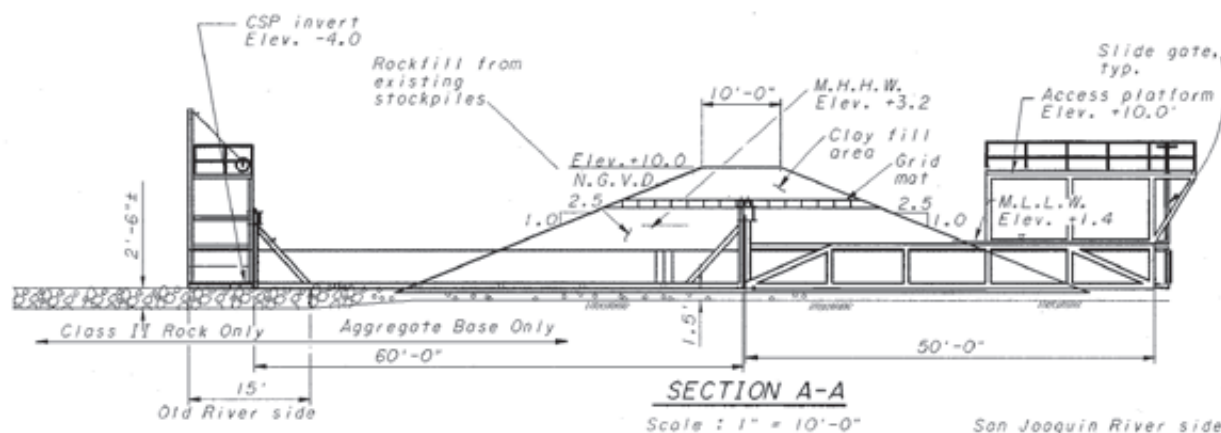



HEAD OF OLD RIVER BARRIER

Barrier Design, Installation and Operation

Installation of the 2007 temporary spring Head of Old River Barrier (HORB) was completed on April 20, two days earlier than scheduled, with the initial operation commencing on April 22. Construction clean-up continued for a short period of days following the initial operation. 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

Figure 4-1
Spring Head of Old River Barrier Cross Section



The spring HORB was first constructed in 1992. Since then, the barrier has been installed in 1994, 1996, 1997, 2000, 2001, 2002, 2003, 2004 and 2007. The 1997 barrier included two open culverts, while the 2000 through 2007 barriers included six operable culverts. The HORB was not installed in 1993, 1995, 1998, 2005, and 2006 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. 

Beginning in 2001, the barrier design included two versions. A “low-flow” barrier when San Joaquin River target flows are below 7,000 cfs would be built to a height of 10 feet mean sea level (MSL). A “high-flow” barrier for the target flow of 7,000 cfs would be built to a height of 11 feet MSL and additional material would be placed to raise the abutments to 13 feet MSL. Both

barrier versions are equipped with six 48-inch diameter operable culverts and an overflow weir back-filled with clay. In 2007, the low-flow version was installed.

The dimensions of the 2007 HORB (Figure 4-1) were similar to the 2000, 2001, 2002, 2003, and 2004 HORB. The base width of the HORB in 2007 was 100 feet and the crest elevation was 10 feet MSL. The top of HORB was constructed with a 75-foot wide notch, protected with concrete grid mats and back-filled with clay. The HORB was designed to safely operate with flows corresponding to stages up to 8.5 feet MSL.

To help mitigate anticipated low water levels in the south delta (downstream of the HORB) caused by the operation of the HORB, two open culverts were installed in the barrier beginning in 1997, and six operable culverts were installed beginning in 2000. Operation of the culverts is controlled by slide gates located on the

upstream side of HORB. DWR relied on daily modeling and field data collection to monitor water levels at three locations within the south Delta to determine when and how long to operate the culverts. Generally, the model forecasts would tend to forecast low-low water levels lower than actual levels observed in the field. Consequently, DWR takes this into consideration when making decisions regarding the culvert operations.

The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish passage. DFG staff conducted a fishery-monitoring program as part of the 2007 HORB operations.

Permitting and Construction

The various permit conditions that are placed on the Temporary Barriers Program, by the USFWS, National Marine Fisheries Service (NMFS), and DFG, require that in-water construction activities for the Head of Old River (HOR), Middle River (MR), and Old River at Tracy (ORT) barriers can begin no earlier than April 7. In addition, construction of the northern abutment and boat ramps of the Grant Line Canal (GLC) barrier and construction of out-of-water portions of the HOR, MR, and ORT barriers may not be started any earlier than April 1. Full closure of the GLC barrier is not required but construction of the north abutment and boat ramps must be completed to the extent that full barrier closure and operation can be readily achieved in a reasonable time frame, if and when directed by DWR. The permit conditions also require that all the above work be completed by April 15th, a total of 15 working days. Following is a brief summary of the various permit conditions:

USFWS Biological Opinion (1-1-01-F-81 dated March 30, 2001)

- 1) The spring HORB barrier installation may begin on April 1 but in-water work shall not occur until April 7, except for construction necessary to place the scour pad and the pad for the culverts (item No. 8, page 6);
- 2) DWR may begin construction of the Middle River barrier on April 1 but in-water work shall not occur until after April 7 (item No. 1, page 4);
- 3) DWR may begin construction of the Old River at Tracy barrier on April 1 but in-water work shall not commence before April 7 (item No. 2, page 4);
- 4) DWR may begin construction of the northern abutment and the boat ramp of the GLC barrier on April 1 provided that the HOR barrier is being constructed concurrently (item No. 3, page 5).

NMFS Biological Opinion (SWR-00-SA-289: MEA on the proposed ACOE permit (200000696) filed on December 4, 2000)

- 1) The spring HORB installation shall begin on April 1 (item 8, page 8);
- 2) The MR barrier construction may begin on April 7 (item 1, page 6);
- 3) The ORT barrier construction may begin on April 1 (item 2, page 6);
- 4) The northern abutment and boat ramp of the GLC barrier may begin construction on April 1 provided that the HORB is being constructed concurrently (item 3, page 7).

DFG 1601 – HORB (2081-2001-009-BD dated April 4, 2001)

HORB Spring Installation – All work in or near the stream zone will be confined to the period beginning no earlier than April 1

DFG 1601 – Agricultural Barriers

MR - All work in or near the stream zone will be confined to the period beginning no earlier than March 1

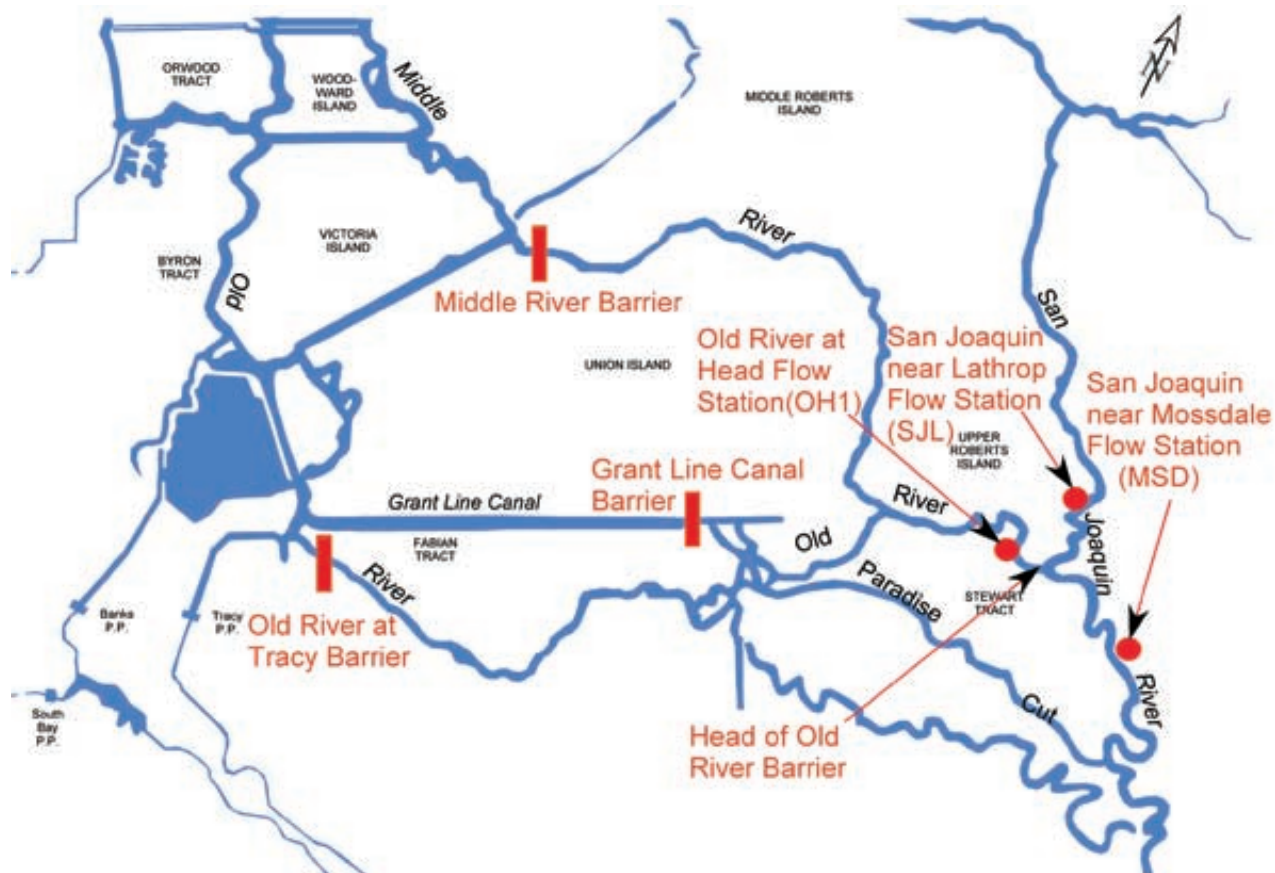
ORT – All work in or near the stream zone will be confined to the period beginning no earlier than April 1

GLC - All work in or near the stream zone will be confined to the period beginning no earlier than April 1

In addition to the above conditions, water users of the South Delta Water Agency (SDWA) and the fisheries agencies impose separate mitigation requirements on DWR for installation and operation of the HORB by itself. As a result, DWR's contractor must sequentially close and start operation of the MR and ORT barriers, and complete as much construction of north abutment and boat ramps on the GLC barrier as possible, before they can close and operate the HORB.

From the contractors point of view there are really two milestones that must be completed in sequence. First and foremost is to obtain closure and operation of the barriers in accordance with the conditions imposed by the project permits/biological opinions and mitigation requirements. The second is to satisfy DWR's contract specifications. The first milestone can be achieved within the required 15 working days but it is unlikely that the contractor can complete the entire amount of work required to satisfy DWR's contract specifications within the same time period.

Figure 4-2
South Delta Temporary Barriers



Therefore, the contractor's construction activities consist of placing enough materials to make sure they obtain closure and operation by April 15th, then following closure they continue placing barrier material above the water line until barrier construction is completed in accordance with DWR's contract specifications. The contractor then conducts site cleanup and demobilizes from the site. This is why work usually continues above water line beyond the April 15 deadline.

Barrier Operations and Monitoring Plan

A barrier operations and monitoring plan was developed based on forecasting and monitoring of tidal conditions. DWR determined the number of culverts to be opened at the HORB so that water levels at Old River near Tracy Road Bridge and Grant Line above Doughty Cut would remain above 0.0 feet MSL and Middle River near Howard Road above 0.3 feet MSL. Based on modeling results and/or field monitoring of water levels in the south delta, six culverts were open after the barrier's closure date of April 20, 2007. On April 26, 2007 three of the culverts were closed, but were reopened on May 16, 2007 because of the concern over the Delta Smelt.

Flow Measurements at and Around the Head of Old River

DWR operates two Acoustic Doppler Current Meters (ADCM) in the vicinity of 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 another in Old River 840 feet downstream of the head of Old River (Old River at Head, OH1). A third acoustical Doppler was installed last year at the abutment of the railroad bridge near Mossdale (Figure 4-2). 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 March 25, 2007 through June 30, 2007 period for the three ADCMs. Figures 4-3, 4-4, and 4-5 show the daily flow range and the mean for the Old River at Head gage, the San Joaquin River below Old River gage, and the San Joaquin River at Mossdale gage respectively.

Table 4-2 shows the mean daily flow of the San Joaquin River gage at Mossdale and the San Joaquin River near Vernalis gage for the duration from April 1, 2007


Table 4-1
Measured Flows in San Joaquin River at Mossdale, Old River at Head and San Joaquin River below Old River.

Date	Old River at Head (OH1)			San Joaquin River below Old River (SJL)			San Joaquin River at Mossdale (MSD)			Flow Split (% of Total Flow)	
	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Flow (cfs)	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Flow (cfs)	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Flow (cfs)	OH1	SJL
3/25/2007	1,210	2,100	1,700	-1,070	1,900	638	1,110	2,900	2,190	72.7%	27.3%
3/26/2007	869	2,210	1,680	-775	1,960	682	1,340	2,920	2,190	71.1%	28.9%
3/27/2007	898	2,380	1,630	-1,090	1,920	556	1,060	2,710	2,060	74.6%	25.4%
3/28/2007	870	2,120	1,570	-899	1,880	580	1,330	2,580	2,090	73.0%	27.0%
3/29/2007	941	2,210	1,610	-915	1,660	482	1,350	2,510	2,050	76.9%	23.1%
3/30/2007	1,070	2,250	1,600	-1,130	1,560	404	1,200	2,430	1,920	79.9%	20.1%
3/31/2007	808	2,290	1,610	-1,230	1,710	333	950	2,380	1,850	82.9%	17.1%
4/1/2007	1,020	2,440	1,690	-1,300	1,720	356	1,170	2,410	1,910	82.6%	17.4%
4/2/2007	921	2,190	1,590	-1,070	1,560	417	1,120	2,550	1,950	79.2%	20.8%
4/3/2007	806	1,970	1,530	-1,060	1,560	369	969	2,400	1,810	80.6%	19.4%
4/4/2007	687	2,000	1,510	-1,210	1,630	314	822	2,410	1,760	82.8%	17.2%
4/5/2007	632	2,100	1,480	-1,230	1,470	227	597	2,330	1,630	86.7%	13.3%
4/6/2007	567	2,050	1,500	-1,290	1,730	225	301	2,340	1,600	87.0%	13.0%
4/7/2007	544	2,000	1,470	-1,350	1,910	401	365	2,410	1,650	78.6%	21.4%
4/8/2007	564	1,990	1,480	-1,210	1,860	408	688	2,500	1,740	78.4%	21.6%
4/9/2007	796	1,920	1,510	-1,100	1,910	507	839	2,580	1,870	74.9%	25.1%
4/10/2007	623	1,780	1,330	-889	1,700	476	856	2,270	1,660	73.6%	26.4%
4/11/2007	663	2,050	1,360	-1,180	1,730	309	562	2,210	1,470	81.5%	18.5%
4/12/2007	621	2,080	1,380	-1,410	1,790	322	784	2,310	1,590	81.1%	18.9%
4/13/2007	721	2,100	1,400	-1,190	1,420	259	817	2,050	1,600	84.4%	15.6%
4/14/2007	683	2,020	1,400	-1,430	1,520	197	723	2,170	1,540	87.7%	12.3%
4/15/2007	836	2,080	1,460	-1,320	1,710	297	1,070	2,390	1,710	83.1%	16.9%
4/16/2007	926	2,250	1,570	-1,110	1,670	422	1,040	2,470	1,880	78.8%	21.2%
4/17/2007	870	2,090	1,600	-1,280	1,600	269	725	2,370	1,680	85.6%	14.4%
4/18/2007	836	2,200	1,410	-1,460	1,710	349	410	2,370	1,660	80.1%	19.9%
4/19/2007	875	1,890	1,480	-1,460	1,660	368	381	2,390	1,610	80.1%	19.9%
4/20/2007	511	2,280	1,060	-1,530	2,460	1,010	-44	2,430	1,640	51.2%	48.8%
4/21/2007	464	928	665	-18	2,900	1,920	866	3,000	2,180	25.7%	74.3%
4/22/2007	389	928	668	852	3,300	2,440	1,800	3,410	2,750	21.5%	78.5%
4/23/2007	558	951	711	2,020	3,390	2,850	2,570	3,570	3,100	20.0%	80.0%
4/24/2007	559	825	673	2,200	3,280	2,830	2,730	3,440	3,080	19.2%	80.8%
4/25/2007	513	811	658	2,240	3,210	2,790	2,630	3,390	3,030	19.1%	80.9%
4/26/2007	368	703	533	2,070	3,300	2,830	2,550	3,400	3,030	15.9%	84.1%
4/27/2007	388	633	482	2,310	3,270	2,880	2,610	3,290	3,010	14.3%	85.7%
4/28/2007	351	588	445	2,040	3,130	2,720	2,390	3,270	2,910	14.1%	85.9%
4/29/2007	323	585	448	2,050	3,240	2,770	2,260	3,370	2,940	13.9%	86.1%
4/30/2007	230	657	420	2,180	3,510	2,900	2,590	3,530	3,100	12.7%	87.3%
5/1/2007	230	500	379	2,130	3,430	2,830	2,380	3,470	2,990	11.8%	88.2%
5/2/2007	256	485	381	2,000	3,310	2,710	2,210	3,280	2,880	12.3%	87.7%
5/3/2007	249	470	350	1,540	3,260	2,610	1,940	3,210	2,720	11.8%	88.2%
5/4/2007	107	488	347	1,590	3,230	2,630	2,020	3,280	2,730	11.7%	88.3%
5/5/2007	275	616	437	1,890	3,350	2,770	2,150	3,240	2,820	13.6%	86.4%
5/6/2007	277	599	416	1,990	3,360	2,830	2,230	3,420	2,930	12.8%	87.2%
5/7/2007	124	571	403	2,080	3,430	2,850	2,290	3,390	2,940	12.4%	87.6%
5/8/2007	235	513	346	2,060	3,360	2,770	2,320	3,410	2,890	11.1%	88.9%
5/9/2007	220	522	356	2,020	3,400	2,790	2,390	3,410	2,950	11.3%	88.7%
5/10/2007	223	467	358	2,250	3,310	2,800	2,580	3,330	2,970	11.3%	88.7%
5/11/2007	269	523	396	2,230	3,220	2,800	2,600	3,310	2,990	12.4%	87.6%
5/12/2007	302	564	437	2,050	3,230	2,790	2,480	3,340	2,970	13.6%	86.4%
5/13/2007	329	562	460	2,090	3,250	2,840	2,550	3,420	3,090	13.9%	86.1%
5/14/2007	339	621	466	2,010	3,430	2,870	2,530	3,550	3,160	14.0%	86.0%
5/15/2007	297	546	450	1,730	3,420	2,780	2,340	3,490	3,030	13.9%	86.1%
5/16/2007	329	777	555	1,520	3,340	2,720	2,160	3,550	3,030	17.0%	83.0%
5/17/2007	491	785	611	1,170	3,360	2,620	1,930	3,560	3,010	18.9%	81.1%
5/18/2007	408	727	583	1,080	3,400	2,640	2,120	3,670	3,050	18.1%	81.9%
5/19/2007	425	800	578	1,420	3,350	2,640	2,150	3,530	3,010	18.0%	82.0%
5/20/2007	360	711	567	1,310	3,310	2,600	2,110	3,440	2,970	17.9%	82.1%
5/21/2007	462	812	606	1,650	3,330	2,680	2,340	3,550	3,020	18.5%	81.5%
5/22/2007	411	1,910	1,210	1,170	2,840	2,320	2,630	3,490	3,000	34.3%	65.7%
5/23/2007	1,260	2,710	1,720	882	2,280	1,790	2,500	3,110	2,820	49.0%	51.0%
5/24/2007	1,020	2,500	1,530	-188	2,100	1,410	2,010	2,930	2,600	52.0%	48.0%
5/25/2007	925	2,280	1,340	-515	2,060	1,270	1,760	2,790	2,450	51.3%	48.7%
5/26/2007	827	2,310	1,230	-816	2,150	1,220	1,520	2,770	2,330	50.2%	49.8%
5/27/2007	755	2,130	1,210	-846	2,270	1,240	1,390	2,790	2,290	49.4%	50.6%
5/28/2007	790	2,280	1,290	-871	2,350	1,210	1,380	2,910	2,350	51.6%	48.4%
5/29/2007	784	2,260	1,290	-1,290	2,410	1,040	1,150	2,930	2,230	55.4%	44.6%
5/30/2007	679	2,040	1,170	-1,070	2,470	1,150	1,230	2,960	2,270	50.4%	49.6%
5/31/2007	671	2,130	1,190	-1,080	2,470	1,140	985	2,930	2,240	51.1%	48.9%
6/1/2007	759	2,120	1,220	-1,060	2,440	1,130	1,060	3,010	2,260	51.9%	48.1%
6/2/2007	742	2,180	1,240	-972	2,470	1,140	1,100	2,910	2,260	52.1%	47.9%
6/3/2007	753	2,190	1,230	-1,210	2,600	1,200	1,100	2,950	2,300	50.6%	49.4%
6/4/2007	691	2,160	1,190	-1,030	2,400	1,110	1,050	2,770	2,140	51.7%	48.3%
6/5/2007	409	2,080	1,160	-1,050	2,410	1,030	1,020	2,580	2,000	53.0%	47.0%
6/6/2007	482	1,900	1,000	-818	2,280	1,160	1,200	2,500	2,020	46.3%	53.7%
6/7/2007	504	1,880	971	-660	2,000	1,060	1,320	2,350	1,940	47.8%	52.2%
6/8/2007	513	1,900	962	-699	1,840	1,000	1,230	2,260	1,900	49.0%	51.0%
6/9/2007	528	1,930	995	-840	1,850	969	1,140	2,220	1,850	50.7%	49.3%
6/10/2007	358	1,980	932	-1,040	1,980	867	840	2,100	1,710	51.8%	48.2%
6/11/2007	434	2,030	981	-1,280	2,190	952	703	2,370	1,830	50.7%	49.3%
6/12/2007	443	2,070	1,030	-1,400	2,230	973	609	2,480	1,880	51.4%	48.6%
6/13/2007	568	2,260	1,140	-1,380	2,360	984	799	2,670	2,040	53.7%	46.3%
6/14/2007	419	2,330	1,100	-1,490	2,350	794	587	2,480	1,760	58.1%	41.9%
6/15/2007	109	2,100	944	-1,510	2,520	727	60	2,340	1,490	56.5%	43.5%
6/16/2007	96	1,840	860	-1,570	2,550	829	128	2,310	1,500	50.9%	49.1%
6/17/2007	186	2,120	891	-1,520	2,540	957	326	2,370	1,660	48.2%	51.8%
6/18/2007	205	2,160	972	-1,420	2,460	876	596	2,360	1,720	52.6%	47.4%
6/19/2007	159	2,160	994	-1,390	2,360	721	591	2,290	1,600	58.0%	42.0%
6/20/2007	6	1,880	777	-1,100	2,240	876	618	1,970	1,510	47.0%	53.0%
6/21/2007	-82	1,660	635	-1,120	1,920	813	584	1,740	1,350	43.8%	56.2%
6/22/2007	71	1,790	678	-1,240	1,720	618	383	1,550	1,170	52.3%	47.7%
6/23/2007	-10	1,740	682	-1,490	1,780	527	261	1,530	1,030	56.4%	43.6%
6/24/2007	-104	1,680	619	-1,540	1,800	516	-11	1,390	906	54.5%	45.5%
6/25/2007	-73	1,700	656	-1,510	1,880	523	-68	1,470	953	55.6%	44.4%
6/26/2007	-97	1,780	703	-1,660	1,960	378	-73	1,450	859	65.1%	34.9%
6/27/2007	-155	1,710	698	-1,660	2,130	441	-135	1,480	863	61.3%	38.7%
6/28/2007	-219	1,620	715	-1,680	2,150	467	-104	1,720	893	60.5%	39.5%
6/29/2007	-195	1,710	727	-1,750	2,200	408	-223	1,570	828	64.0%	36.0%
6/30/2007	-325	1,490	596	-1,670	2,160	430	-275	1,450	763	58.1%	41.9%

through June 30, 2007. Moreover, Figure 4-6 presents in graphical format the mean daily flow for the San Joaquin River gage at Mossdale and the San Joaquin River near Vernalis gage for the same period.

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 the output generated 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. In 2007 no seepage was observed at any of the monitoring sites. A link to the continuous time series data in the water data library is available on the internet. 

In 2007, DWR installed Doppler “Argonaut” flow measuring devices inside culverts 1, 4 and 6. Data was recorded every 15 minutes during the period when the HORB was in operation. The flow through a completely submerged culvert is primarily dependent on the water levels at the two ends of the culvert, but is also dependent on culvert inlet geometry, slope, size and roughness. If it is assumed that all of these factors are similar for all six of the culverts, then the measured flow in any of these culverts would be a reasonable estimate of the flow in each of the other culverts. Table 4-3 summarizes the measured flows in culverts 1, 4, and 6 and estimates the total mean daily flow in all six culverts.

Barrier Emergency Response Plan

In addition to the operation and monitoring plan, DWR has also prepared an “Emergency Operations Plan for the Spring HORB”. The plan provided that if the daily measured or forecasted flow at Vernalis exceeded a flow that would correspond to stage at the HORB of 10.0 feet MSL, and the stage was likely to exceed 11.0 feet MSL (the height of the barrier under the “high-flow” target), the barrier would be removed. Vernalis flows and stages at the barrier were not high enough in 2007 to warrant action under the emergency operations plan.

Fish Entrainment Monitoring at the Head of Old River Barrier

All six culverts in the Head of Old River Barrier (HORB) were installed for the 2007 VAMP test period. However, only three of the six culverts were open during entrainment monitoring. The six culverts are installed to maintain water quality and water levels in the south Delta, downstream of the HORB. Since the culverts are

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

Date	Mean Daily Flow (cfs)	
	San Joaquin River at Mossdale [A]	San Joaquin River near Vernalis [B]
4/1/07	1,910	1,950
4/2/07	1,950	1,930
4/3/07	1,810	1,790
4/4/07	1,760	1,730
4/5/07	1,630	1,680
4/6/07	1,600	1,680
4/7/07	1,650	1,710
4/8/07	1,740	1,780
4/9/07	1,870	1,880
4/10/07	1,660	1,670
4/11/07	1,470	1,630
4/12/07	1,590	1,730
4/13/07	1,600	1,680
4/14/07	1,540	1,730
4/15/07	1,710	1,910
4/16/07	1,880	1,990
4/17/07	1,680	1,850
4/18/07	1,660	1,760
4/19/07	1,610	1,780
4/20/07	1,640	1,880
4/21/07	2,180	2,700
4/22/07	2,750	3,500
4/23/07	3,100	3,790
4/24/07	3,080	3,670
4/25/07	3,030	3,590
4/26/07	3,030	3,520
4/27/07	3,010	3,370
4/28/07	2,910	3,160
4/29/07	2,940	3,160
4/30/07	3,100	3,200
5/1/07	2,990	3,090
5/2/07	2,880	2,960
5/3/07	2,720	2,830
5/4/07	2,730	2,900
5/5/07	2,820	2,970
5/6/07	2,930	3,050
5/7/07	2,940	3,050
5/8/07	2,890	3,090
5/9/07	2,950	3,170
5/10/07	2,970	3,170
5/11/07	2,990	3,250
5/12/07	2,970	3,330
5/13/07	3,090	3,390
5/14/07	3,160	3,450
5/15/07	3,030	3,410
5/16/07	3,030	3,400
5/17/07	3,010	3,360
5/18/07	3,050	3,370
5/19/07	3,010	3,300
5/20/07	2,970	3,280
5/21/07	3,020	3,260
5/22/07	3,000	3,100
5/23/07	2,820	2,960
5/24/07	2,600	2,810
5/25/07	2,450	2,670
5/26/07	2,330	2,570
5/27/07	2,290	2,530
5/28/07	2,350	2,540
5/29/07	2,230	2,430
5/30/07	2,270	2,420
5/31/07	2,240	2,340
6/1/07	2,260	2,350
6/2/07	2,260	2,390
6/3/07	2,300	2,350
6/4/07	2,140	2,200
6/5/07	2,000	2,090
6/6/07	2,020	2,020
6/7/07	1,940	1,950
6/8/07	1,900	1,950
6/9/07	1,850	1,880
6/10/07	1,710	1,740
6/11/07	1,830	1,860
6/12/07	1,880	1,970
6/13/07	2,040	2,040
6/14/07	1,760	1,760
6/15/07	1,490	1,610
6/16/07	1,500	1,590
6/17/07	1,660	1,660
6/18/07	1,720	1,680
6/19/07	1,600	1,550
6/20/07	1,510	no data
6/21/07	1,350	no data
6/22/07	1,170	no data
6/23/07	1,030	1,110
6/24/07	906	1,100
6/25/07	953	1,130
6/26/07	859	1,060
6/27/07	863	1,090
6/28/07	893	1,090
6/29/07	828	1,040
6/30/07	763	1,000

Figure 4-3
Daily Flow Range - Old River at Head

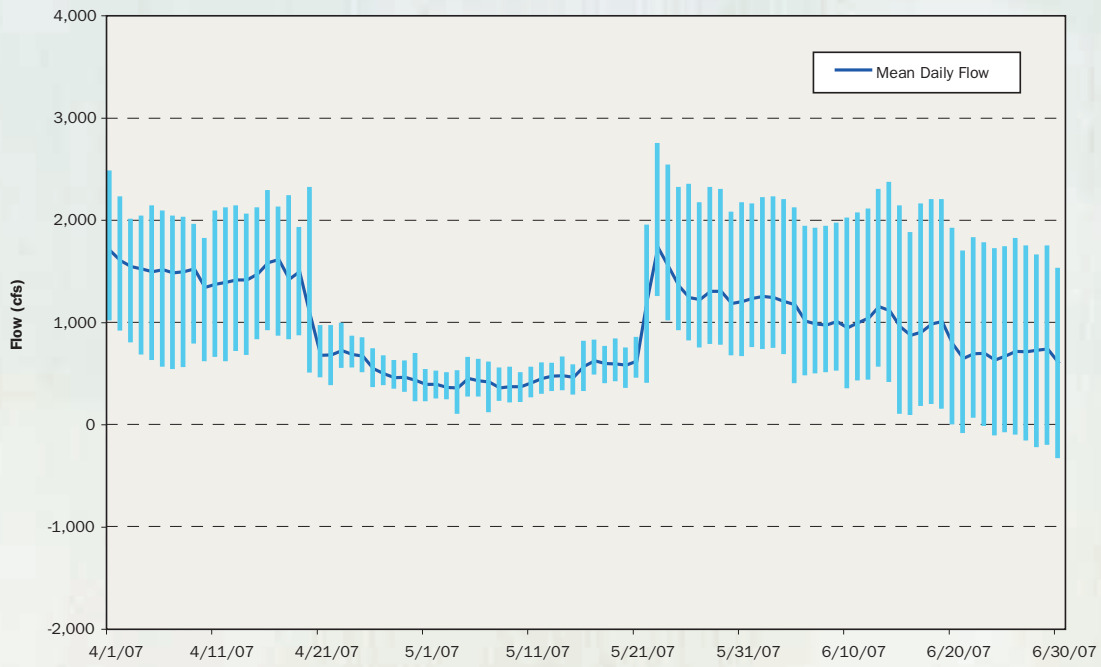


Figure 4-4
Daily Flow Range - San Joaquin River below Old River Gage

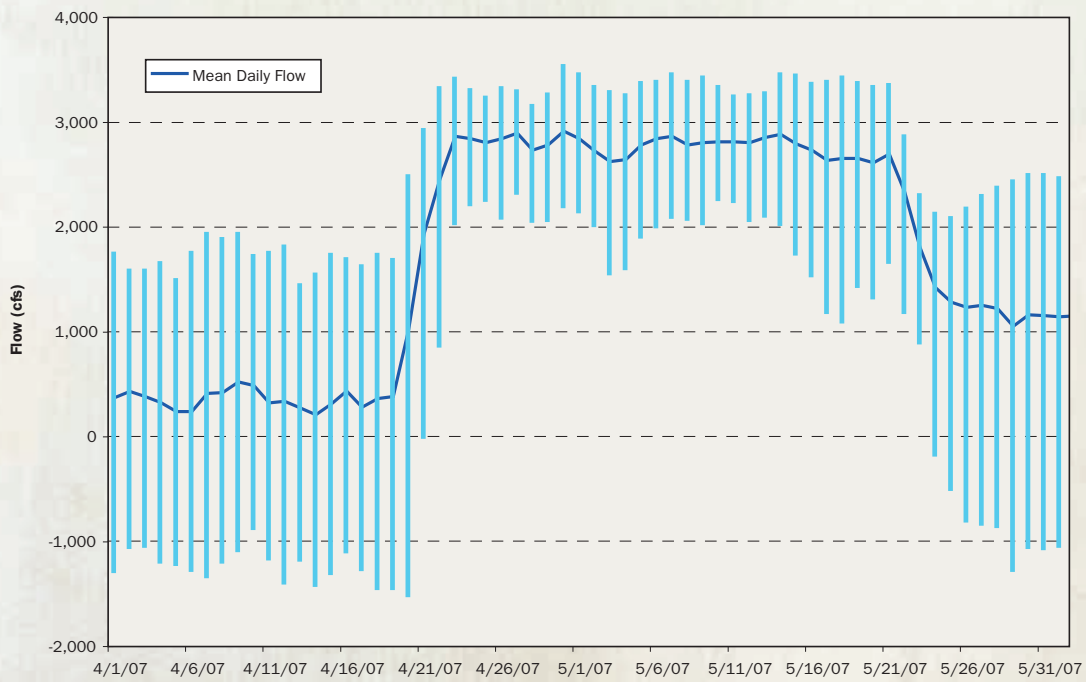


Figure 4-5
Daily Flow Range - San Joaquin River at Mossdale

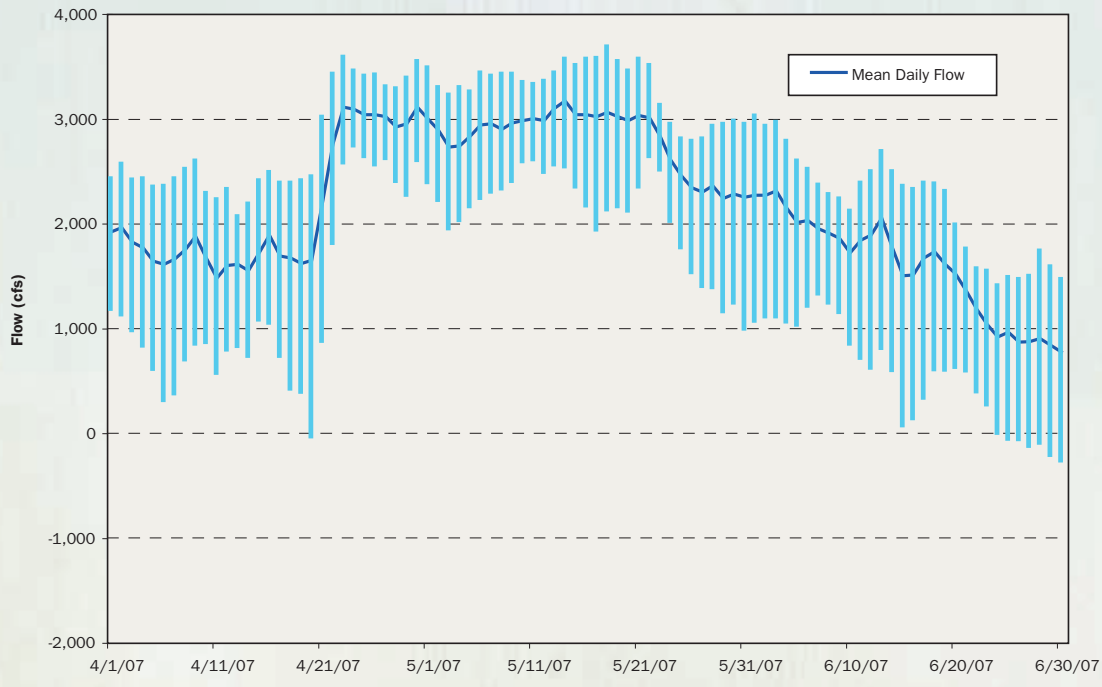


Figure 4-6
San Joaquin River Flow near Vernalis and at Mossdale



not screened, juvenile Chinook salmon and other fish species that pass near the culverts are vulnerable to entrainment. A fish monitoring program was designed and implemented by the DFG to evaluate and quantify fish entrainment at the HORB. Results from this fishery investigation are intended, in part, to provide information on the design and operation of a future permanent operable barrier at the head of Old River.

Materials and Methods

Fish entrained into the culverts were caught with fyke nets. The nets have a 48-inch cylindrical mouth tapering down to a 1-foot square cod-end, and are made of 1/2 inch braided mesh. Five of the six nets are 60 feet long and one net is 40 feet long. A live-box (15.5 x 19.5 x 36 inches), constructed of perforated aluminum sheet metal, was attached to the cod-end of each net. Each live-box has an aluminum baffle designed to reduce water velocities within the live-box and improve survival of captured fish. The culverts were numbered from 1 to 6 with number 1 located next to the shoreline (viewed from downstream) and number 6 located mid-channel (Figure 4-7). On April 27, fyke nets were attached to the downstream slide gate flanges of all six culverts. These gates were not lowered over the culverts at this time and thus, were not sampling. The slide gates on culvert numbers 1, 4 and 6, with attached nets and live boxes, were lowered over the culvert outfalls at 14:00 hours on Monday, April 29 to commence fish entrainment monitoring. Only culvert numbers 1, 4 and 6 were opened and remained opened throughout the monitoring period. On Friday, May 4, at 13:00, the nets were raised, checked, and then piled onto the frames. The nets did not fish over the weekend. The following Monday, at 13:00 hours, the nets for culvert numbers 1, 4 and 6 were lowered back into the water. All nets were removed at noon on Friday, May 11.

The fyke nets were checked at 01:00, 06:00, 13:00, and 20:00 hours Monday through Friday. The nets were checked by closing the culvert slides gate (upstream side) for about 20 minutes, enabling the live-boxes to be pulled onto a boat. Fish were removed from the live-boxes and placed into buckets. Once all the nets had been checked and reset, the collected fish were processed. All the fish were identified and counted. Salmon were checked for a clipped adipose fin and for the presence of a color-mark on the dorsal, anal, or caudal fin. Salmon that had a clipped adipose fin were saved for CWT processing. All salmon were measured (fork-lengths) to the nearest millimeter. Culvert number, date, time, water temperature, and diel-period were recorded for each net check. Except for adipose fin clipped salmon, all fish were released downstream of the HORB into Old River.

Figure 4-7
Culverts in the HORB were numbered from 1 to 6, with number 1 closest to shore. Culvert numbers 2, 3 and 5 were closed throughout the monitoring period.



Table 4-3. Flow in HORB Culverts

Date	Mean Daily Flow (cfs)				Total [1]
	Culvert 1	Culvert 4	Culvert 6	Open Culverts	
4/26/07 [2]	82	79	89	1,4,6	251
4/27/07	78	78	88	1,4,6	245
4/28/07	72	75	86	1,4,6	233
4/29/07	69	72	83	1,4,6	224
4/30/07	66	67	72	1,4,6	205
5/1/07	60	58	60	1,4,6	178
5/2/07	60	58	61	1,4,6	179
5/3/07	57	56	58	1,4,6	171
5/4/07	59	59	65	1,4,6	183
5/5/07	62	61	70	1,4,6	192
5/6/07	64	63	73	1,4,6	200
5/7/07	60	58	64	1,4,6	182
5/8/07	57	55	59	1,4,6	171
5/9/07	56	54	59	1,4,6	168
5/10/07	54	53	57	1,4,6	164
5/11/07	55	56	62	1,4,6	173
5/12/07	56	57	67	1,4,6	179
5/13/07	57	58	68	1,4,6	183
5/14/07	59	59	70	1,4,6	188
5/15/07	56	56	66	1,4,6	179
5/16/07 [3]	53	53	65	1,2,3,4,5,6	256
5/17/07	49	50	62	1,2,3,4,5,6	322
5/18/07	49	49	62	1,2,3,4,5,6	320
5/19/07	48	48	61	1,2,3,4,5,6	315
5/20/07	50	49	63	1,2,3,4,5,6	325
5/21/07 [4]	47	47	60	1,2,3,4,5,6	309

[1] Assumes average of measured flows for Culverts 2, 3 and 5 when open
 [2] Partial day record of flow: 10:30 to 23:45
 [3] Culverts 2, 3 and 5 were opened on May 16; estimate of total flow assumes these culverts were open for half of May 16.
 [4] Partial day record of flow: 0:00 to 10:15

Unlike in previous years, there were no VAMP salmon releases upstream of the HORB at Mossdale or Durham Ferry. Consequently, no entrainment loss indices were calculated for 2007. Instead, an unmarked salmon average daily entrainment index (Entrainment Index) was generated from the HORB fish entrainment results to track relative changes in entrainment among years. For each year of entrainment monitoring, an Entrainment Index was calculated by dividing the total number of unmarked salmon caught by the number of days sampled. The index was not adjusted for the number of open culverts or the occasional lost entrainment samples due to gravel or debris. The Entrainment Index represents overall entrainment regardless of HORB culvert gate operation.

To track relative changes in unmarked salmon abundance just upstream of the barrier, salmon catch from the Mossdale Kodiak Trawl (MKT) was used to calculate an average 5 hour daily abundance index (Abundance Index). The Abundance Index was calculated by summing the daily catch of unmarked salmon (standardized to fifteen 20 minute tows) and dividing by the number of days sampled. The Abundance Index was calculated for the same days in which there was entrainment monitoring. Abundance and Entrainment Indices are calculated for a two to three week period during the VAMP test period. No indices were calculated for 2005 and 2006 because the HORB was not installed due to high San Joaquin River flows.

Fish catch was calculated for each culvert. Catch-Per-Unit-Effort (CPUE) for salmon comparison among years was calculated as the number of fish collected per hour per culvert. Standard deviation is used to describe the variability round the mean. DWR installed flow meters in culverts number 1, 4 and 6. Unmarked salmon entrainment density (fish/af) was calculated per culvert sampling period by dividing the catch by the amount of water that flowed through the culvert (mean flow (cfs) * sampling duration (s) * 43,560 (af/cf)).

Results

The HORB was closed on April 22; however, construction on the barrier continued for another four days. As mentioned previously, only culvert numbers 1, 4 and 6 were open during the fish monitoring period. The remaining culverts were opened May 16, after fish monitoring was completed. DFG monitored the HORB culverts over 10 days, for approximately 167 hours of sampling per culvert, and collected 95 samples. Two samples from culvert number 4 were loss due to the process of clearing the net of gravel and resetting the net at the next net check.

Table 4-4
The raw abundance and composition of fishes entrained at the HORB in 2007. Chinook salmon catch is divided into CWT salmon, unmarked salmon, color-marked salmon and radio-tagged salmon.

Species	Catch
White Catfish	185
Common Carp	85
Sacramento Sucker	81
Channel Catfish	29
Bluegill	12
Tule Perch	11
Redear Sunfish	3
Lamprey Spp.	2
Striped Bass	2
Prickly Sculpin	2
Green Sunfish	2
Golden Shiner	2
Brown Bullhead	1
Goldfish	1
Largemouth Bass	1
Threadfin Shad	1
Inland Silverside	1
Total Chinook Salmon	51
CWT Salmon	1
Unmarked Salmon	48
Color-Marked Salmon	0
Acoustically tagged Salmon	2
Total	472

Almost 500 fish were collected representing 17 species from 10 families of fish. No delta smelt (*Hypomesus transpacificus*), juvenile steelhead (*Oncorhynchus mykiss*), or splittail (*Pogonichthys macrolepidotus*) were collected in the fyke nets. The most abundant species was white catfish (*Ictalurus catus*), followed by common carp (*Cyprinus carpio*) (Table 4-4). Of the 51 salmon caught; 1 had a CWT; 46 were unmarked; and 2 were acoustically tagged. No color-marked salmon were caught this year. Overall, the number of salmon entrained per hour (0.1 ± 0.2) was lower than it was in previous years (0.7 in 2004, 3.4 in 2003, 2.5 in 2002, 1.4 in 2001). The mean fork length for unmarked salmon was 85 ± 7.6 mm and the one CWT salmon was 93 mm.

Unmarked salmon were caught throughout the monitoring period (Figure 4-8). The average unmarked salmon CPUE over the entire monitoring period was 0.1 ± 0.2 fish/hour/culvert. The highest unmarked salmon

Figure 4-8

The daily average number of unmarked salmon entrained per culvert hour at the HORB in 2007. The catch is separated by day and night. No sampling occurred on May 5 and 6.

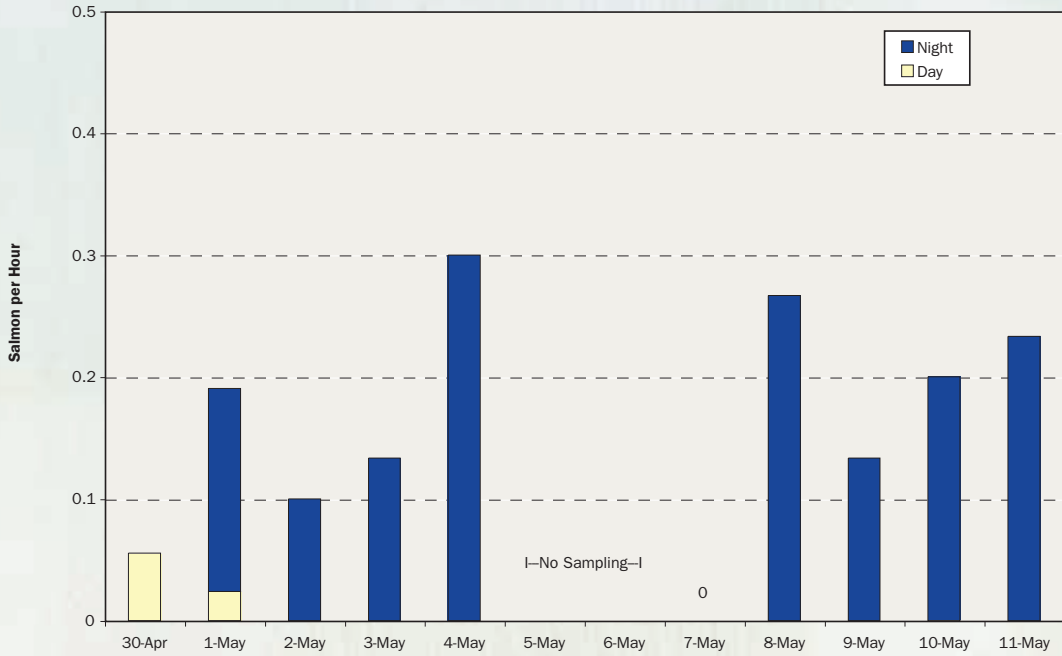


Figure 4-9

Mean unmarked salmon Abundance Index and Entrainment Index during the annual VAMP period when both Mossdale Kodiak Trawl and HORB entrainment monitoring were sampling. Indices were not calculated for 2005 and 2006 because the HORB was not installed due to high San Joaquin River flows. Mean San Joaquin River flow during VAMP was measured at Vernalis, CA.

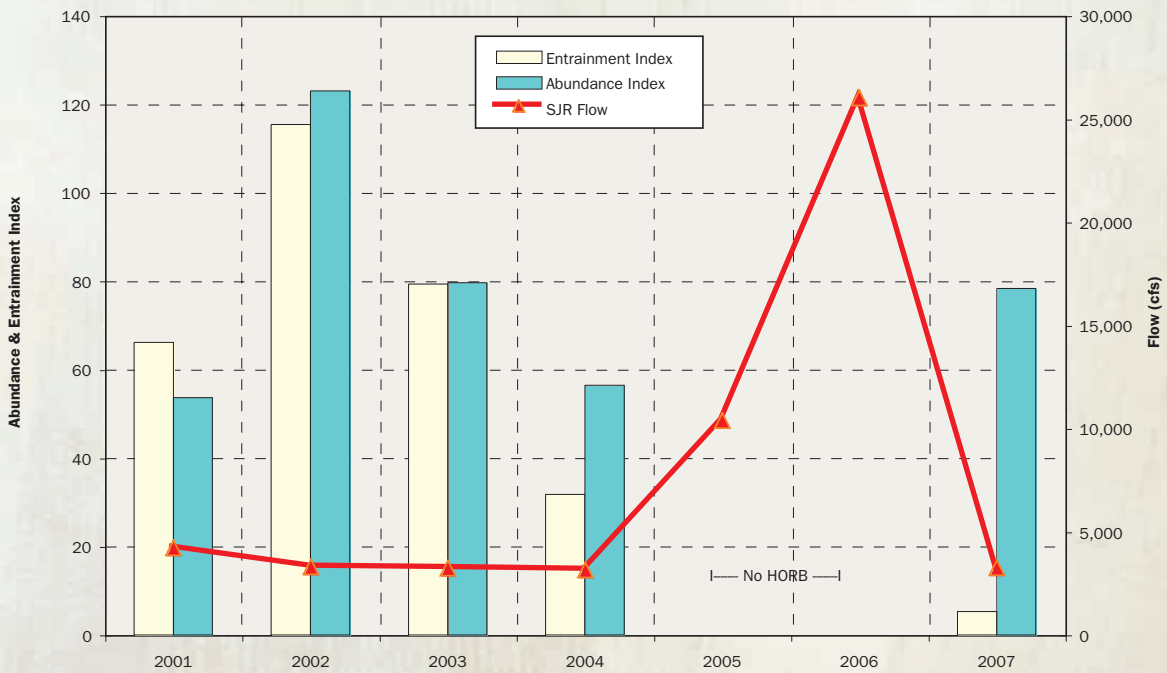


Table 4-5
The percentage of the total number of unmarked salmon caught by culvert and year, and 2007 culvert flow and entrainment fish density. Catch comparisons made only for time periods when culverts were fully operational and fyke nets were fishing. An "X" indicates the culvert was closed. Days indicate the number of days the culverts were compared in the given culvert operational status.

	Year	Days		Culvert Number					
				1	2	3	4	5	6
Catch									
	2001	6.2	Percent	3%	7%	7%	18%	20%	44%
	2002	11.0	Percent	10%	12%	16%	33%	16%	12%
	2003	19.7	Percent	X	X	X	17%	39%	45%
	2004	2.0	Percent	X	X	X	15%	39%	46%
	2004	5.9	Percent	22%	X	11%	0%	5%	62%
	2007	7.3	Percent	21%	X	X	24%	X	55%
Flow (cfs)									
	2007	7.3	Percent	33%	X	X	32%	X	34%
			Avg ± SD	59 ± 8.8	X	X	58 ± 8.5	X	61 ± 8.9
Density ((Fish/af) * 100)									
	2007	7.3	Avg ± SD	1.2 ± 3.0			1.5 ± 2.9		3.0 ± 4.1

CPUE (0.8 fish/hour/culvert) occurred on May 4 and May 8. The average CWT salmon CPUE over the entire monitoring period was 0.002 ± 0.020 fish/hour/culvert. The highest CWT salmon CPUE (0.2 fish/hour/culvert) occurred on May 10.

In order to compare relative trends in unmarked salmon entrainment, an Entrainment Index and Abundance Index was calculated for each of the previous years in which we conducted entrainment monitoring. The 2007 Abundance Index was similar to the 2001, 2003 and 2004 Abundance indices (Figure 4-9). For the most part, the Entrainment Index tracked the Abundance Index, except in 2007. Although 2003 and 2007 had nearly identical Abundance Indices, the 2007 Entrainment Index was approximately 15 times lower. Both 2003 and 2007 had 3 open culverts. Although river flow can influence emigration patterns, San Joaquin River flow was similar among study years (2001-2004 and 2007) and flow probably had a negligible affect (Figure 4-4).

Unmarked salmon entrainment was highest in culvert number 6 and lowest in culvert number 1. Approximately half of the salmon entrained in 2007 were entrained through culvert number 6, which is similar to 2003 and 2004 (Table 4-5). Although 55 % of the entrained salmon went through culvert number 6, only 34 % of the water flowed through this culvert (Table 4-5). Salmon density for fish entrained through culvert number 6 was 0.03 fish/af, twice the density of culvert numbers 1 and 4.

Salmon entrainment differed greatly between diel periods. More unmarked salmon were entrained at night (47) than during the day (2). This year's nighttime entrainment is higher than in previous years when approximately 75% of the salmon were caught at night.

Discussion

The HORB is relatively effective in keeping salmon on the San Joaquin side of the barrier. Previous studies at the HORB indicate typically less than one percent of the VAMP CWT salmon released upstream of the HORB is entrained through the HORB culverts (SJRGA, 2001, 2002, 2003, 2004). Because there was no VAMP CWT salmon releases in 2007, we were unable to estimate the percentage of salmon entrained at the HORB. As an alternative to directly estimating entrainment using CWT salmon, entrainment and abundance indices were generated for unmarked salmon to compare relative changes in entrainment among years.

Total fish entrainment at the HORB was much lower this year than in previous years. Due to a staff shortage, the fyke nets were fished over a period of 10 days. Although the number of days sampled was reduced, the proportional decrease in overall salmon entrainment was much greater than expected, even when we account for the number of operational culverts. There was an 86% decrease in CPUE compared to 2004, the previous low. A large contributing factor for the overall decline in salmon entrainment was the practically non-existent CWT salmon catch. In previous years, CWT salmon can account for more than half of all the salmon entrained.

This year's single CWT salmon catch is by far the lowest on record.

Although CWT salmon typically account for a large percentage of the overall salmon entrainment, there was also a sharp decline in unmarked salmon entrainment. This decline in entrainment might be due to a decline in the number of outmigrating juvenile salmon. However, the unmarked salmon Abundance Index during the 2007 VAMP period was similar to previous years with a barrier. While we were sampling at the HORB, it appears there was no sharp decline in the number of unmarked salmon just upstream of the barrier.

The decline in the 2007 Entrainment Index might be related to culvert gate operation. In previous years when only three culverts were opened (2003 and part of 2004), the three culverts closest to the channel were opened and the three closest to shore were closed. This year, the culvert at the end, one in the middle, and the one closest to shore were open. The zone of entrainment might be higher with three adjacent open culverts. There is probably a larger draw of water at a fixed distance from an open culvert if the adjacent culverts are also open.

Over the years, we've noticed the culvert closest to the shore (number 1) typically entrains the fewest number of salmon. It was thought that the lower entrainment might be related to lower flows in culvert number 1. Visually, it appears less water flows through culvert number 1 compared to the other culverts. Theoretically, flows should be the same in all culverts since it's the head difference between upstream and downstream water levels that is responsible for flow. In 2002, a cursory check of flows among culverts using a hand held flowmeter suggested flow through culvert number 1 was about 10 cfs lower than flow through the other five culverts (SJRGA, 2002). However, in 2007, flowmeters in culvert numbers 1, 4 and 7 indicate flow was similar among culverts.

The position of outmigrating salmon in the water column probably is the biggest factor affecting entrainment. The proximity of culvert number 1 to the shore and culvert number 6 to the center of the channel, may account for the large entrainment discrepancies between the two culverts. Salmon entrainment densities suggest salmon are more abundant in the center of the channel. Juvenile salmon may prefer to migrate down the middle of the channel rather than along the shoreline. Predation might also be higher along the shore which would reduce the number of salmon vulnerable to entrainment at culvert number 1.

The data collected over the HORB monitoring years strongly suggests salmon are more vulnerable to entrainment at night. Salmon entrainment at night was

higher in 2007 than in previous years. In 2004, 80% of the unmarked salmon were entrained at night. In 2007, approximately 95 % of the entrained unmarked salmon were caught at night. Although the MKT caught between 40 and 208 unmarked salmon per day (for a total of 678) just upstream of the barrier using surface tows, the HORB entrained between 0 and 1 salmon (for a total of two) during that same daylight timeframe. This suggests salmon are more surface oriented during the day than at night. Since the culverts are placed on the bottom of the channel, salmon are less likely to be entrained if they remain near the surface.

Although overall salmon entrainment was lower this year, it appears the approximately 400 acoustically tagged salmon released upstream of the HORB were entrained at a similar rate as VAMP CWT salmon from previous studies. Acoustically tagged salmon were released at Durham Ferry and Mossdale as part of juvenile migration study in the south Delta (see Chapter 5). No acoustically tagged juvenile salmon from the first set of releases and two acoustically tagged salmon from the second set of releases were entrained at the HORB. The overall entrainment loss for acoustically tagged salmon was 0.5 % which is similar to VAMP CWT entrainment losses at the HORB from 2001-2004. It appears the modified gate operation did not benefit acoustically tagged salmon to the degree that it benefited unmarked salmon. However, the acoustically tagged salmon releases were very small compared to the relatively large VAMP CWT salmon releases of previous years. A single acoustically tagged salmon has a bigger impact on the entrainment loss calculation than a single CWT salmon has on the VAMP CWT entrainment loss calculation.

As in previous years with a barrier, a large amount of gravel was caught in the nets which resulted in three loss samples. It is recommended that VAMP delay any future CWT salmon releases by at least 5 days beyond the closure of the HORB. The delay allows for completion of the barrier and minimizes the field crew's exposure to heavy equipment operation. It also allows time for any loose material near the barrier to pass through the culverts before the nets are attached. If keeping outmigrating salmon out of Old River and in the San Joaquin River is beneficial to their survival, then it might be prudent to only open culvert numbers 1, 4 and 6 during peak salmon migration. It might be possible to further reduce salmon entrainment by opening the culverts closest to shore and only open culverts during daylight hours. A possible experiment to further test culvert gate operations on salmon entrainment is to only open culvert numbers 1, 2 and 3 for the first VAMP CWT salmon release and only open culvert numbers 4, 5 and 6 for the second VAMP release.

