Environmental Water Account Expenditures for Chinook Salmon in Water Year 2006

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The EWA was used for three actions taken in 2005-2006 for juvenile salmon. Unlike, previous years, no EWA costs were incurred for Delta Action 8 in early December 2005. EWA assets were used for and just prior to the Vernalis Adaptive Management Plan (VAMP) in late-April and May 2006, and for several days in June after the VAMP period. B(2) water was used concurrently with the EWA during some of these periods.

Winter and spring-run Chinook Loss

In 2005-2006 the loss of juvenile winter-run Chinook at the Delta Fish Facilities was 2601; well below the incidental take level of 76,626 authorized in the biological opinion for SWP/CVP operations. The percent loss of hatchery-origin juvenile winter-run Chinook, and the two groups of Coleman Hatchery late-fall-run Chinook serving as surrogates for out-migrating yearling spring-run Chinook never approached the incidental take levels (1%) for those releases. Accordingly, no EWA water was used during the winter and early spring months with the purpose of minimizing the entrainment loss of winter or spring-run Chinook.

Juvenile winter-run Chinook were lost at the Delta Fish Facilities in low numbers from mid-December to mid-February. Losses increased from mid-February through March, which was expected, and tapered off in April and early May (Figure 1). At the Delta Fish Facilities winter-run juveniles are identified using the Delta Model length-at-date criteria. The winter Chinook hatchery production of approximately 173,515 Chinook was released at Caldwell Park on February 2, 2006. Nine were recovered at the Delta Fish Facilities for an expanded loss of 125 or 0.07% of the total release (Figure 2). The Chinook were recovered between 2/28/2006 and 3/10/2006 and ranged in length from 100-113mm (avg. = 105mm). The incidental take level is set at 0.5% of the total release.

In 2005/2006 the November and December releases of hatchery late-fall Chinook surrogates were combined into one release. The release of approximately 131,000 late-fall Chinook was made on December 2, 2005 in coordination with the Delta Action 8 experiment. Twenty-three of these surrogates were recovered at the Delta Fish Facilities for an expanded loss of 420 or 0.32% of the total release (Figure 2). The surrogates were recovered between 12/19/2005 and 1/3/2006 and ranged in length from 114-190mm (avg. = 143mm). The incidental take level for all surrogate releases is 1% of the total release.

The second surrogate release of approximately 65,496 late-fall Chinook was made on January 19, 2006. Three of these surrogates were recovered at the Delta Fish Facilities for an expanded loss of 62 or 0.09% of the total release (Figure 2). The surrogates were recovered between 1/31/2006 and 3/6/2006 and ranged in length from 126-155mm (avg. = 143mm). High flows in late December and early January may have contributed to the lower than normal recoveries at the Delta Fish Facilities.

Delta Action 8

In past years, small amounts of EWA were used to control exports in an experiment to determine how relative juvenile salmon survival in the interior Delta was affected by exports. This experiment has been conducted almost annually since 1993. A large amount of background material and report on the Delta Action 8 experiments is provided at http://www.delta.dfg.ca.gov/jfmp/patfiles.asp . The overall question attempting to be addressed is: should exports be reduced in the November – January period from the present 65% E/I ratio to 35% to protect juvenile salmon migrating through the Delta at that time (Delta Action 8).

In December of 2005, coded wire tagged late-fall yearlings were released into the Delta at Georgiana Slough (interior Delta), Ryde (main stem Sacramento River)(Figure 3) and Port Chicago (just downstream of the confluence of the Sacramento and San Joaquin Rivers) as in many past years as part of Delta Action 8 experiments. Marked fish were recovered at Chipps Island (Figure 3) and will be recovered in future years in the ocean fishery. Recovery rates (and survival indices) of marked fish released in Georgiana Slough relative to those released at Ryde have been used to estimate relative interior Delta survival, which has then been regressed against mean Central Valley Project (CVP) and State Water Project (SWP) exports to determine if relative survival in the interior Delta is influenced by exports.

Past data and that generated in December of 2005, indicates that the survival of the Georgiana Slough group is significantly less than the Ryde or Isleton groups (Figure 4). The interior Delta survival ratio (recovery rates of the Georgiana Slough group relative to the Ryde/Isleton groups) is correlated to mean combined exports at the CVP and SWP for the three days after the Georgiana Slough release. The relationship using Chipps Island relative recovery rates is weaker ($p<0.10$) than that based on the ocean recovery rates ($p<0.05$) (Figure 5) but both indicate a similar response of interior Delta survival to exports. The ocean data has fewer data points ($n=13$ versus 15) but has higher recovery rates and lower variances than estimates based on recoveries at Chipps Island. The fact that these two measures of survival indicate the same type of relationship with exports gives us more confidence that the response is real.

The USFWS received a CALFED Science grant to review the design, implementation and interpretation of juvenile salmon coded wire tag experiments conducted in the Delta. As part of this process, Ken Newman, a statistician now with USFWS in Stockton, will be reviewing the results of Delta Action 8 and providing alternative analytical and statistical approaches. A summary of his analyses to date on Delta Action 8 data is

provided in Appendix A.

One of the limitations in interpreting the past data has been the variability in exports during the 10 to 14 day experimental period. To lessen this concern in 2005, we requested that EWA and B2 assets be used to stabilize combined SWP/CVP exports for the 10 day period following the Georgiana Slough release on December 8, 2005. The projects were successful at stabilizing exports with exports ranging between 10,371 cfs and 10878 cfs and averaging 10,600 during the 10 day period. Exports ranged between 8126 and 13,083 for the remainder of December. There were no water quality impacts associated with this request for Delta Action 8 experiment in 2005 and no EWA costs were incurred. If there had been any costs associated with keeping exports stable at the SWP during the course of the experiment, EWA had been willing incur them.

Another limitation in better understanding the relationship of interior Delta survival to exports is our inability to gather low export data for this 10 to 14 day period. There have only been a few times data has been gathered with low exports, and during these experiments, exports were only curtailed to low levels for a few days. Thus the average export values change dramatically for these low export tests, depending on what averaging period is used. Most of the variation in the relationships between interior Delta survival and exports occurs at the low export levels. Conducting an experiment with low exports for 10 to 14 days is very costly, but would result in a better test. The cost of a low export test is the difference in export levels for a curtailment versus those levels absent any curtailment. The high cost of a 10 to 14 day low export test has limited our ability to conduct this type of experiment.

The Delta Action 8 is an attempt to manipulate variables and test a hypothesis: Is relative interior Delta survival a function of exports? To better understand how overall survival between Sacramento and Chipps Island can be improved by reducing exports, the proportion of juvenile salmon diverted into the interior Delta must be known. However, the proportion of water and juvenile salmon diverted into the interior Delta is not a function of exports but one of tide, flow and channel velocity. Directly testing the influence of exports on survival between Sacramento and Chipps Island is more difficult since 1) the proportion of salmon entering the interior Delta from Sacramento likely changes between years and 2) survival is also affected by other factors which vary between years. The paired experimental design (Georgiana Slough versus Ryde) allows us to control for some of the other factors (flow, temperature, etc.) affecting survival because effects would be similar between groups within a year. Furthermore, we are assuming that exports do not or to a much lower level, affect the survival of juvenile salmon released at Ryde. Such pairings (treatment and control) make the ratios a better measure to use to assess the relative affect of exports.

On May 27, 2005 a workshop on Delta Action 8 was conducted by the CALFED Science Program. At that workshop, Brian Manly (statistical consultant) suggested the observed regressions between the Georgiana Slough/ Ryde survival ratio and exports were driven by water temperature, with the highest survival obtained at the lowest water temperature. However, the paired experimental design would theoretically factor out the role of water

temperature on survival, since the low water temperature would likely benefit both the control (Ryde) and treatment (Georgiana Slough) groups, with the ratio unaffected by temperature.

We have previously assumed that the proportion of fish diverted into the interior Delta was the same as the proportion of water diverted from the Sacramento River and resulted in different proportions depending on whether the Delta Cross Channel gates were open or closed. Radio tagging results obtained within the last five years has indicated that diversion into the Delta Cross Channel and Georgiana Slough is a function of DCC gate status as well as river flow and tidal conditions. For instance even with the DCC gates closed there appears to be variation in the proportion of fish diverted into Georgiana Slough depending upon the tides at the time the fish pass the Slough. In a study in 2001, a larger proportion of radio tagged fish appeared to enter Georgiana Slough when the tide was changing from an ebb to a flood than when it was ebbing (attachment 5 at http://www.delta.dfg.ca.gov/jfmp/patfiles.asp, D. Vogel, personal communication).

To determine how the survival of juvenile salmon migrating into the Delta from Sacramento might compare to those released in the interior Delta and the mainstem Sacramento, marked fish have been released at Sacramento and in the upper Sacramento River at Battle Creek in some years in conjunction with the Georgiana Slough and Ryde releases. There was a Battle Creek release but no Sacramento release in December of 2005, due to a spring power outage at the hatchery which killed many of the fish proposed for use in the Delta for this study. In three past years (2003-2005), the Sacramento release survived more similarly to those released at Ryde, indicating not many of them migrated into the interior Delta with the DCC gates closed (Backgound material). The release made at Battle Creek in 2006 (December 2) also survived more similarly to those released at Ryde than those released into Georgiana Slough, indicating most did not migrate into the interior Delta via Georgiana Slough with the DCC gates closed (Table 1).

One of the recommendations at the May, 2004 workshop was to combine coded wire tag releases in the future with ultrasonic tagging work to better determine how salmon split at various junctions in the Delta and to better understand how exports affect the entire juvenile salmon population migrating through the Delta from Sacramento. This recommendation has facilitated the planning of a paired coded wire tag and VEMCO ultrasonic tagging experiment in the Delta for December 2006 and January 2007. This experiment is designed to determine how many juvenile salmon released at Sacramento (in four discrete release groups over a 24 hour period) split at the various junctions with the DCC gates open and closed. The ultrasonic tags will be detected by receivers placed through-out the Delta as part of a larger CALFED Science experiment conducted by Peter Klimley (UC Davis), Bruce MacFarlane, Steve Lindley and Arnold Ammann (NOAA). The coded wire tag groups will be released at the same time the ultrasonic tags are released to provide two independent estimates of survival through the Delta for each case. Estimates will be compared and assessed to determine how best to measure survival through the Delta and assess the role of exports to interior Delta survival in future years. Further detail on the experiment planned this fall is available in Appendix

B.

A separate but coordinated ultrasonic tagging experiment in the Delta led by Jon Burau (USGS), will release HTI ultrasonic tags with the VEMCO and coded wire tagged fish released at Sacramento in December and January. The purpose of this ultrasonic tagging experiment is to determine how juvenile salmon migrate through a large bend in the river. They will be tracked 3 dimensionally through that area of the river and HTI receivers placed downstream will determine whether they go into Steamboat and Sutter Sloughs or stay in the main steam Sacramento River. The coded wire tagged fish will be used as targets in complimentary hydro-acoustic sampling (Appendix C).

These results of these and future ultrasonic and coded wire tagging experiments will help us better determine the role of exports on survival through the Delta.

Pre-VAMP Experiment

EWA was used for SWP curtailments between April 29 and May 2 to protect unmarked juvenile salmon migrating past Mossdale. Costs during this period were 3.4 taf.

VAMP Experiment

Between May 3 and June 2, the VAMP experiment was conducted, with 2006, the seventh year of a 12-year experiment. Spring flows in the San Joaquin River were too high to install a head of Old River Barrier (HORB), thus the experimental design was modified to better measure survival through the south Delta without a HORB. The VAMP is not only an experiment but a protective measure for naturally produced juvenile salmon migrating from the San Joaquin basin tributaries.

To take advantage of a unique opportunity, VAMP tests in 2006, were modified to evaluate the relative role exports on smolt survival at relatively high flows. Two VAMP tests were conducted; one at exports of 1500 cfs and one at exports of 6000 cfs. San Joaquin River flows were roughly 25,000 cfs for the entire VAMP period.

The start of the VAMP period was delayed in 2006 as it was in 2005 from the typical mid-April date to the beginning of May, to provide protection for a greater number of smolts expected to migrate through the Delta later than in drier years. EWA costs for modifying SWP pumping was 54.4 taf for VAMP export curtailments from May 3 – June 2.

Salmon smolt survival as indexed by the VAMP releases at Mossdale in 2006, suggested survival was greater for the first release, with the lower exports, than it was for the second release under higher exports. While the 95% confidence levels of the point estimates were significantly different, the confidence levels around the difference between the two estimates included 0, indicating no significant difference (Figure 6). Differential recovery rates using Chipps Island data has resulted in greater variance than with the combined ocean and Chipps Island recoveries (Figure 7). Thus it is likely that

the difference in survival estimates from the two 2006 experiments will show a significant difference once the ocean recoveries are complete.

The majority of salmon smolts sampled at Mossdale in 2006 migrated into the delta during the higher export period, later in May and early June. Some protection may have been provided by keeping exports at 6000 cfs and waiting until later in June to increase exports to higher levels.

Smolt survival estimates for the marked fish used in VAMP (with the HORB operating) were significantly lower in 2003 and 2004 than in previous VAMP years (2000-2002) (Figure 8). Relatively high river flows (~9000 cfs) were expected to be helpful to migrating smolts in 2005 but the HORB could not be installed and resulting survival somewhat higher, but still low. Flows were even greater in 2006 and while survival improved for the first release (0.12), the second release was similar to levels observed since 2003.

Updated analyses from all of the VAMP experiments (and those south Delta experiments prior to VAMP) do show statistically significant relationships between flow and smolt survival (using combined recoveries from the ocean and inland where available) from both Durham Ferry and Mossdale to Jersey Point with the HORB in place (Figure 9). The data without the HORB is more variable and not statistically significant (Figure 10), especially when 2005 and 2006 data are included. Recovery data for smolts released at Dos Reis (on the San Joaquin River, downstream of Old River) and Jersey Point suggests that survival on the San Joaquin River downstream of upper Old River, increases as flows increase (Figure 11). Again the relationship is much better when the 2005 and 2006 is excluded. This data would infer that the survival for the smolts that stay on the San Joaquin River when there isn't a HORB, will have higher survival as flows increase. Pilot ultrasonic tagging work suggests that most smolts released at Mossdale in 2006, did not migrate downstream on the San Joaquin River, but migrated through upper Old River (Attachment D). Our evidence indicates that this route on average has significantly higher mortality than those that migrate on the mainstem San Joaquin River (Table 2). Plus and minus 2 standard errors is roughly equivalent to the 95% confidence interval.

The role of exports on smolt survival has been problematic to identify. The VAMP design has two target conditions (exports at 1500 and 3000 cfs at 7000 cfs flows with the HORB) that were specifically included in the design to identify this relationship. Data need to be gathered at these target conditions to determine the export affect on smolt survival. Even though these target conditions are contained within the VAMP design for this purpose, they have not yet been tested due to hydrologic constraints in obtaining a 7000 cfs flow level when the HORB is in place. Experiments like those conducted in 2006, will help in determining the role of exports at a variety of flows without the HORB.

Adult escapement data (1952-2005) indicate that flows and flows/export do account for a significant amount of the variability in adult escapement (all year classes) even with the noise associated with the varying year classes within annual escapement. More of the variability in escapement is accounted for using flow/exports than when using flow alone,

when there was no HORB in place (Figure 12 and Figure 13). The best relationship for escapement in the years when the HORB was in place, for at least part of the migration season was with flow alone perhaps as a result of the narrow range of relatively low export levels (1,450 to 2,350 cfs) during the tests with the HORB.

The use of EWA and b2 water for Delta Action 8 and VAMP experiments will help in the long term to determine what conditions are best for juvenile salmon migrating through the Delta. Concerns for delta smelt and naturally migrating Chinook salmon limit test conditions such that the extremes in exports can not be tested within the negotiated framework. The experiments in 2006 were unique in that some separation in export conditions could be tested even when delta smelt abundance was low and concern for them was high. Thus it is important to test the extremes within the VAMP framework with the HORB in place if possible and continue to assess survival for the remaining years of the experiment.

The future of VAMP tests, with the HORB in place, appears uncertain. The delta smelt working group has recommended in the last few years, that the HORB not be installed during the VAMP period even if flows are low enough for its installation and operation. Recent results suggest survival through the Delta for smolts originating from the San Joaquin basin has been low since 2003 and does not appear to have rebounded with the higher flows in 2006 as has been the case in previous wet years. The smolts migrating from the San Joaquin basin need additional protection to increase their survival through the Delta. If the HORB cannot be installed, higher spring flows and lower exports, should be considered for testing. Continuing to measure survival through the Delta, in of itself, is valuable and will give an indication of the condition of stocks in the San Joaquin basin.

Post VAMP

In response to a sharp increase in juvenile Chinook salvage on June 5, the WOMT reduced combined pumping levels to 6,000 cfs until approximately June 24 when decreased salvage coupled with high Delta water temperatures indicated that smolt emigration from the San Joaquin system was nearly complete. The EWA cost for the post-VAMP export curtailment was 90.6 taf. This action was not directly related to the VAMP experiment and was initiated to extend protection to San Joaquin Basin Chinook outmigrants.

Table 1: Survival indices for groups of late-fall hatchery yearlings from Coleman National Fish Hatchery released upstream (Battle Creek) and in the Delta (Georgiana Slough, and Ryde).

TagCode	Release Site	Date	Time	Truck Temp (F)	River Temp (F)	# Released	Avg. Size (mm)	First Catch	Last Catch	# Recovered	Minutes Fished	% Time Sampled	Survival Index	Group Index
05-27-80	Battle Creek	12/2/2005	n/p	n/p	n/p	45475	116	12/17/2005	12/29/2005	17	2350	0.126	0.387	
05-27-81	Battle Creek	12/2/2005	n/p	n/p	n/p	80014	116	12/12/2005	2/10/2006	30	8562	0.097	0.500	
						125489		12/12/2005	2/10/2006	47	8562	0.097		0.500
05-27-84	Georgiana Slough	12/8/2005	1345	51	48	17631	123	-	-	0	-	-	0.000	
05-27-85	Georgiana Slough	12/8/2005	1345	51	48	17592	123	12/18/2005	12/19/2005	3	360	0.125	0.177	
05-27-86	Georgiana Slough	12/8/2005	1332	57	48	17515	122	12/22/2005	12/22/2005	1	200	0.139	0.053	
05-27-87	Georgiana Slough	12/8/2005	1332	57	48	17676	122	12/19/2005	12/20/2005	2	400	0.139	0.106	
						70414		12/18/2005	12/22/2005	6	960	0.133		0.083
05-27-88	Ryde (Koket)	12/9/2005	1330	51	48	12746	126	12/14/2005	12/20/2005	3	1360	0.135	0.227	
05-27-89	Ryde (Koket)	12/9/2005	1330	51	48	12255	125	12/16/2005	1/3/2006	8	3085	0.113	0.753	
05-27-90	Ryde (Koket)	12/9/2005	1340	53	48	12798	132	12/14/2005	12/27/2005	7	2560	0.127	0.560	
05-27-91	Ryde (Koket)	12/9/2005	1340	53	48	13218	127	12/15/2005	12/29/2005	6	2750	0.127	0.464	
						51017		12/14/2005	1/3/2006	24	3485	0.115		0.531

Table 2: Ratio between CDRR of marked smolts released at Dos Reis and upper Old River between 1985 and 1990.

Year	DR/UOR Ratio	SE	"+ 2SE	"- 2 SE
1985	0.989	0.008	1.005	0.973
1986	1.898	0.069	2.036	1.761
1987	2.479	0.129	2.736	2.222
1989	0.958	0.208	1.374	0.543
1989	4.349	1.075	6.499	2.199
1990	1.696	0.535	2.765	0.627
1990	3.169	1.049	5.267	1.070
Mean	2.220		2.681	1.758

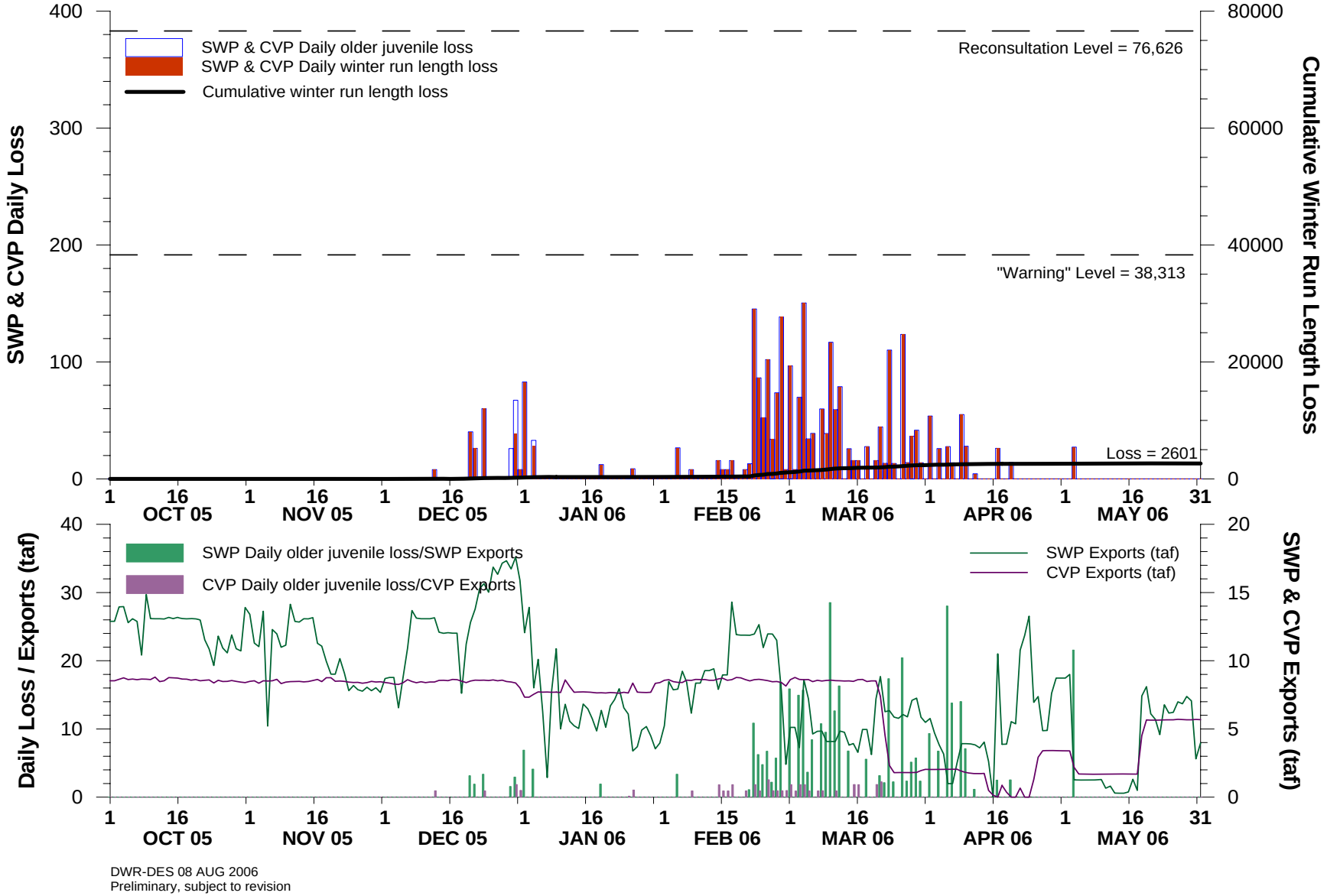

Figure 1. Winter-run and older juvenile Chinook loss at the Delta Fish Facilities, October 2005 through May 2006.

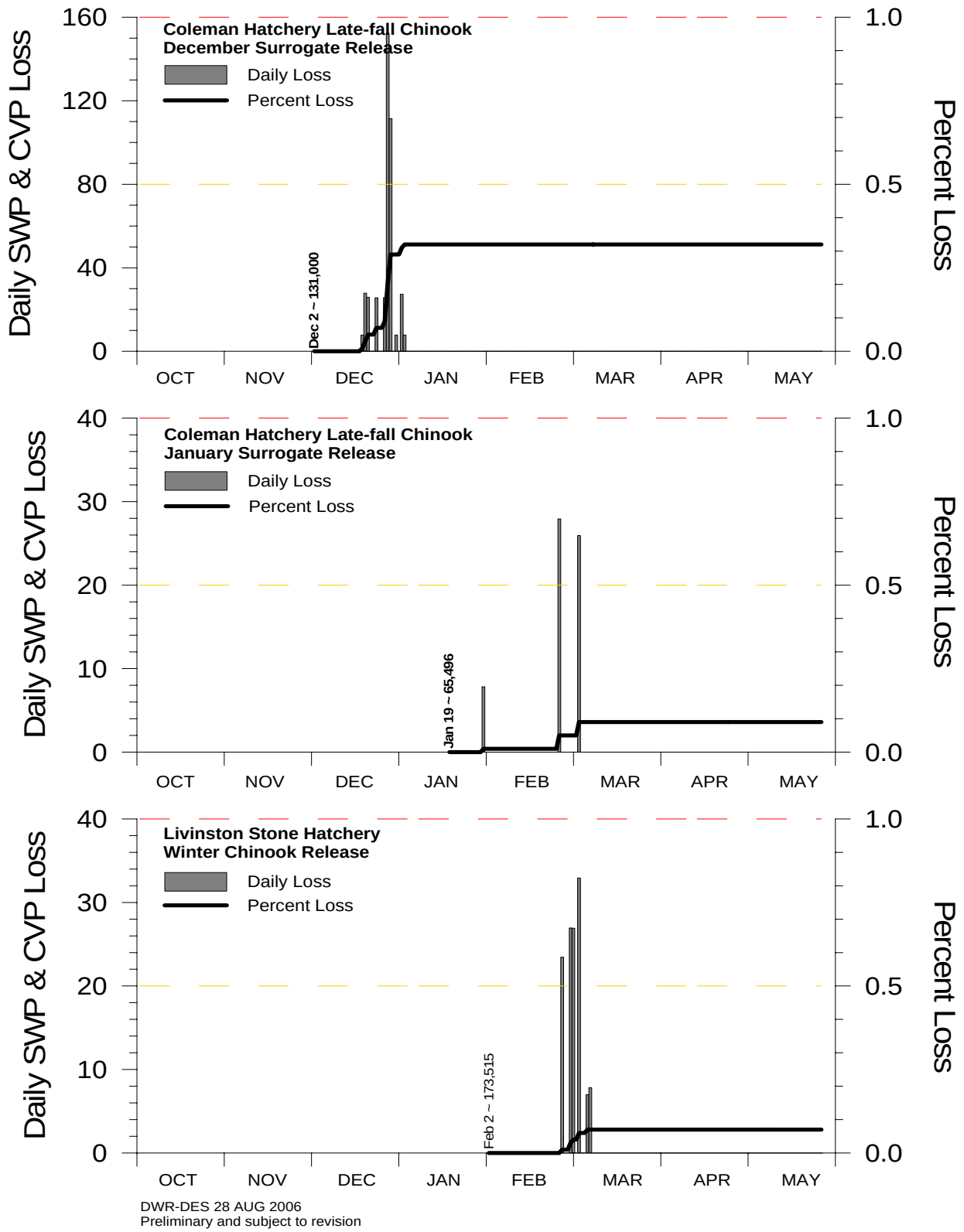

Figure 2. Coleman Hatchery late-fall and Livingston Stone Hatchery winter-run Chinook loss at the Delta Fish Facilities, October 2005 through May 2006.

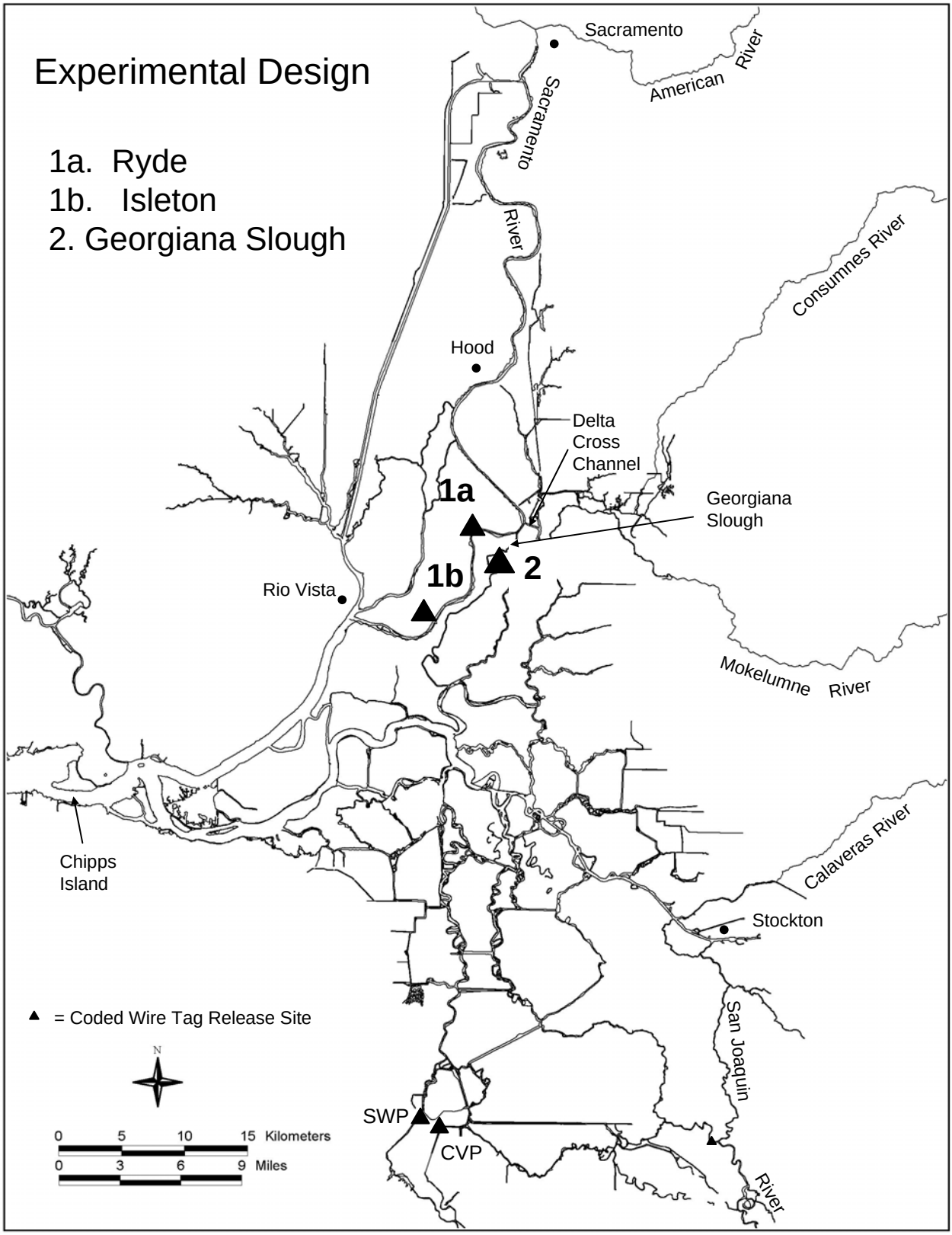

Figure 3. Experimental release sites for Delta Action 8

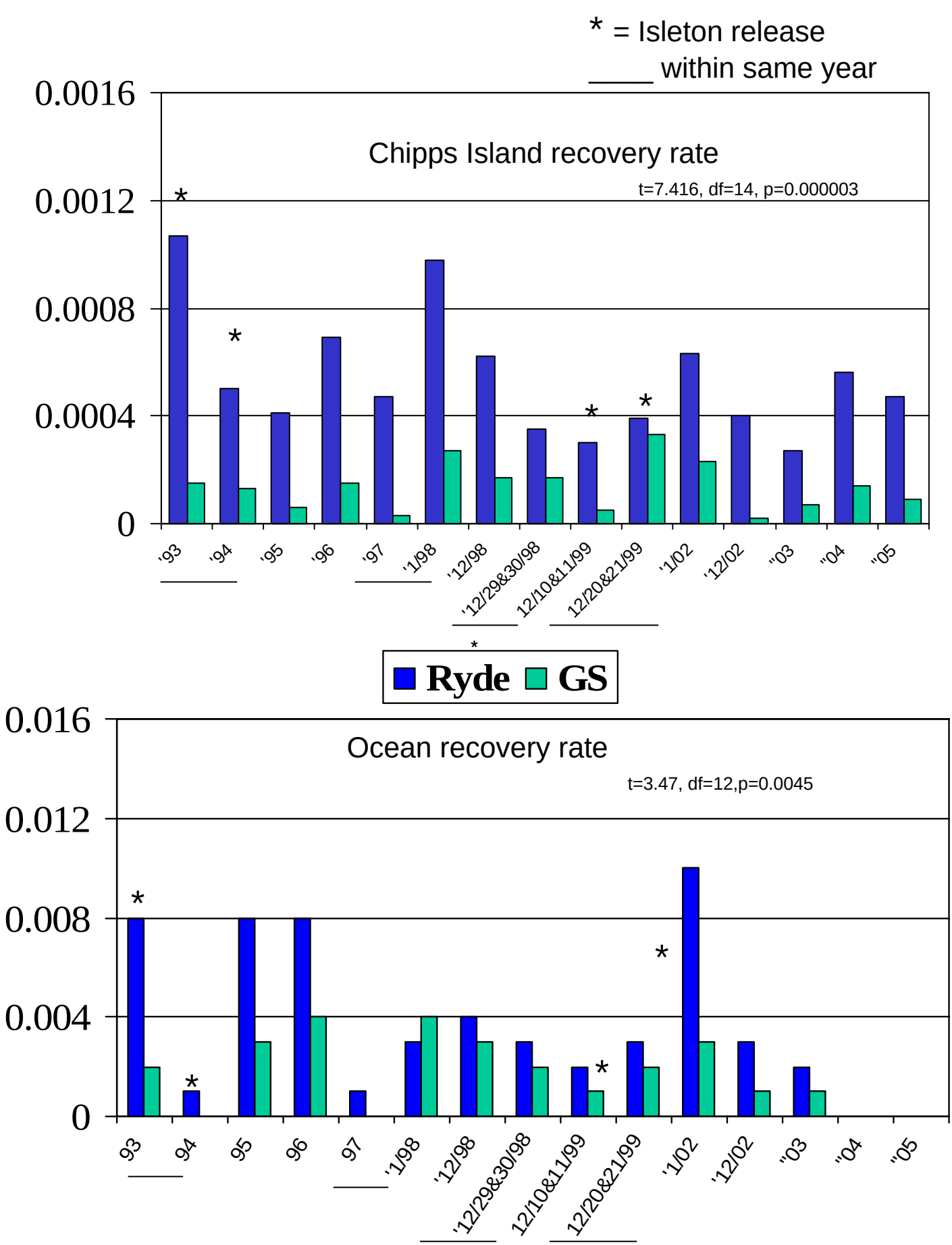

Figure 4. Relative recovery rates of marked fish released at Ryde or Isleton and Georgiana Slough between 1993 and 2005

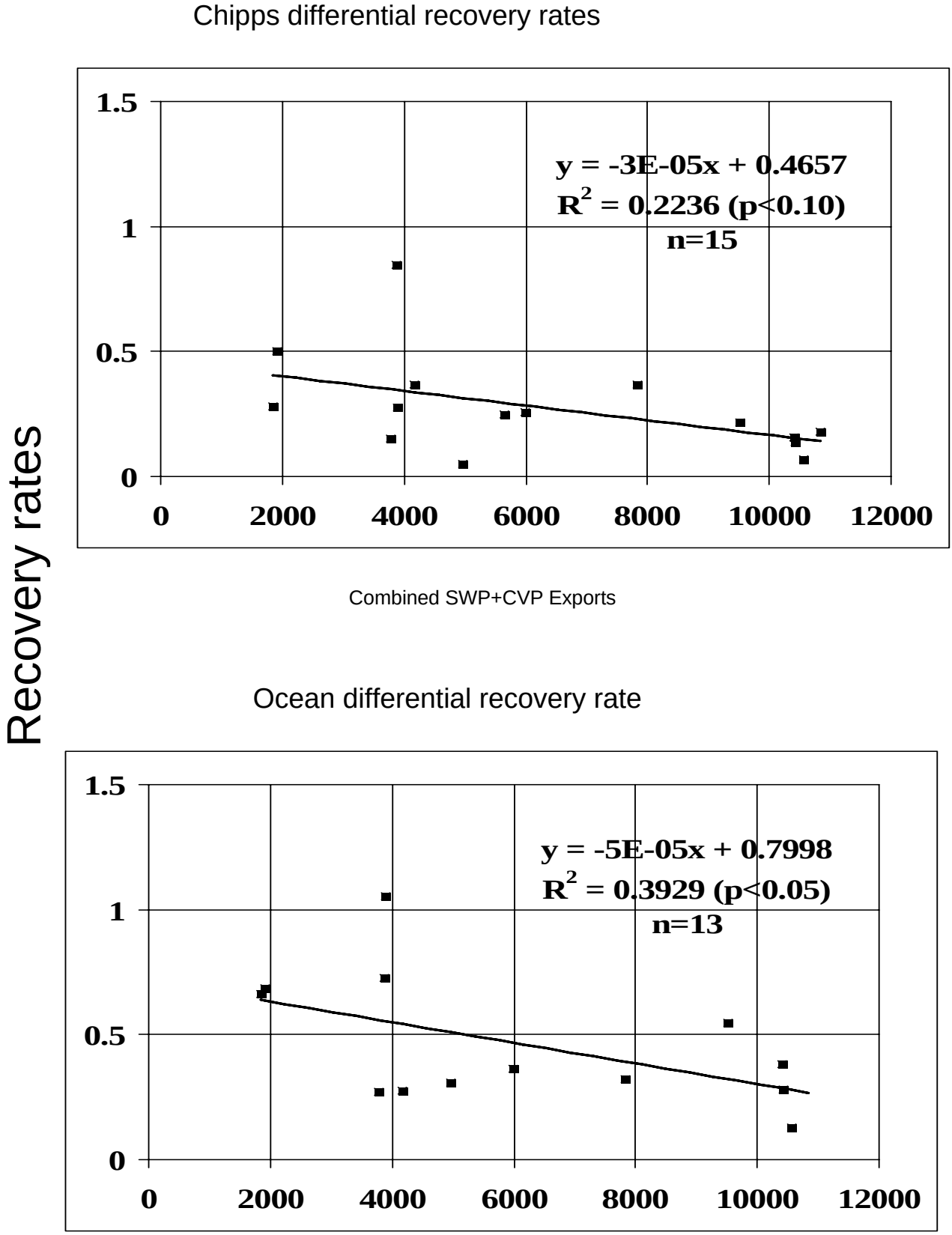

Figure 5: Differential Recovery Rates for late-fall released at Georgiana slough relative to those release at Ryde versus CVP+ SWP export s 3 day average after release

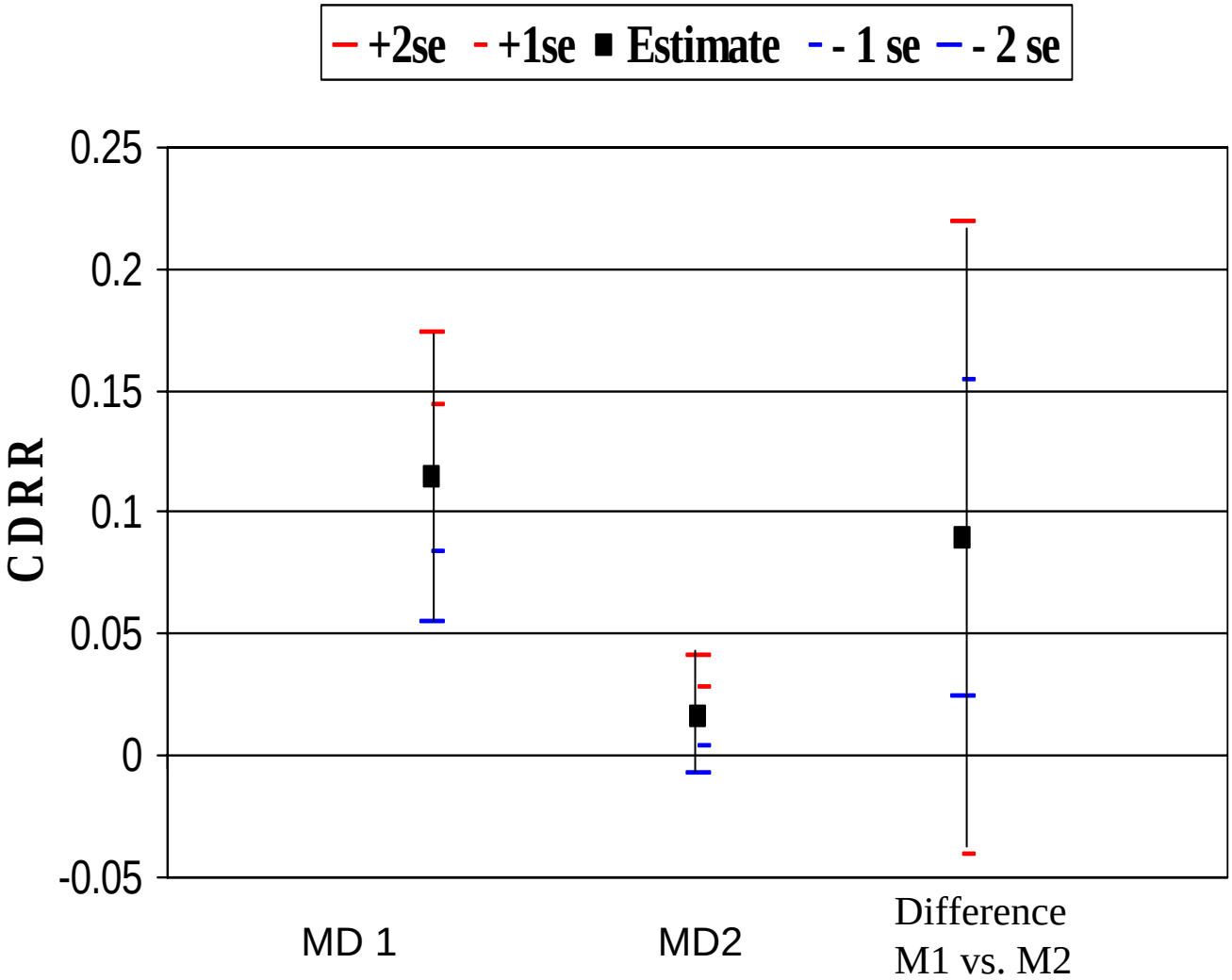

Figure 6: Combined Differential Recovery Rates (CDRR) (+ / - 1 and 2 standard errors) of CWT smolts released at Mossdale (MD) relative to those released at Jersey Point for the first (1), second (2) release groups and the difference between the 1st and 2nd release groups at Mossdale in 2006. The first release group had average exports for the 10 days after release of 1542 and the second release group had average exports of 6092.

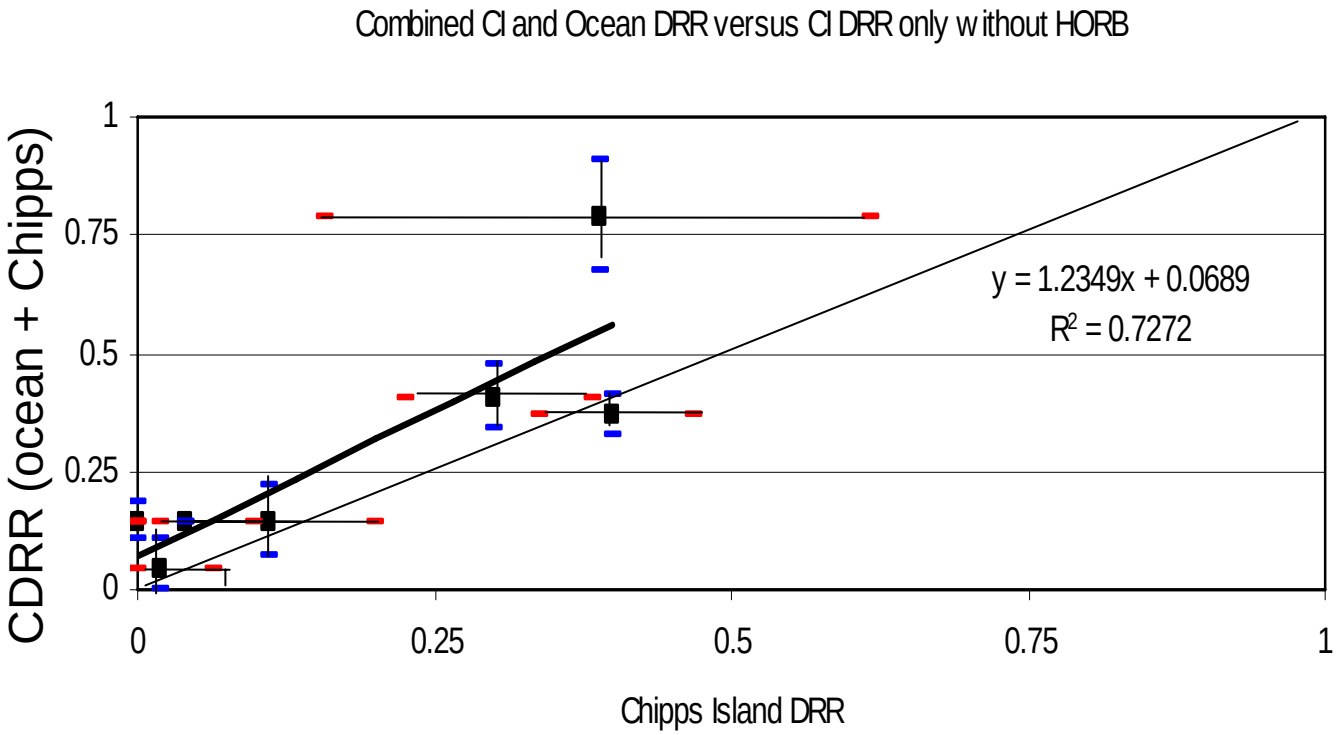

Figure 7: CDRR using ocean and Chipps Island recoveries versus just using Chipps Island recoveries (DRR)of the Mossdale or Durham Ferry and Jersey Point releases without the HORB in place.

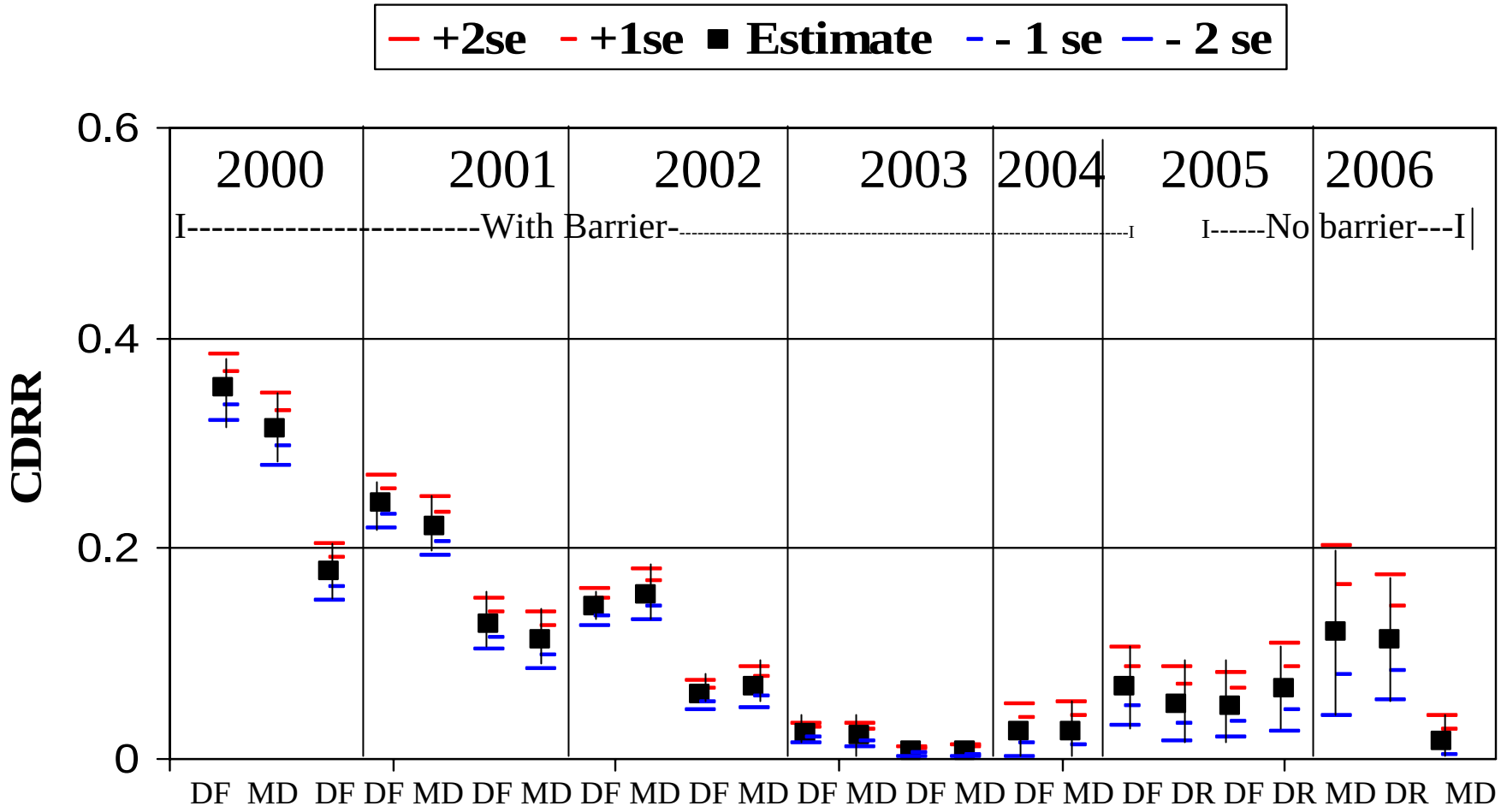

Figure 8: Combined Differential Recovery Rates (CDRR) (+ / - 1 and 2 standard errors) of CWT smolts released at Durham Ferry (DF), Mossdale (MD) and Dos Reis (DR) relative to those released at Jersey Point for the first and second release groups in 2000 – 2006. Recovery rates include recoveries from the Chipps Island, Antioch and ocean fishery for releases made prior to 2004. 2004 – 2006 data only includes recoveries from Antioch and Chipps Island. Only one set of releases was made in 2004.

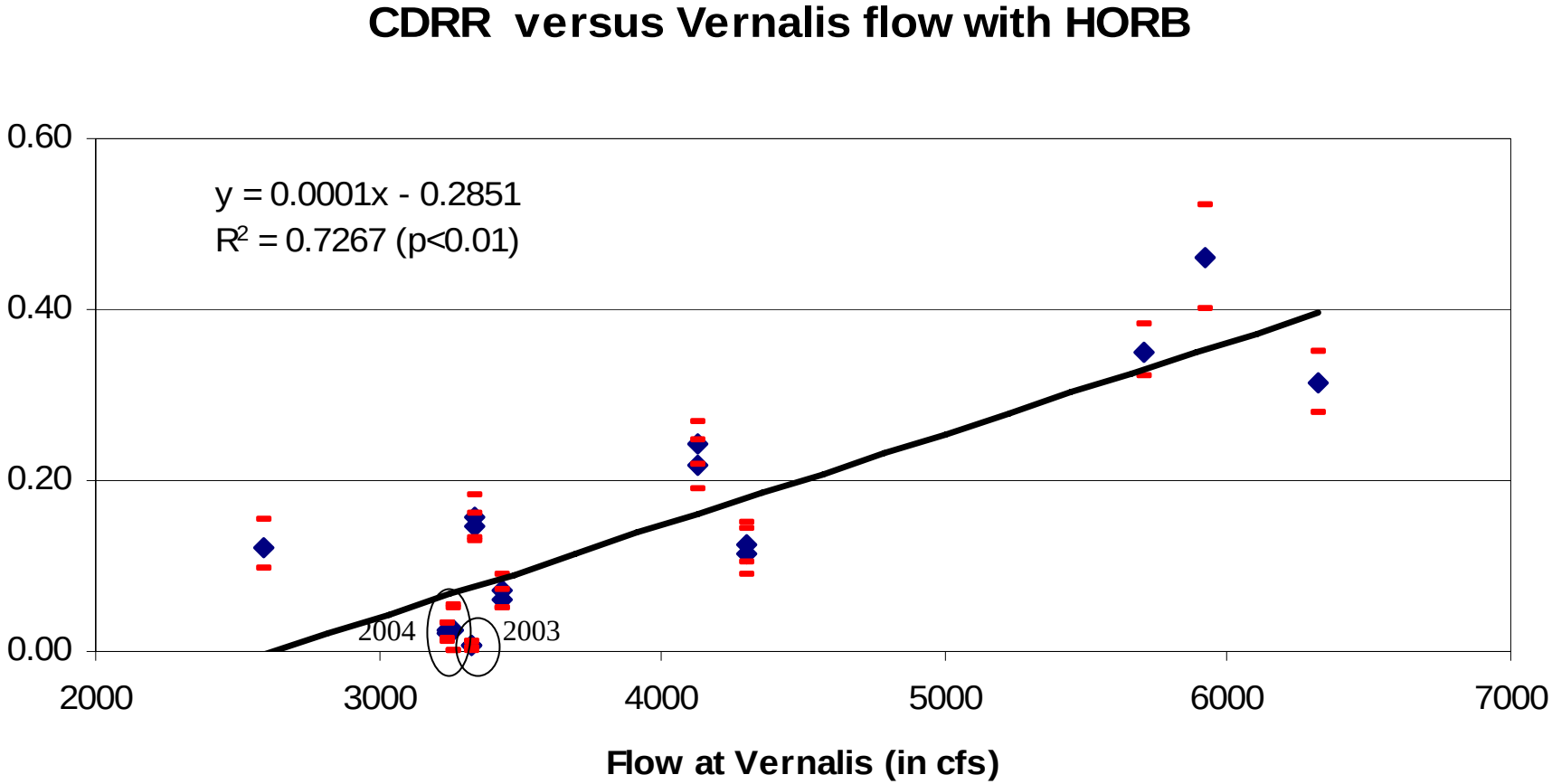

Figure 9: CDRR (point estimates of survival) plus and minus 2 standard errors using Chipps Island, Antioch and ocean recoveries, for groups released at Mossdale and/or Durham Ferry and Jersey Point in 1994, 1997, 2000-2004 and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release with the HORB in place. Antioch recoveries are not available for 1994 and 1997and ocean recoveries are not yet available for 2004 releases.

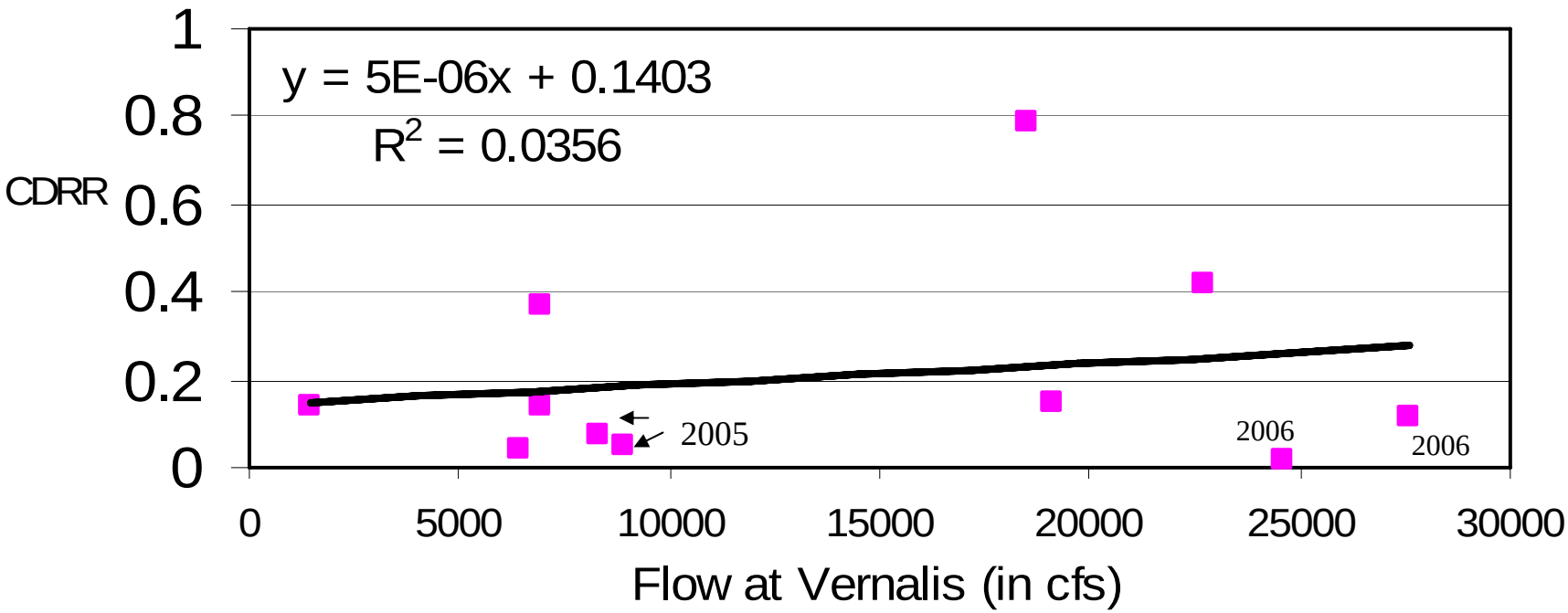

Figure 10: CDRR using combined Chipps Island and ocean recoveries between Mossdale or Durham Ferry and Jersey Point between 1994 - 1999.and 2005-2006 (the 2005 and 2006 only includes recoveries from Antioch and Chipps Island) and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release without the HORB in place.

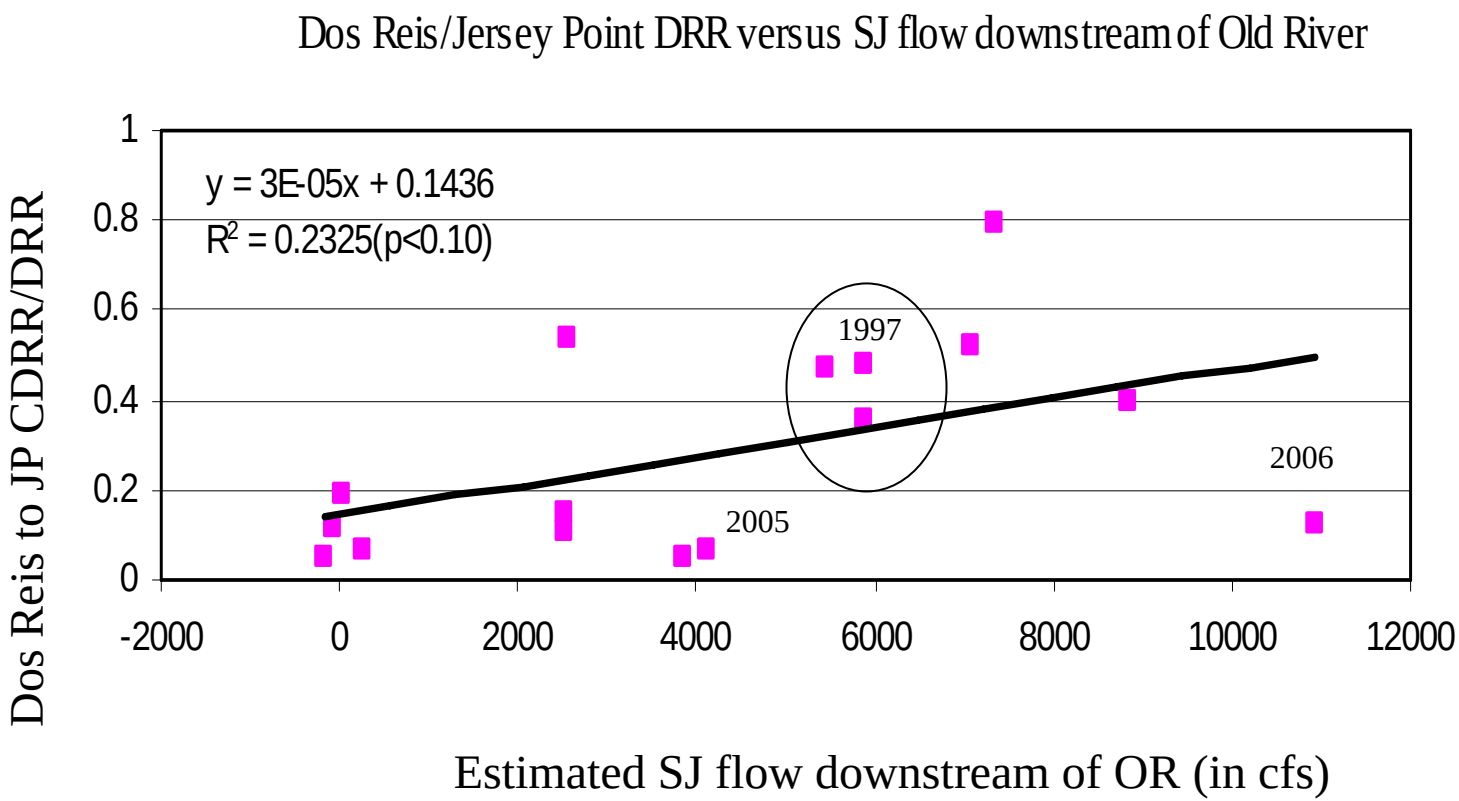

Figure 11: Survival between Dos Reis and Jersey Point (with recoveries at Chipps Island and the ocean fishery) with and without the HORB and estimated San Joaquin flows downstream of Old River between 1989 -1991, 1995-1999, 2005 and 2006. 1997 data was gathered with the HORB in place. 2005 and 2006 data only has Chipps Island and Antioch recoveries available at this time.

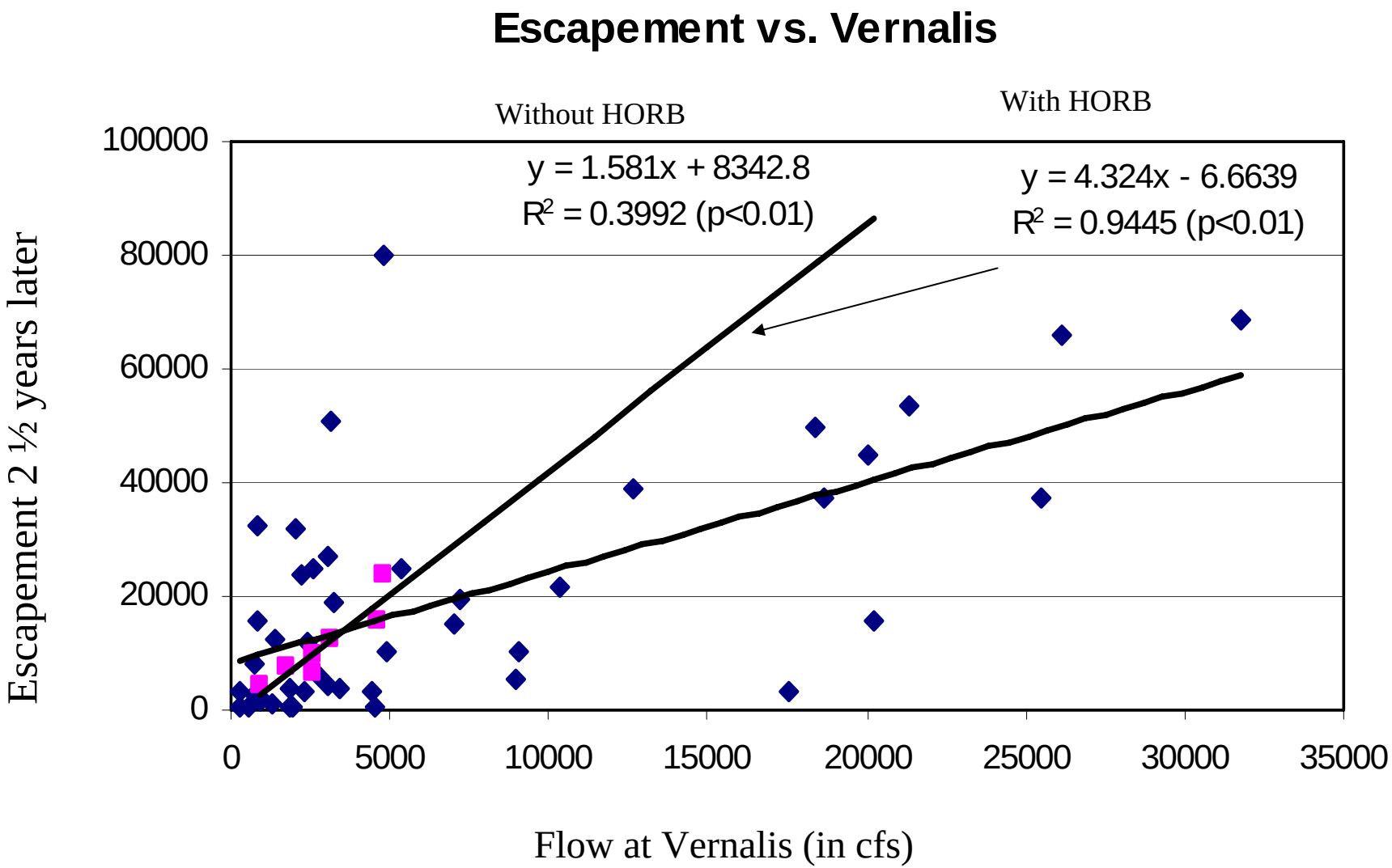

Figure 12: Vernalis flows (April 15 – June 15) versus escapement 2 ½ years later in years with and without the HORB between 1951 and 2003

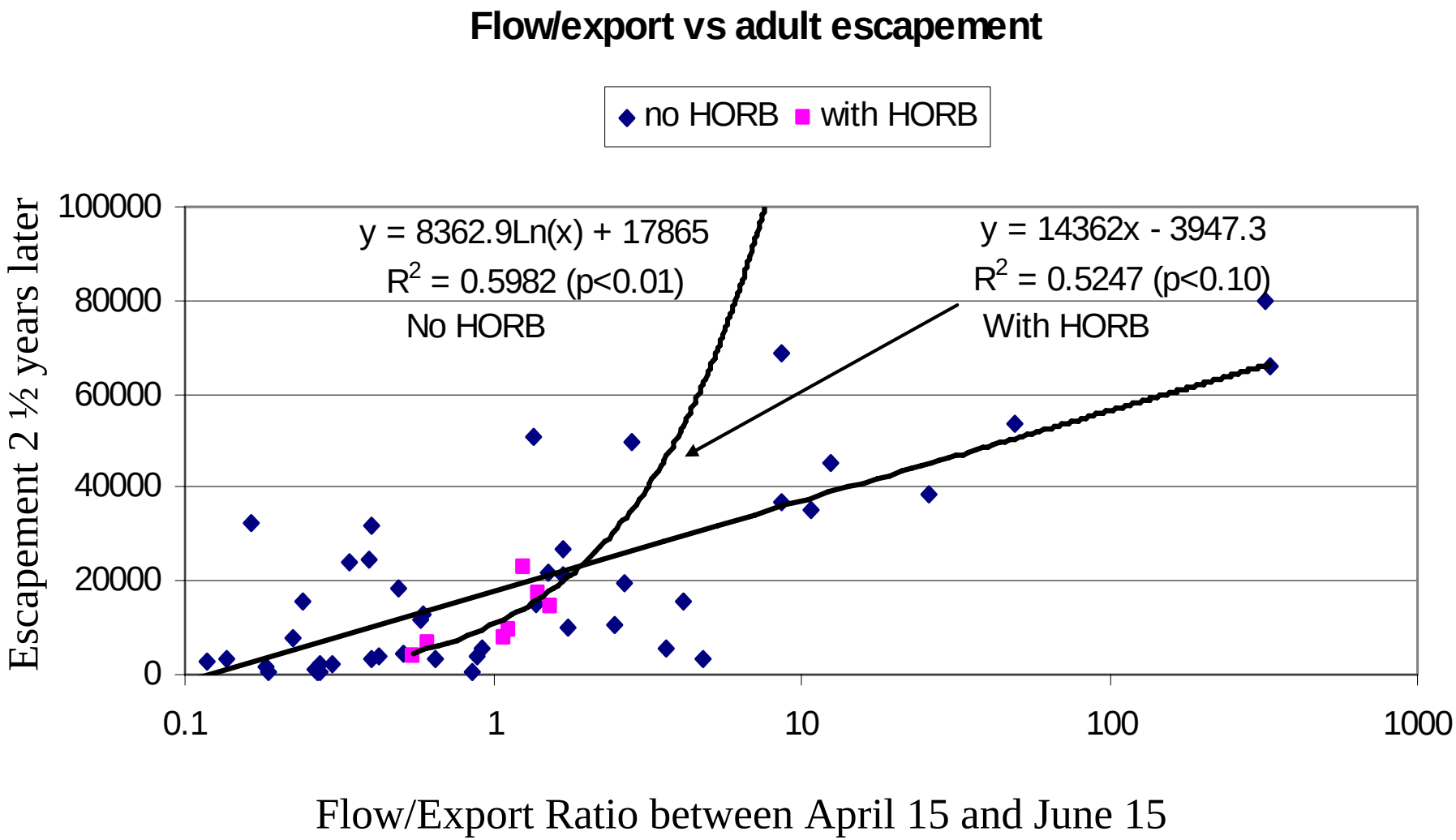

Figure 13: Vernalis flow/export ratio versus adult escapement 2 ½ years later in years with and without the HORB in place between 1951 and 2003.