKT are difficult for a variety of reasons. Biases that can affect catch include the habitat (channel width, depth and flow are not the same between and within the sample sites), the sporadic and uneven distribution of migrating salmon, boat and crew differences affecting how the Kodiak net is towed, and MKT and ORKT flow meters might have different calibrations which would effect water volume calculations. Using the ratio of CWT to unmarked salmon in each trawl minimizes some of these biases and other sampling differences, and allows the two rivers to be compared with some certainty. Although direct CPUE comparisons and abundance estimates are presented here, they are to provide general insights to salmon movement and must be viewed with caution.

To determine if marked salmon had a similar migration rate into Old River as unmarked salmon, the daily percent of CWT salmon was compared between the two rivers. Proportionally, CWT and unmarked salmon were migrating down Old River at the same rate. It appears the marking and subsequent release does not affect salmon outmigration relative to the unmarked fish. Although during the Durham Ferry releases, a higher proportion of CWT went down Old River compared to unmarked salmon. There might be some differences for the Durham Ferry released salmon. Once the CWT salmon results from the MKT are available, the Durham Ferry salmon catch can be compared to the other CWT salmon catches to specifically find if there is a migration difference into Old River for in-delta salmon releases.

It is not possible to determine the total number of Durham Ferry released CWT salmon that migrated down Old River. The ORKT caught very few salmon (combined, less than 0.05 %) from the two Durham Ferry releases. The 2002-2004 results from the 24 hour entrainment studies at the HORB indicate salmon released around noon at Durham Ferry start reaching the head of Old River in about 12 hours. Consequently, entrainment of Durham Ferry salmon is highest (63 ± 20 %) during the first night following a fish release. Only 16 ± 15 % of the total Durham Ferry salmon entrainment occurs during the following day. Extrapolating the ORKT day results to include the nighttime period would greatly underestimate the number of Durham Ferry fish migrating down Old River.

ORKT and the MKT salmon abundance estimates were calculated using the same method. Salmon abundance was estimated by multiplying salmon density by river flow and trawling duration. Although the abundance estimates based on the MKT vulnerability study might be more accurate, this method was not used since no vulnerability study was conducted in Old River. However, the color-marked salmon vulnerability study releases were used to provide information on the accuracy of the MKT salmon abundance estimates. The range in the accuracy of the eight estimates (Table 4-4) might be caused by several factors, such as the uneven distribution of salmon as they migrate downstream, the variability in trawling, and the ability to detect the color-mark on recaptured fish. On average, it appeared the MKT underestimated the color-marked fish by half. Thus, a correction factor could be used with these calculations to get a better estimate of outmigrating salmon.

The ORKT would probably have a smaller correction factor compared to the MKT. Since the channel is narrower in Old River than it is in the San Joaquin River, ORKT sampled a larger percentage of the channel width. The resulting calculated fish densities in Old River might be closer to the actual densities than the densities calculated in the San Joaquin River. Consequently, salmon catch in the MKT would be adjusted upward to a greater degree than in the ORKT. Adjusting both the MKT and ORKT for catch efficiencies would probably decrease the daily calculated percentages of salmon heading down Old River that are presented in Table 4-6.

Color-marked salmon released for the MKT vulnerability study were not recaptured by the ORKT on two of the three releases that occurred while ORKT was sampling. The most likely reason for the zero catch is that the net was being moved back upstream while the marked fish were migrating down Old River. Based on the timing of the MKT catch and the time ORKT caught color-marked fish in Old River, the boats trawling in Old River reached the end of the sampling area and picked up the net before the color-marked fish arrived. The net was then reset upstream (around 1100 hrs) after the color-marked fish entered Old River. This means that an approximately 1.5 mile stretch of river is not sampled as the net is moved back upstream. Any fish in this section of the stream will pass by undetected. On May 20, when color-marked fish were caught, the net was reset upstream earlier (0930 hrs). The ORKT was sampling near the head when marked fish entered Old River.

An attempt was made to estimate the number of salmon migrating down Old and San Joaquin River during the trawling periods. For these comparisons, it was assumed catch efficiency was the same between the ORKT and MKT.

Table 4-6
Estimated total number of unmarked and CWT salmon in a section of the San Joaquin upstream of Old River and at the head of Old River, for a 5 hour period per day, and the percent migrating down Old River. Estimates based on salmon densities from the Kodiak trawls multiplied by river flow and trawling duration.

	San Joaquin River		Old River		Percent down Old River		
Date	Unmarked	CWT	Unmarked	CWT	Flow	Unmarked	CWT
5/2/05	1,411	1,811	600	739	52%	43%	41%
5/3/05	994	2,061	390	1,633	51%	39%	79%
5/4/05	1,133	947	862	709	50%	76%	75%
5/5/05	158	244	423	382	49%	267%	157%
5/6/05	340	280	131	111	49%	39%	40%
5/7/05	400	136	201	61	48%	50%	45%
5/8/05	334	186	471	176	48%	141%	95%
5/9/05	670	138	208	137	49%	31%	99%
5/10/05	460	950	23	350	49%	5%	37%
5/11/05	1,095	321	432	132	49%	39%	41%
5/12/05	389	487	17	33	50%	4%	7%
5/13/05	993	1,476	181	100	50%	18%	7%
5/14/05	1,050	738	299	504	51%	29%	68%
5/15/05	2,059	621	765	361	51%	37%	58%
5/16/05	518	233	534	232	51%	103%	100%
5/17/05	1,491	193	738	234	51%	50%	121%
5/18/05	874	169	331	199	50%	38%	118%
5/19/05	1,581	279	275	56	50%	17%	20%
5/20/05	4,292	434	491	29	50%	11%	7%
Mean					50%	55%	64%
Standard Deviation					1%	61%	43%

As previously mentioned, the catch efficiency is probably different between the two trawls. Although we can correct for the MKT estimates based on the color-marked salmon releases, we have no correction for ORKT; thus, neither catch was adjusted. These abundance estimates are probably underestimating, to a different degree, the actual number of salmon in each river. When catch is adjusted for flow, it appears on a daily basis that a little more than half of the salmon in the San Joaquin River turn down Old River. During this time period, half of the San Joaquin River flow was also heading down Old River. In general terms, it appears salmon are going with the flow.

When comparing the ORKT and MKT salmon abundance estimates, the daily percentage of CWT and unmarked salmon heading down Old River is similar on most days. These results are similar to the previously mentioned CWT to unmarked salmon percent analysis. However, there is some variability among sampling days. If salmon always migrated in proportion to the flow split, we would expect low variability among the daily percentages of salmon migrating down Old River. However, the variability around the mean for both unmarked and CWT is large, e.g. ranges from 4 % to 267 % for unmarked salmon. The reason for this variability could be due to the natural variability in salmon migration which might then be compounded by trawling biases.

The 2005 flow-catch results differ from the 1995 Real-Time Monitoring (RTM) Program's Kodiak trawling results on the San Joaquin River at Dos Reis and head of Old River. RTM trawling indicated salmon densities were higher, except on one sampling day, in Old River than in the San Joaquin River (IEP 1996). In order to more accurately compare the 1995 RTM results to the 2005 Kodiak trawl results, the raw data from the 1995 Dos Reis and Old River trawls were obtained from the USFWS. The 1995 data was then analyzed using the same methods that were used on the

2005 data. For the 1995 trawling, it was assumed the catch efficiencies were the same between rivers. River flows at OH1 and SJL during the 1995 Kodiak trawling period (8 days) were estimated by using Vernalis flows and equating it to OH1 and SJL flows through regression analyses. On average, flows at OH1 were calculated at 9,971 ± 462 (95 % confidence interval) cfs and at SJL 8,812 ± 658 (95 % confidence interval) cfs. An estimated 53 % of the San Joaquin River flow went down Old River. When salmon density is expanded by flow, it appears on a daily average, 66 ± 17 % of the unmarked salmon and 70 ± 18 % of the CWT salmon migrated down Old River. These percentages are higher than the 2005 percentages for Old River. This could be due to the higher flows in 1995, compared to 2005, which might change downstream migration routes.

The RTM results also might be affected by the order in which Dos Reis and Old River were sampled. A single crew conducted five tows at Dos Reis and Old River. The Old River site was always sampled first, in the morning, and Dos Reis was sampled afterwards, late morning to midday. The higher 1995 salmon densities in Old River could be due to higher salmon activity and vulnerability in the morning than during midday. The 2005 Kodiak trawl results indicate more salmon are caught in the morning than midday. Salmon (unmarked and CWT combined) were 171 % more numerous in the first five tows than in the next five tows (tows 6 – 10) in the ORKT. In the MKT, salmon were 117 % more numerous in the first five tows than in the next five tows. If a single crew is to sample both rivers, the river sampled first should alternate to overcome any morning sampling bias.

In conclusion, direct comparisons of expanded salmon abundance estimates between the ORKT and MKT were difficult due to the unknown catch efficiency of the ORKT. Although the catch efficiencies between the ORKT and MKT are probably different, they were assumed to be similar for some of the analyses. Thus, some of these results must be viewed with caution. Proportionally, there is no statistical difference on a daily basis between CWT and unmarked salmon heading down Old River. CWT and unmarked salmon are moving into Old River at a similar rate. The flow split between the San Joaquin River and Old River was 50-50. It appears juvenile salmon migrate down Old River in proportion to the flow: about half of the flow and roughly half of the salmon went down Old River. However, there was a lot of variability among the daily percentages of salmon heading down Old River. This variability might be due to natural variability in salmon migration patterns which are magnified by sampling biases and the subsequent abundance calculations. Salmon migration down Old River might also change at different river flows and pumping rates at the state and federal water projects. More data is needed to elucidate the relationship between flow and catch in Old and San Joaquin rivers.

If Kodiak trawling is conducted in future years, due to no HORB installation, VAMP should release some of their fish at Mossdale. Salmon released at Mossdale, in the morning, would pass the Kodiak trawls in larger numbers than

salmon released at Durham Ferry. This would substantially increase the CWT salmon catch in the ORKT and MKT, and might make comparisons between the two rivers a little easier. The ability to adjust catch in the ORKT based on salmon vulnerability (catch efficiency) would improve the estimate and comparison of salmon abundance to the San Joaquin River. In order for any vulnerability studies to be conducted for the ORKT, the sample site would have to be moved at least two miles downstream, and likely three to four miles, to find a suitable trawling reach. A sample site further downstream would allow time for color-marked salmon released near the head to adjust to Old River flows.