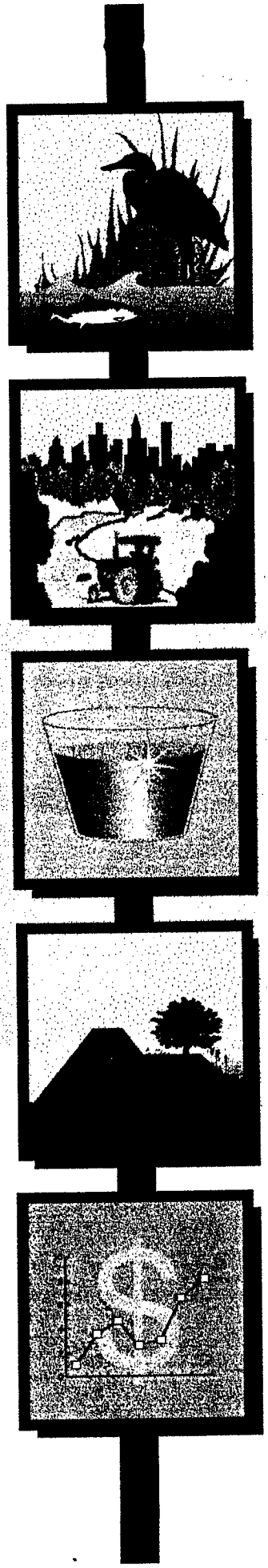
RON OTT/SAC



CALFED
BAY-DELTA
PROGRAM

DNCT
EWA Gaming Workbook

APPENDIX.

D-015938

D-015938

WATER SUPPLY

W.S

From: Bherbold@aol.com
Date: Tue, 11 May 1999 21:36:50 EDT
Subject: Effort to identify water supply priorites
To: Bherbold@aol.com, wrccwd@ccnet.com, swri@ix.netcom.com, dfullerton@n-h-i.org, ewinkler@mwd.dst.ca.us, jsnow@water.ca.gov, hydrobro@ix.netcom.com, Bjmill@aol.com, gchan@mwd.dst.ca.us, PFUJITANI-IBR21H@ibr2inet.mp.usbr.gov
CC: ronott@water.ca.gov
X-Mailer: AOL 4.0 for Windows 95 sub 4

Following a discussion with Dave Schuster a week ago I have written the attached email to describe an issue which I believe is a necessary next step in the DNCT gaming exercise if we are to have any hope of success for all three interest groups. Please read and respond soon. Thanks

WSUPPLY.WPD

This email is a solicitation of your interest and availability for a rather rapid development effort. If you would like to be part of this effort please reply with a list of your availabilities in the remainder of the month.

This email continues a discussion from several weeks ago where I suggested a need for more detailed information on what water supply and water quality targets the DNCT Gaming Effort should address. Grace Chan responded to that email and conversations with Dave Schuster and Dan Nelson have given me encouragement that we may be able to progress beyond the kinds of '400 TAF' positions that have so far represented water supply goals.

I am hopeful that we can develop a set of water supply targets and priorities that will reflect the water supply needs at a level of detail comparable to that which we have for biological resources.

> An example of the value of higher levels of detail in targets. For biological resources we have a series of priorities which have enabled the DNCT Gaming effort to identify which tools are most useful for various purposes and to assess how hydrological variability interacts with those tools. For example in drier years, we have generally found that water transfers can be used to back water up into Shasta in years when Shasta's carryover storage is projected to drop below 1.9. The water in Shasta can then be used to improve temperature conditions for Winter-run while it is being held and better water flow conditions for fall-run spawning when it is released in the Fall. The water can then be stored in San Luis to be transferred in exchange for a reduction in delta export rates when the salmon smolts are on their way through the delta in the winter or spring. Thus, under limiting hydrologies, it appears possible to achieve a high degree of improved biological protection by facilitating shifts in storage and export conditions from month to month. In wetter conditions, on the other hand, the DNCT gaming has often found that targeted levels of biological protection are often more difficult to meet because all facilities are in use in all months and there is greatly restricted access to storage or pumping capacity.

Grace Chan's summary of MWD's hopes raises a number of questions but does not provide much information to base our gaming effort around. She reports " [In] CALFED Stage 1, MWD is still looking for 1.8 MAF in wet years, 1.35 MAF on average,1.0 MAF for 1928-34 dry period, and 0.65 MAF in critical dry year. These demand numbers were developed before MWD member agencies require a blending salinity target to support their local recycling and groundwater programs. To meet blending targets, MWD would need on average an additional 200,000 AF if TDS is between 200 and 250 mg/l and 400,000 AF if TDS is between 250 and 300 mg/l."

This kind of summary of hoped-for outcome, like the CVP users demand for 200-400 TAF, provides little guidance to the game. If we can assume that no side is going to get everything they would like, it is then up to the game to pursue each user's need in each user's order of priority. The better we can understand the priorities of each user, the more likely we are to bring the DNCT to a satisfactory conclusion. To get a better understanding of priorities and how they might interact with other users, I pose a series of sample questions below. As before, I do not expect single, authoritative answers to these questions; I am describing my areas of ignorance of issues surrounding water supply and water quality that might lead to more active management by all parties in the gaming effort.

1. What San Joaquin River flows, in which month, represent times when deliveries to

Westlands are augmented by the James Bypass? Can we fit this into delta modeling so that environmental conditions in wet years better represent expected reality? Failure to do this requires unnecessary work for the EWA and may hide a way to generate water into the EWA at times of no impact on water users.

2. Are there wet years when reduced local demands, filled storage sites, or deliveries from other sources reduces MWD's need from the delta? If so, how can we fit this into delta modeling?

3. Are there dry and critically dry years when unimpaired flows and reservoir storage levels make increased deliveries an unsuitable target?

4. If degradations of water quality increase MWD's volumetric demand does an improvement reduce their needs by a similar amount? Can we use occasional regional exchanges that improve water quality to substitute for some quantity of water out of the delta. Using Grace's statements it appears that access to water with TDS less than 100 could free up enough water to satisfy the CVP target volume in drier years. Is that correct?

5. What is the best way to represent the shortages experienced by Westlands? Should we try to reduce the number of years when deliveries are less than 60%? Should we aim for raising the average over a multi-year period? All other things being equal, we would likely have very different impacts on water quality and fish if we tried to achieve four years at 75% vs two year at 50% and two years at 100%.

6. How does groundwater enter the gaming? Should we assume that groundwater is available in earlier years of a dry period and not in later years? How do different assumptions about groundwater availability affect delta operations and modeling?

Just as food for thought I have attached data on CVP deliveries from the base case DNCT has been using that includes the Accord, full b(2), and the Trinity. The data are presented as annual deliveries, percent of demand, a running average over 10 years of the percent of demand and the number of years in each ten year period when deliveries were greater than 60%. Clearly the choice of measure of success can greatly change what we would try to accomplish in any given year in the game. I suspect CalFed could, within stage I, develop a strategy that (a) increases the deliveries in years when deliveries are less than 40% of demand or (b) increases the number of years when deliveries are at least 60% or (c) facilitates transfers that bring deliveries up to 100% in many years or (d) ensures that average deliveries across any 10 year period are at least 65% or (e) works toward ensuring that any 10 year period contains 5 years with more than 75% deliveries. What should the measure of success be? Is there a high priority to ensure a minimum in all years and a second priority to achieve a higher minimum level in other years?

We already are seeing that some manipulations to protect fish result in benefits to water supply and water quality. If we can look at a year and identify the highest priority fish, WQ, and water supply needs we may be able to maximize benefits across uses.

YEAR	cvpdel	cvp%	cum%	yrs>60
1922	2953	89		
1923	2608	79		
1924	1247	38		
1925	2202	67		
1926	2071	63		
1927	2692	82		
1928	2546	77		
1929	1900	58		
1930	2082	63		
1931	1334	40	66	7
1932	1665	50	62	6
1933	1142	35	57	5
1934	1437	44	58	5
1935	2240	68	58	5
1936	2615	79	60	5
1937	2504	76	59	5
1938	3171	96	61	5
1939	2449	74	63	6
1940	2537	77	64	6
1941	2962	90	69	7
1942	2847	86	72	8
1943	2571	78	77	9
1944	2397	73	80	10
1945	2487	75	80	10
1946	2734	83	81	10
1947	2462	75	81	10
1948	2399	73	78	10
1949	2528	77	79	10
1950	2389	72	78	10
1951	2559	78	77	10
1952	3179	96	78	10
1953	2788	84	79	10
1954	2673	81	79	10
1955	2432	74	79	10
1956	2758	84	79	10
1957	2565	78	80	10
1958	2747	83	81	10
1959	2569	78	81	10
1960	2378	72	81	10
1961	2374	72	80	10
1962	2584	78	78	10
1963	2788	84	78	10
1964	2330	71	77	10
1965	2446	74	77	10
1966	2628	80	77	10
1967	2998	91	78	10
1968	2635	80	78	10
1969	3167	96	80	10
1970	2652	80	81	10
1971	2716	82	82	10
1972	2542	77	82	10
1973	2567	78	81	10

1974	2737	83	82	10
1975	2781	84	83	10
1976	1910	58	81	9
1977	1146	35	75	8
1978	2896	88	76	8
1979	2651	80	75	8
1980	2517	76	74	8
1981	2557	77	74	8
1982	2755	83	74	8
1983	3202	97	76	8
1984	2717	82	76	8
1985	2520	76	75	8
1986	2203	67	76	9
1987	2174	66	79	10
1988	1892	57	76	9
1989	2003	61	74	9
1990	1718	52	72	8
1991	992	30	67	7
1992	1297	39	63	6
1993	2756	84	61	6
1994	2352	71	60	6
AVG:	2411	73	74	9
MIN:	992	30	57	5
MAX:	3202	97	83	10

SUMMARY OF WATER SUPPLY DELIVERIES (TAF/YR)

					Accord + Upstream AFRP		Accord + in-Delta AFRP		
Game	Year	Water Supply Base For Game	Water Supply Added in Game	Total Water Supply in Game	Water Supply*	Game W.S. Relative to Accord + Upstream	Water Supply	Game W.S. Relative to Accord + In-Delta AFRP	Comments
	1991	2,169	15	2,184	2,339	-155	2,138	46	
	1992	2,816	135	2,951	3,101	-150	2,762	189	
	1993	5,774	135	5,909	5,797	112	5,471	438	
	1994	5,840	135	5,975	5,605	370	5,413	562	
1	1995		0	0		0		0	120 diverted but not delivered
	Game Avg. for 1991-4	4,150	105	4,255	4,211	44	3,946	309	
	Avg. for 73 Years	5,544		5,544	5,555	-11	5,329	215	
	Avg. for Crit. Yrs.	3,954		3,954	4,101	-147	3,845	109	
	1991	2,203	75	2,278	2,339	-61	2,138	140	95 EWA in SLR could have been borrowed
	1992	2,997	45	3,042	3,101	-59	2,762	280	
	1993	5,950	105	6,055	5,797	258	5,471	584	
	1994	5,803	135	5,938	5,605	333	5,413	525	
2	1995		15	15		15		15	120 in Webb at end of year
	Game Avg. for 1991-4	4,238	90	4,328	4,211	118	3,946	382	
	Avg. for 73 Years	5,606		5,606	5,555	51	5,329	277	
	Avg. for Crit. Yrs.	3,976		3,976	4,101	-125	3,845	131	
	1991	2,259	280	2,539	2,339	200	2,138	401	With 285 in initial storage
	1992	3,137	no game	no game	3,101	no game	2,762	no game	
	1993	6,030	300	6,330	5,797	533	5,471	859	
	1994	6,107	no game	no game	5,605	no game	5,413	no game	
3	1995		no game	no game		no game		no game	
	Game Avg. for 1991-4	4,383	290	4,435	4,211	367	3,946	630	
	Avg. for 73 Years	5,800		5,800	5,555	245	5,329	471	
	Avg. for Crit. Yrs.	4,077		4,077	4,101	-24	3,845	232	
	1991	2,172	0	2,172	2,339	-167	2,138	34	
	1992	2,746	0	2,746	3,101	-355	2,762	-16	
	1993	5,748	0	5,748	5,797	-49	5,471	277	
	1994	5,739	0	5,739	5,605	134	5,413	326	
4	1995			0		0		0	
	Game Avg. for 1991-4	4,101	0	4,101	4,211	-109	3,946	155	
	Avg. for 73 Years	5,493	0	5,493	5,555	-62	5,329	164	
	Avg. for Crit. Yrs.	3,897	0	3,897	4,101	-204	3,845	52	

*Assumes all Accord flow standards met at Vernalis and Trinity minimum flows at 340 TAF/yr.

SUMMARY OF WATER SUPPLY EXPORTS (TAF/YR)

						Accord + Upstream AFRP		Accord + All AFRP		
Game	Year	Historic Exports	Water Supply Base For Game	Water Supply Added in Game	Total Water Supply in Game	Water Supply*	Game W.S. Relative to Accord + Upstream	Water Supply	Game W.S. Relative to Accord + In-Delta AFRP	Comments
	1991	3,102	2,664	15	2,679	2,904	-225	2,638	41	
	1992	2,911	2,822	135	2,957	3,289	-332	3,017	-60	
	1993	4,840	6,705	135	6,840	6,533	307	6,123	717	
	1994	3,807	5,564	135	5,699	5,401	298	5,313	386	
1	1995	5,055		0	0		0		0	120 diverted but not delivered
	Game Avg. for 1991-4	3,665	4,439	105	4,544	4,532	12	4,273	271	
	Avg. for 73 Years	N/A	5,748		5,748	5,765	-17	5,533	215	
	Avg. for Crit. Yrs.	N/A	4,011		4,011	4,189	-178	3,930	81	
	1991	3,102	2,709	75	2,784	2,904	-120	2,638	146	95 EWA in SLR could have been borrowed
	1992	2,911	3,016	45	3,061	3,289	-228	3,017	44	
	1993	4,840	6,921	105	7,026	6,533	493	6,123	903	
	1994	3,807	5,517	135	5,652	5,401	251	5,313	339	
2	1995	5,055		15	15		15		15	120 in Webb at end of year
	Game Avg. for 1991-4	3,665	4,541	90	4,631	4,532	99	4,273	358	
	Avg. for 73 Years	N/A	5,814		5,814	5,765	49	5,533	281	
	Avg. for Crit. Yrs.	N/A	4,053		4,053	4,189	-136	3,930	123	
	1991	3,102	2,856	280	3,136	2,904	232	2,638	498	With 285 in initial storage
	1992	2,911	2,894	no game	no game	3,289	no game	3,017	no game	
	1993	4,840	7,160	300	7,460	6,533	927	6,123	1,337	
	1994	3,807	5,736	no game	no game	5,401	no game	5,313	no game	
3	1995	5,055		no game	no game		no game		no game	
	Game Avg. for 1991-4	3,665	4,662	290	5,298	4,532	580	4,273	918	
	Avg. for 73 Years	N/A	6,015		6,015	5,765	250	5,533	482	
	Avg. for Crit. Yrs.	N/A	4,148		4,148	4,189	-41	3,930	218	
	1991	3,102	2,660	0	2,660	2,904	-244	2,638	22	
	1992	2,911	2,772	0	2,772	3,289	-517	3,017	-245	
	1993	4,840	6,782	0	6,782	6,533	249	6,123	659	
	1994	3,807	5,569	0	5,569	5,401	168	5,313	256	
4	1995	5,055			0		0		0	
	Game Avg. for 1991-4	3,665	4,446	0	4,446	4,532	-86	4,273	173	
	Avg. for 73 Years	N/A	5,703	0	5,703	5,765	-62	5,533	170	
	Avg. for Crit. Yrs.	N/A	3,949	0	3,949	4,189	-240	3,930	19	

*Assumes all Accord flow standards met at Vernalis and Trinity minimum flows at 340 TAF/yr.

B.J. 1/12/99

D-015947

WRMI Studies Summary

	CALFED Years 4-7										
	Study 4A	Study 12	Study 13	Study 4AB	Study 4B	Study 4E	Study 4F	Study 4G	Study 4D	Study 5	Study 7
Base Criteria:											
Accord											
Upstream AFRP											
Additional Environmental Measures											
In Delta AFRP[7]											
QWEST[8]											
Facility Improvements/ Tools											
Expanded Banks	10,300			10,300	10,300	10,300	10,300	10,300	10,300	10,300	10,300
JPoD											
300 TAF Kern GW[1]											
50 TAF Castaic flex[2]											
100 TAF Purchase Options[3]											
Madera Ranch[4]											
In-Delta Storage[5]											
[illegible]											
[illegible]											

Caveats:
1st Yr. tools used to mitigate In-Delta AFRP impact to:

73 Year Averages:											
Total Deliveries	5849	5961	6081	5708	5786	5952	5934	5874	5887	4412	6003
Difference from Base	266	378	498	125	203	369	351	291	304	-1171	420
1928-1934 Average											
Total Deliveries	4232	4354	4739	4153	4207	4391	4336	4303	4381	2696	4539
Difference from Base	93	216	601	14	68	252	197	164	242	-1443	400
1987-1992 Average											
Total Deliveries	4150	4275	4596	4039	4114	4299	4219	4255	4315	1365	4490
Difference from Base	187	312	633	76	152	336	256	293	352	-2598	527

1 Kern Water Bank max use = 150 TAF/year (500 cfs put/take)
2 50 TAF of MWD storage in Castaic leased per year
3 Purchases limited to 30 TAF per month between May and November only
4 Madera Ranch max use = 400 TAF, 120TAF/year (400 cfs put/take) Apr-Oct
5 In-Delta storage use = 200 TAF, used in April, May, and July only, part of COA, not considered exports.
6 Export-to-Inflow ratios per WR Order 98-9 eliminated.
7 In-Delta Actions include 1, 3, 4, 5, 6, and 7
8 QWEST >0 Nov-Jan, if Jan 8ri >= 1 MAF Qwest >= 1000 cfs Feb-Mar, else Qwest >=0 Feb-Mar

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WRMI Studies Summary

	CALFED Years 1-4											
	Base	Study 10	Study 11	Study 0B	Study 9	Study 8A	Study 8B	Study 1	Study 1B	Study 2	Study 6	Study 3
Base Criteria:												
Accord												
Upstream AFRP												
Additional Environmental Measures												
In-Delta AFRP [7]												
QWEST [8]												
Facility Improvements/ Tools												
Expanded Banks								8,500	8,500	8,500	8,500	8,500
JPoD												
300 TAF Kern GW [1]												
50 TAF Castaic flex [2]												
100 TAF Purchase Options [3]												
Madera Ranch [4]												
In-Delta Storage [5]												
[illegible]												
[illegible]												

Caveats:
1st Yr. tools used to mitigate In-Delta AFRP impact to:

73 Year Averages:												
Total Deliveries	5583	5710	5808	5519	4158	5633	5553	5809	5666	5736	5834	4243
Difference from Base		127	225	-64	-1425	50	-30	226	83	153	251	-1340
1928-1934 Average												
Total Deliveries	4139	4257	4581	4058	2341	4145	4125	4208	4131	4195	4317	2489
Difference from Base		118	442	-81	-1797	6	-14	70	-8	56	178	-1650
1987-1992 Average												
Total Deliveries	3963	4052	4325	3868	1134	3960	3966	4074	3997	4081	4098	1221
Difference from Base		90	362	-95	-2829	-2	3	112	34	118	135	-2741

1 Kern Water Bank max use = 150 TAF/year (500 cfs put/take)
2 50 TAF of MWD storage in Castaic leased per year
3 Purchases limited to 30 TAF per month between May and November only
4 Madera Ranch max use = 400 TAF, 120TAF/year (400 cfs put/take) Apr-Oct
5 In-Delta storage use = 200 TAF, used in April, May, and July only, part of COA, not considered exports.
6 Export-to-Inflow ratios per WR Order 98-9 eliminated.
7 In-Delta Actions include 1, 3, 4, 5, 6, and 7
8 QWEST >0 Nov-Jan, if Jan Bri >= 1 MAF Qwest >= 1000 cfs Feb-Mar, else Qwest >=0 Feb-Mar

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FIGURE 1

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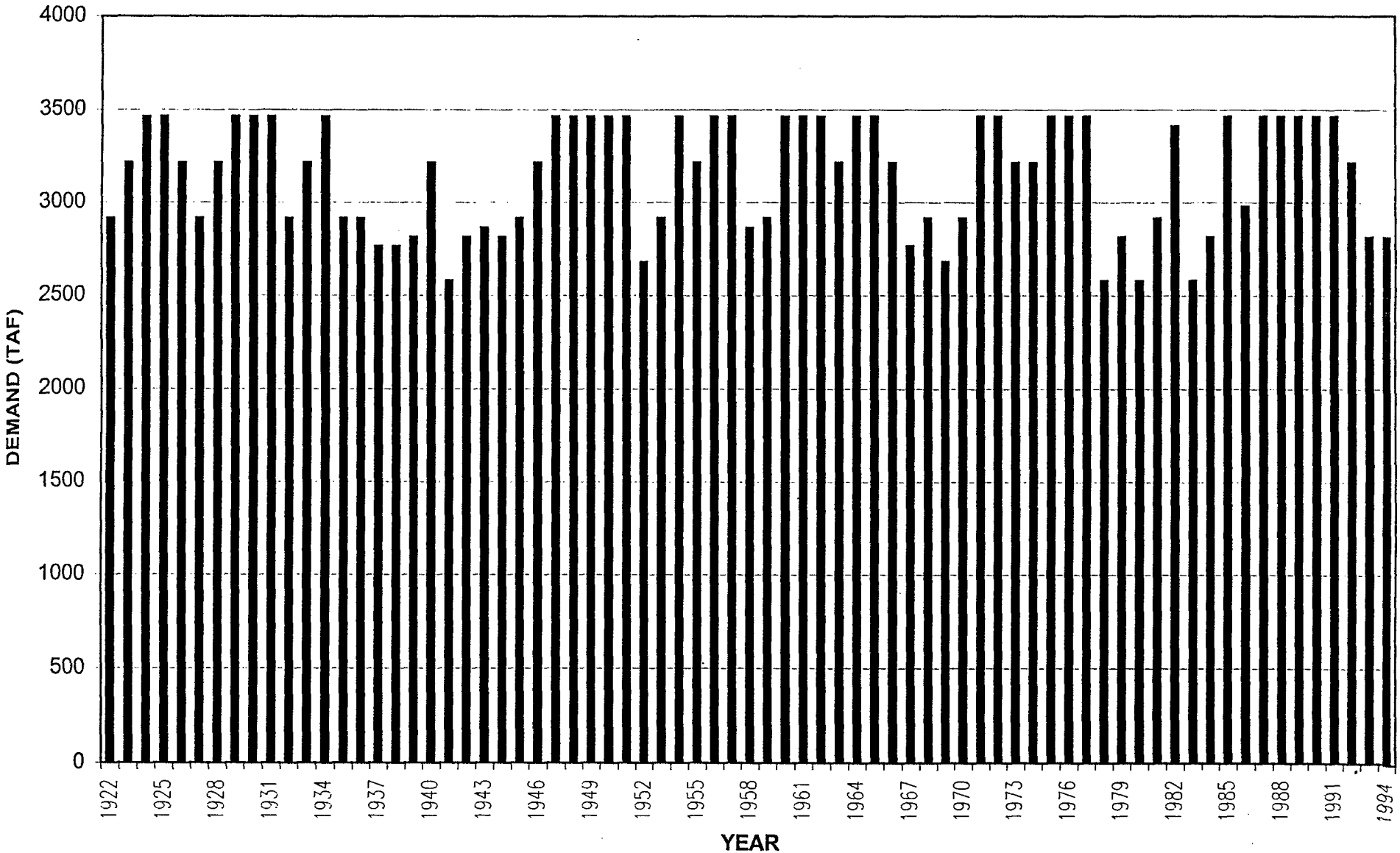
TOTAL ANNUAL 1995 LEVEL SWP DEMAND
(Not including losses)



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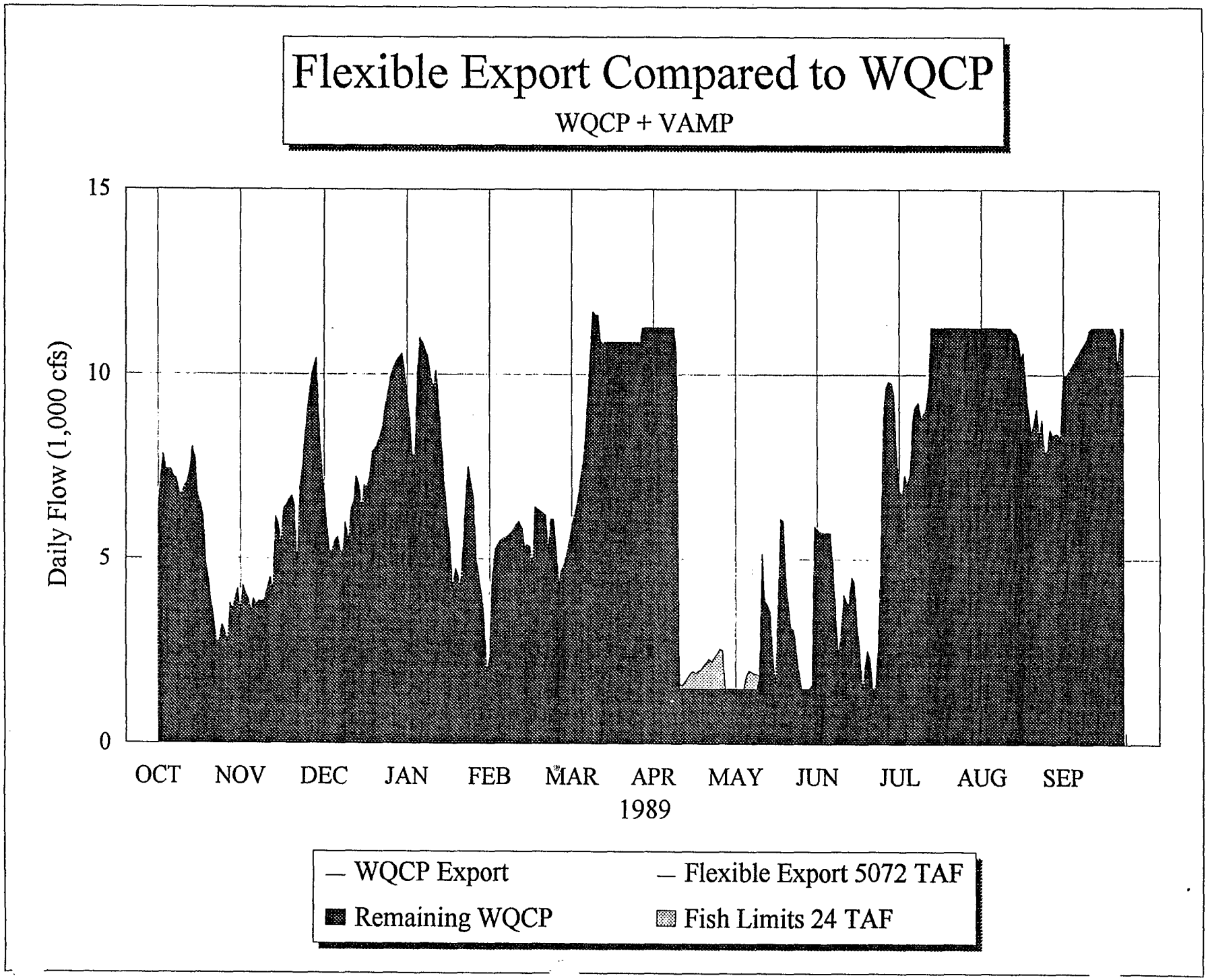

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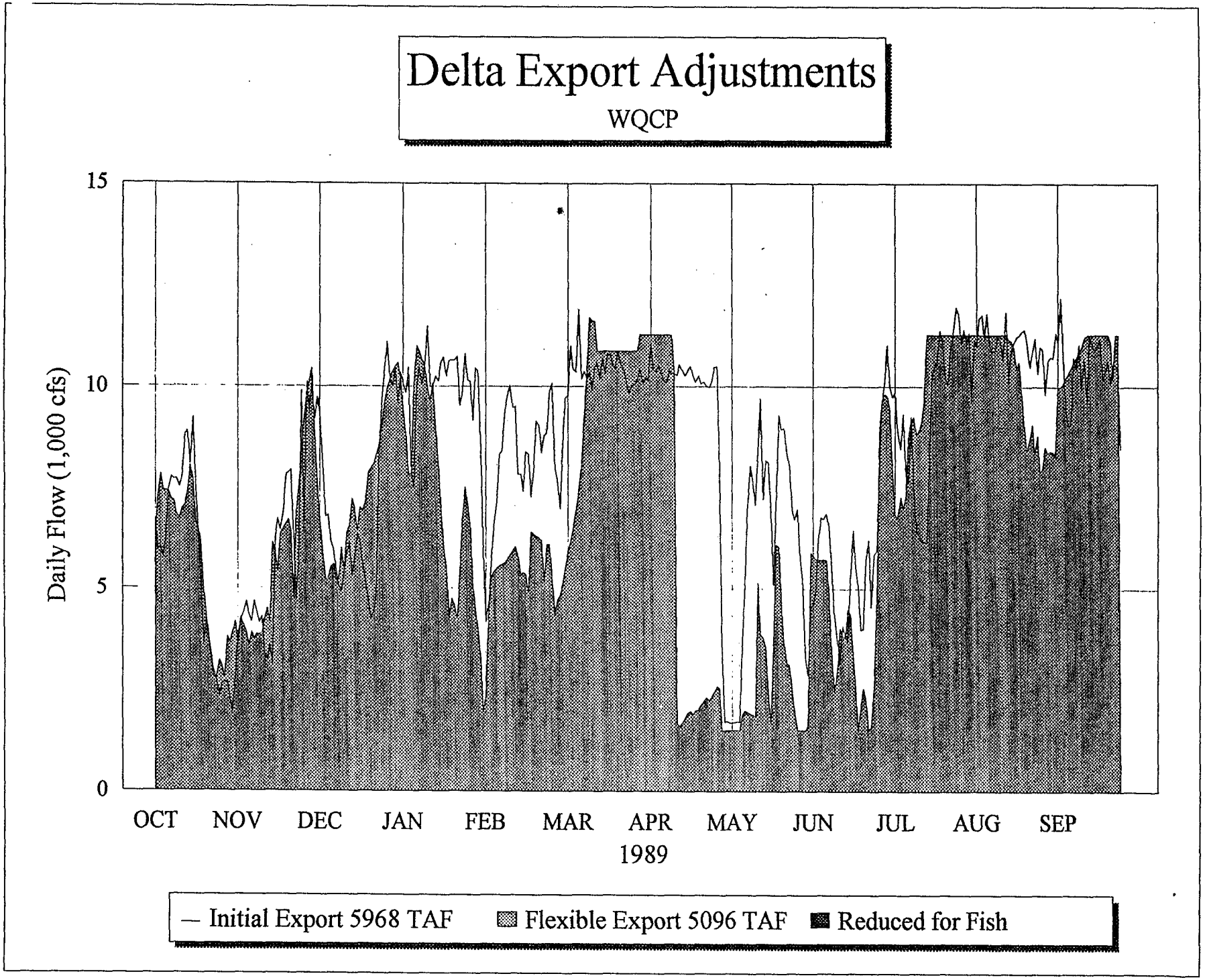

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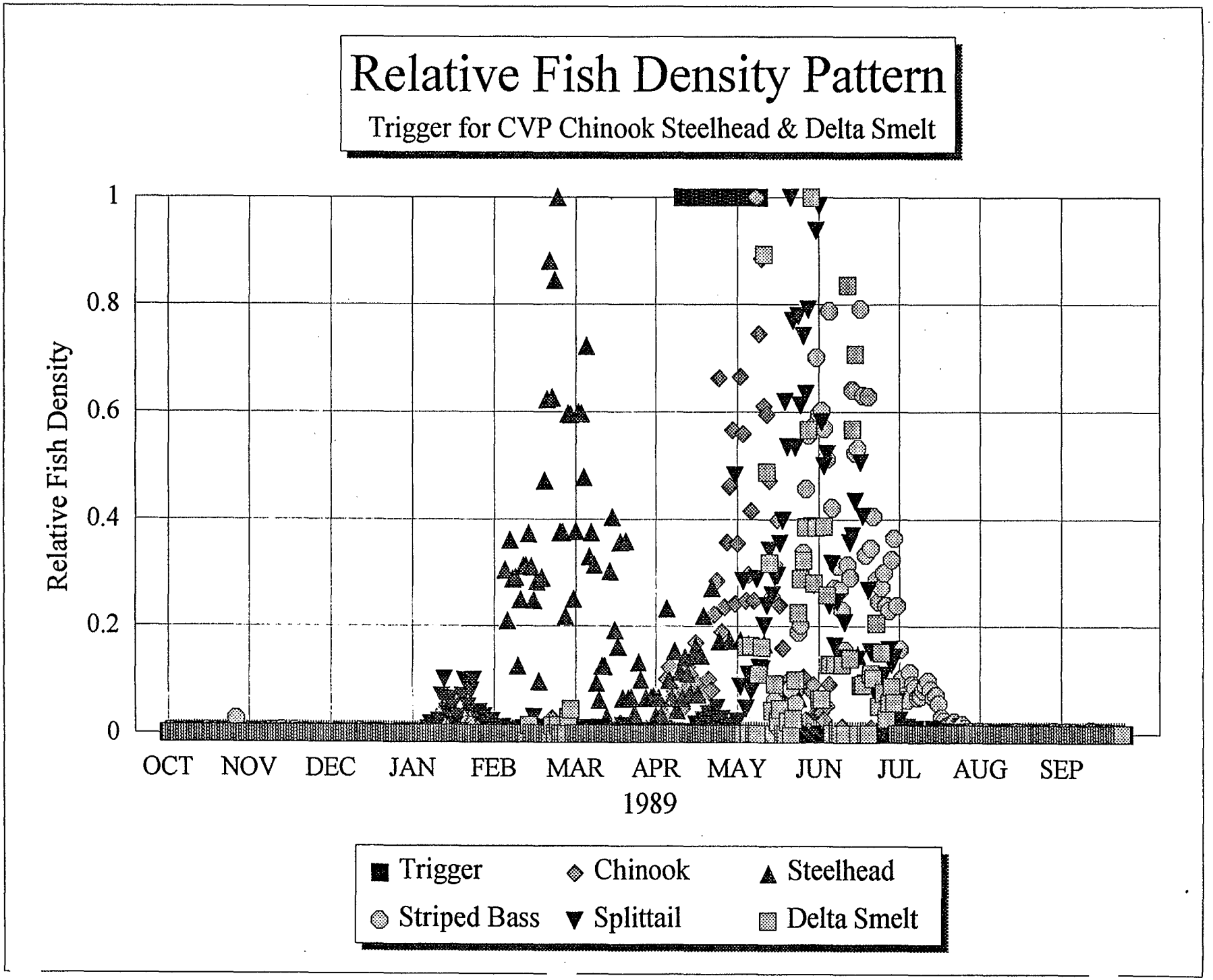

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Demonstration of Flexible Operations

Example 1: Use CVP Salvage Density for 1) Chinook 2) Steelhead 3) Striped Bass 4) Splittail 5) Delta Smelt
Set triggers to protect 50% of 1) Chinook 2) Steelhead 3) Delta Smelt assuming full export pumping
Triggers inlcude a total of 63 days; 13 days within the VAMP window (April 15 to May 15)

Case	Total Exports (TAF)	Change in Exports from WQCP (TAF)	Export Reduction for Fish Trigger (TAF)		Chinook Salvage (fish)	Steelhead Salvage (fish)	Striped Bass Salvage (fish)	Splittail Salvage (fish)	Delta Smelt Salvage (fish)
1989 Historical	5968	872	0		23,000	4,500	2,980,000	106,000	2,960
WQCP (No SJR Pulse)	5096	0	0	Base Salvage	12,200	3,365	2,590,000	67,000	2,370
WQCP + VAMP (30 days)	5072	-24	24	Salvage	11,600	3,340	2,590,000	66,600	2,360
				% Reduced	5%	1%	0%	1%	0%
WQCP & Fish Triggers	4726	-370	369	Salvage	9,475	1,890	2,055,000	52,000	1,430
				% Reduced	22%	44%	21%	22%	40%
Full Capacity & Fish Triggers	5088	-8	377	Salvage	9,640	2,135	2,090,000	52,700	1,430
				% Reduced	21%	37%	19%	21%	39%
Full Cap + No E/I & Triggers	5439	343	609	Salvage	9,820	2,260	2,150,000	55,000	1,440
				% Reduced	15%	32%	17%	17%	39%
Full + No E/I + X2=7100 & Triggers	5518	422	701	Salvage	11,325	2,265	2,185,000	70,000	1,500
				% Reduced	2%	32%	16%	-5%	36%

Full Pumping allowed higher exports in March, April, July, August, September.

Relaxed E/I allowed higher exports in November, December, January, February, September.

Relaxed X2 allowed higher exports in May.

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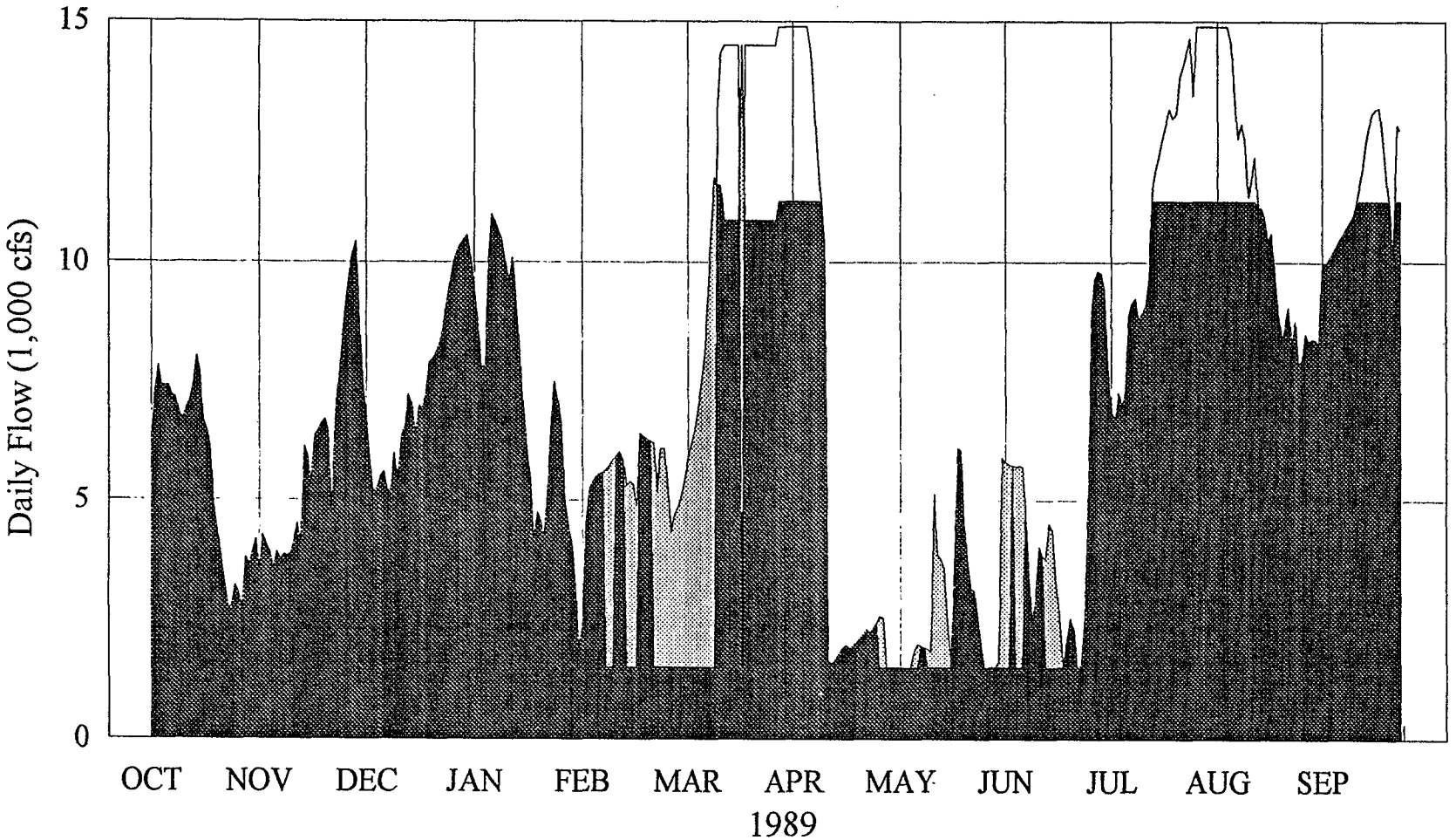
Flexible Export Compared to WQCP

Full Capacity + Triggers



— WQCP Export
— Flexible Export 5088 TAF
Remaining WQCP
Fish Limits 377 TAF

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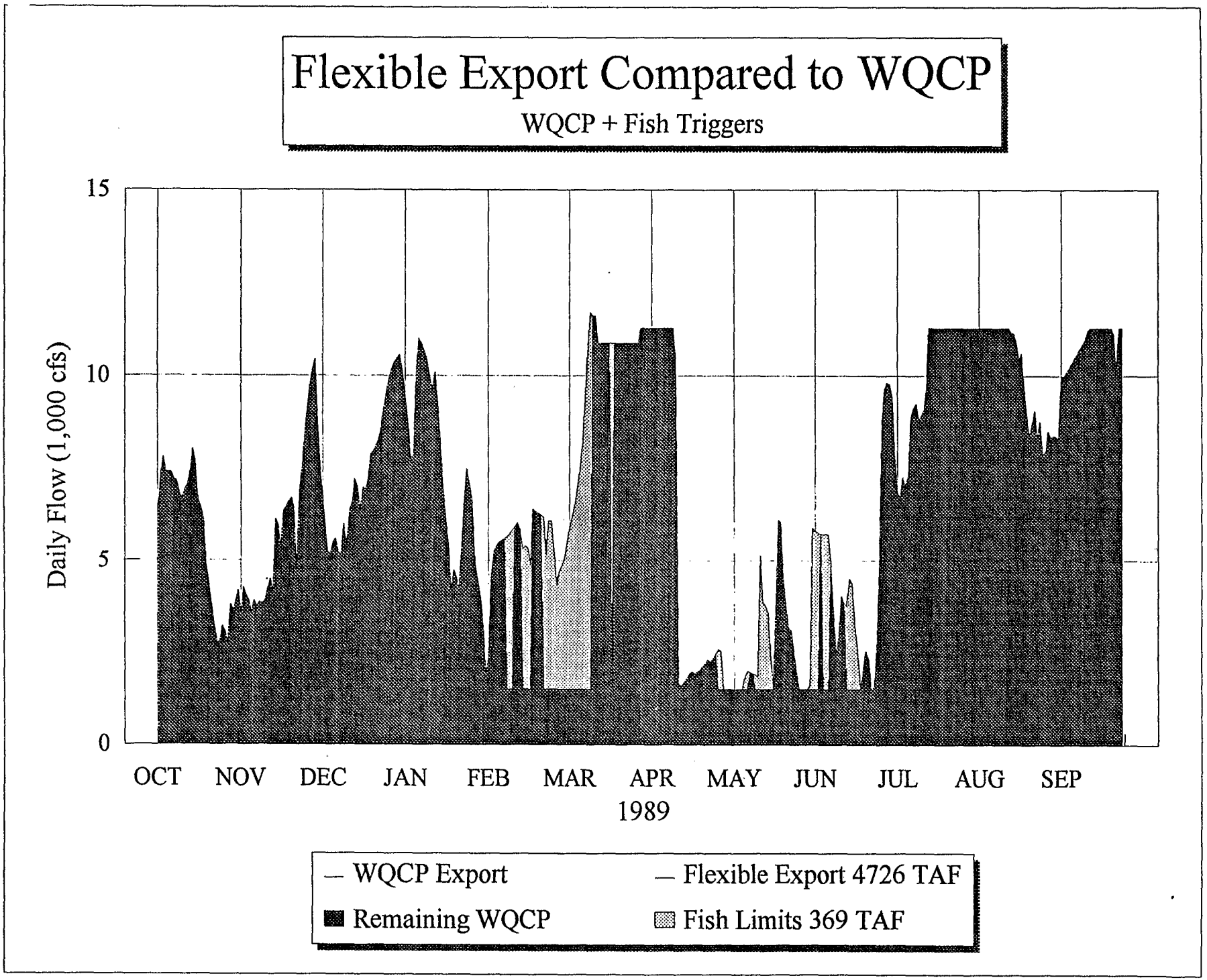

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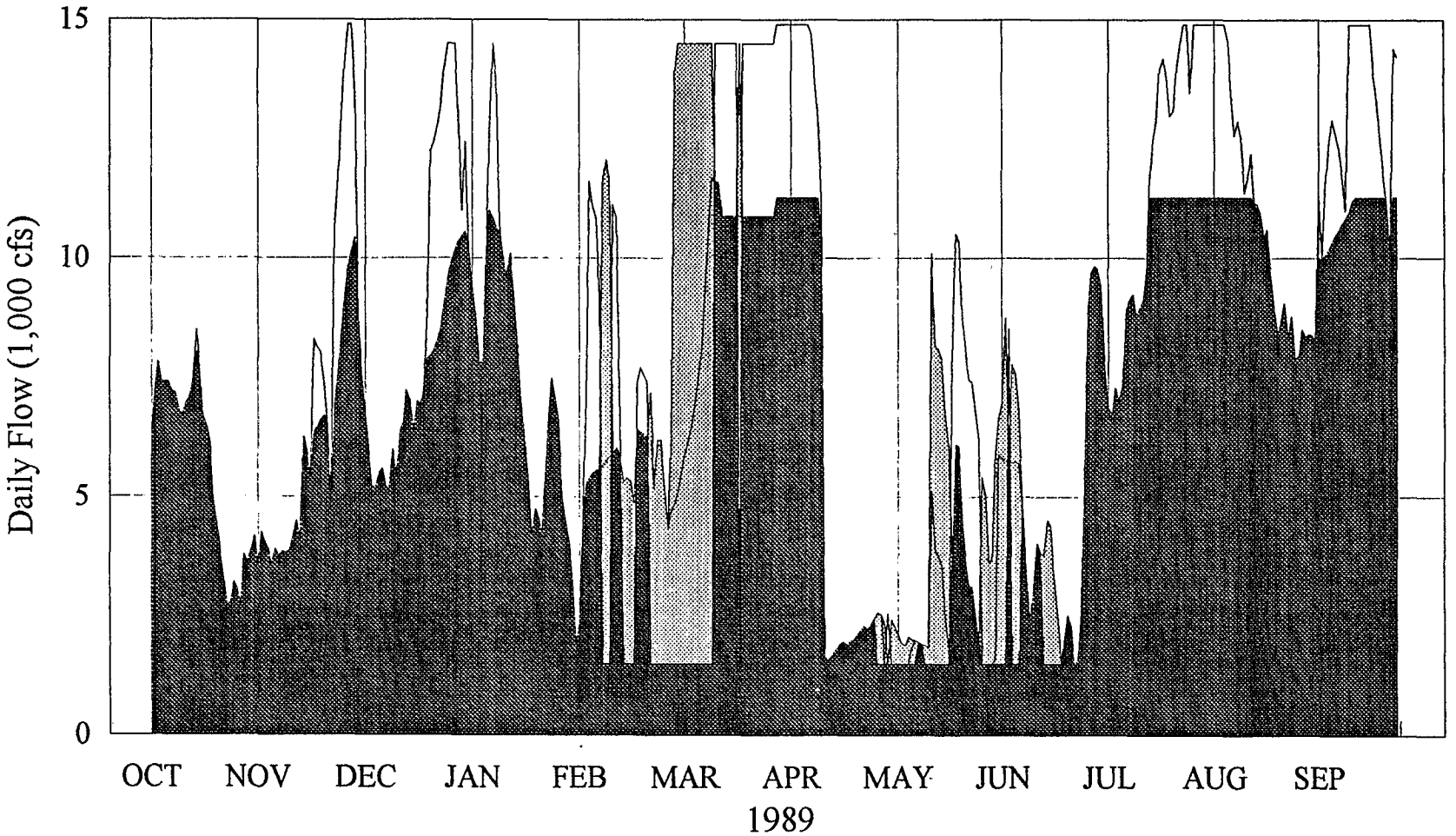
Flexible Export Compared to WQCP

Full Cap + No E/I + X2=7100 + Triggers



— WQCP Export — Flexible Export 5518 TAF

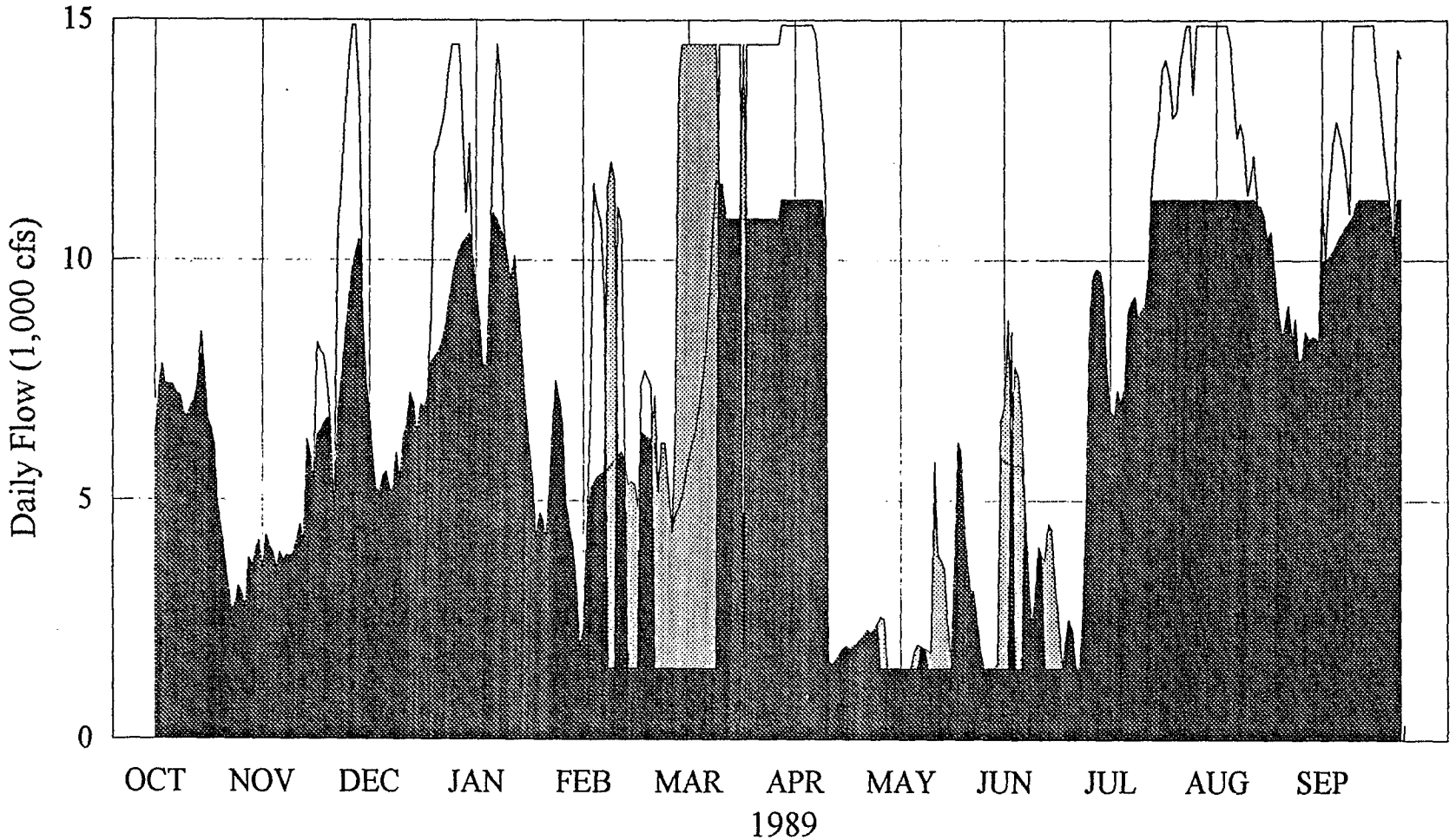
■ Remaining WQCP ▒ Fish Limits 701 TAF

D-015956

D-015956

Flexible Export Compared to WQCP

Full Capacity + No E/I + Triggers



— WQCP Export — Flexible Export 5439 TAF

Remaining WQCP Fish Limits 609 TAF

D-015957

D-015957

SWP DELIVERY DECISION

	month	Oroville storage (A)	SWP SL storage (B)	Forecast Feather R. Inflow (C)	WSI (A+B+C)	DI	Delivery	Carryover
1991	JAN	893	42	791	1726	1596	1000	596
	FEB	878	64	701	1643	1500	1000	500
	MAR	785	42	607	1434	1333	1000	333
	APR	1172	420	971	2563	2324	1110	1214
	MAY	1359	439	578	2376	2205	1110	1095
1993	JAN	1098	455	1622	3175	2783	1450	1333
	FEB	1666	889	2630	5185	5640	2880	2760
	MAR	2175	1067	3048	6290	7327	2880	4447
	APR	2964	1067	2421	6452	7327	2880	4447
	MAY	3456	1003	1736	6195	7328	2880	4448

WSI: Water supply index = sum of Oroville, SWP San Luis and forecast Feather River inflow.
DI: Delivery index = sum of delivery and carryover storage.

CVP DELIVERY DECISION

	month	Shasta storage	Folsom storage	CVP SL storage	Forecast Sac. R. Inflow	Forecast Amer. R. Inflow	WSI	DI	Delivery	Carryover
1991	FEB	1246	102	609	1615	298	3870	2501	1000	1501
	MAR	1138	83	575	1285	271	3352	2501	1000	1501
	APR	1449	234	767	1565	713	4728	2618	1000	1618
	MAY	1550	346	790	1263	469	4418	2501	1000	1501
1993	FEB	1865	575	625	2853	1494	7412	5152	2540	2612
	MAR	2587	575	752	3158	2047	9119	7109	3287	3822
	APR	4000	675	970	2451	1793	9889	7603	3434	4169
	MAY	4552	800	826	1967	1382	9527	7144	3434	3710

WSI: Water supply index = sum of Shasta, Folsom, CVP San Luis and forecast Sac. R. and Amer. R. inflows.
DI: Delivery index = sum of delivery and carryover storage.

Full Demand

3434
2880
6314 = 6.291

excess go down.

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D-015958

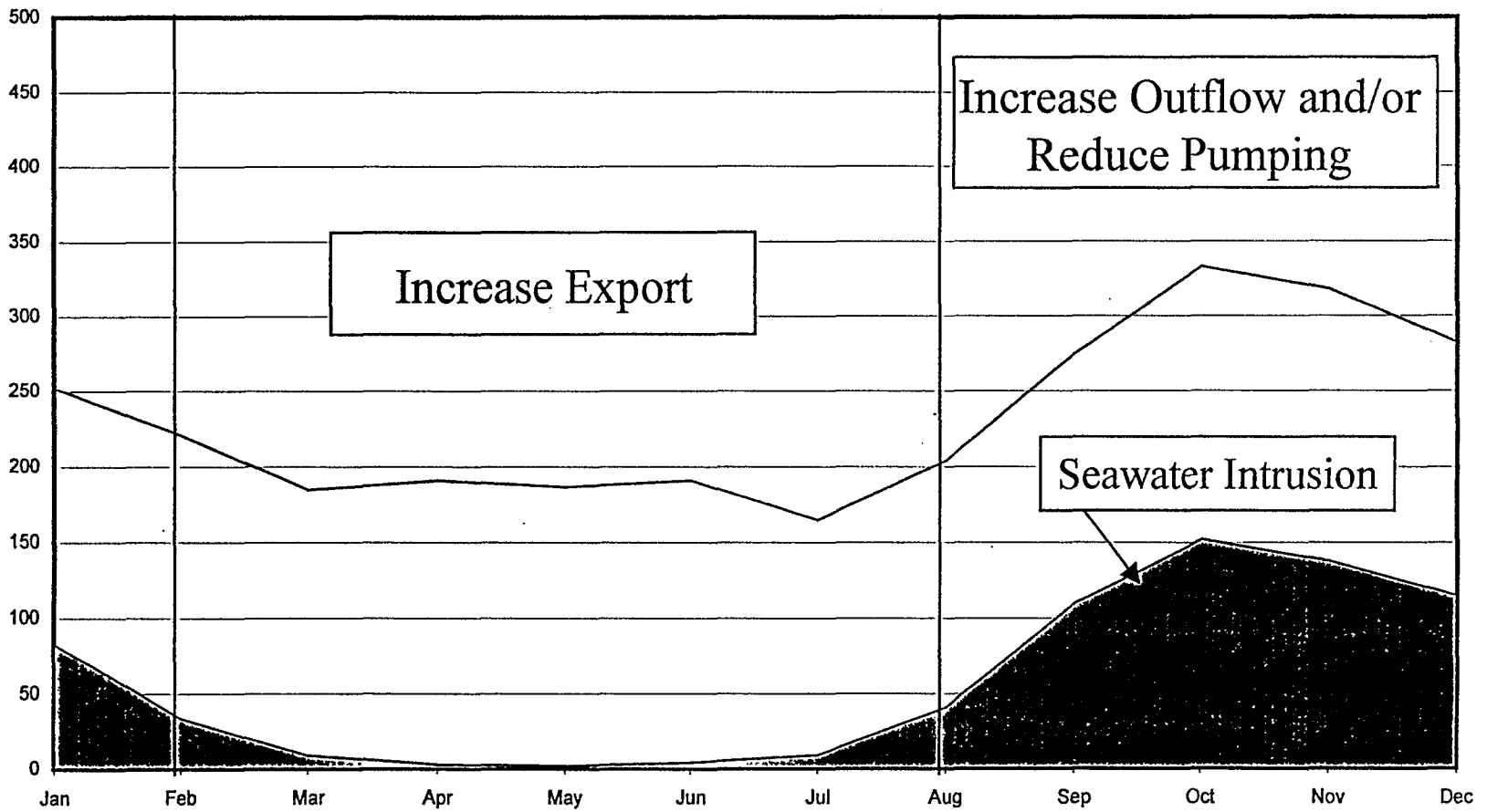
WATER QUALITY

D-015959

from Grace Chan MWD

D-015960

Average Monthly TDS at Banks PP



D-015960

Water Quality Improvement Tools

- Flexible operations from Feb. - Jul.
  - Share EWA tools
- Increase outflow and/or curtail pumping from Aug. - Dec.
  - Alternate use of water supply from facilities and storage
- Operate head of Old River barrier for water quality

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D-015961

Water Quality Improvement Tools

- Increase through Delta flows from Sacramento River
  - Delta cross channel operations
  - New Hood diversion
- South of the Delta operations
  - O'Neill bypass (5 to 10% improvements)
  - Water quality exchanges

D-015962

D-015962

Increase Outflow/Curtail Pumping for Water Quality

	Water Quality Improvements (TDS reduction in % & mg/L)		Water Supply (AFY)
	Rock Slough	Banks PP	
73 yr Average	17% 350 to 290	12% 269 to 237	50,000
1928-34	21% 410 to 326	14% 327 to 283	196,000
1986 -92	23% 437 to 338	17% 328 to 273	106,000

Operating Criteria : Accord + AFRP

D-015963

D—015963

Increase Through-Delta Flow from Sacramento River

	Rock Slough		Banks PP	
	TDS (mg/L)	Bromide (ug/L)	TDS (mg/L)	Bromide (ug/L)
Accord +	299	215	234	338
Accord & AFRP	350	288	269	446
Accord & AFRP w/ 2,000 cfs Hood Diversion	300	236	234	362

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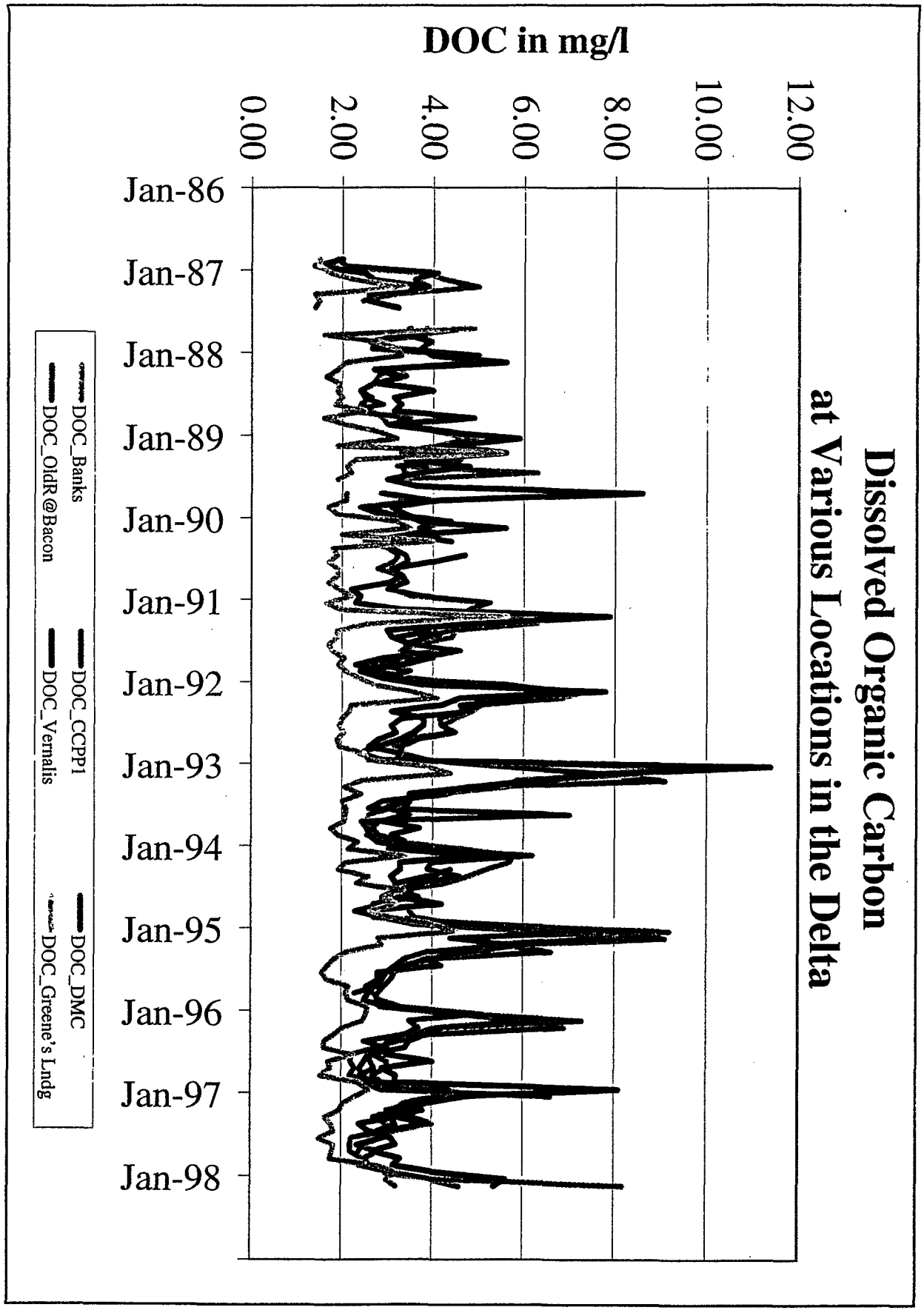
D-015964


Dissolved Organic Carbon
at Various Locations in the Delta
DOC in mg/l
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
DOC_Banks
DOC_CCPP1
DOC_DMC
DOC_OldR@Bacon
DOC_Vernalis
DOC_Greene's Lndg

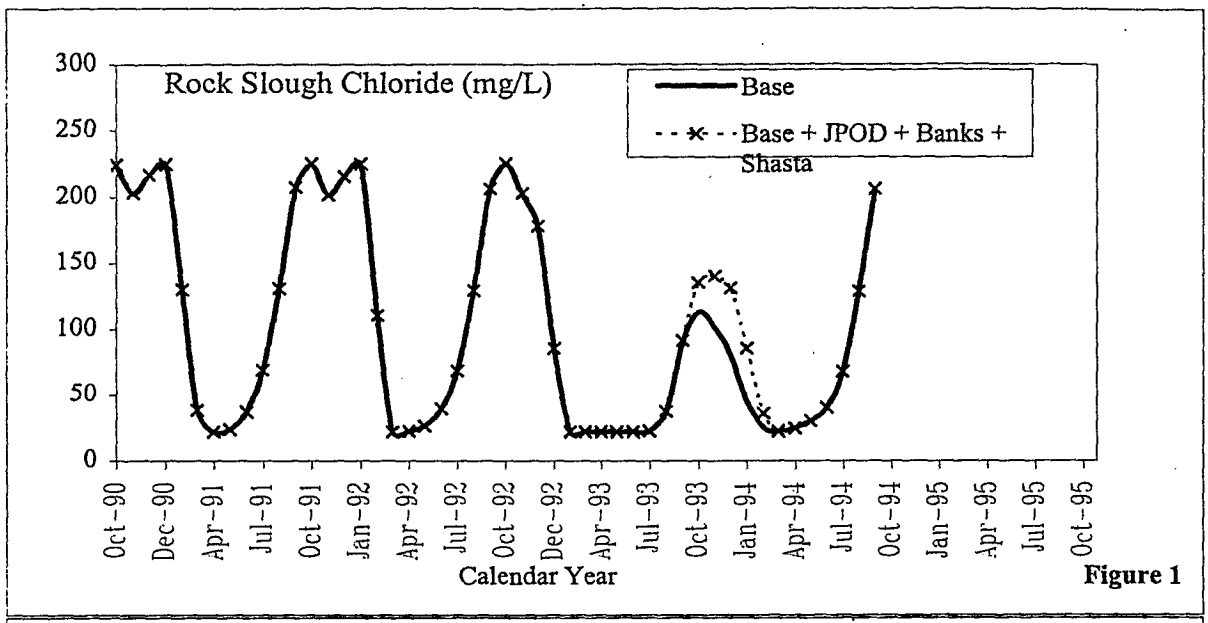


Figure 1

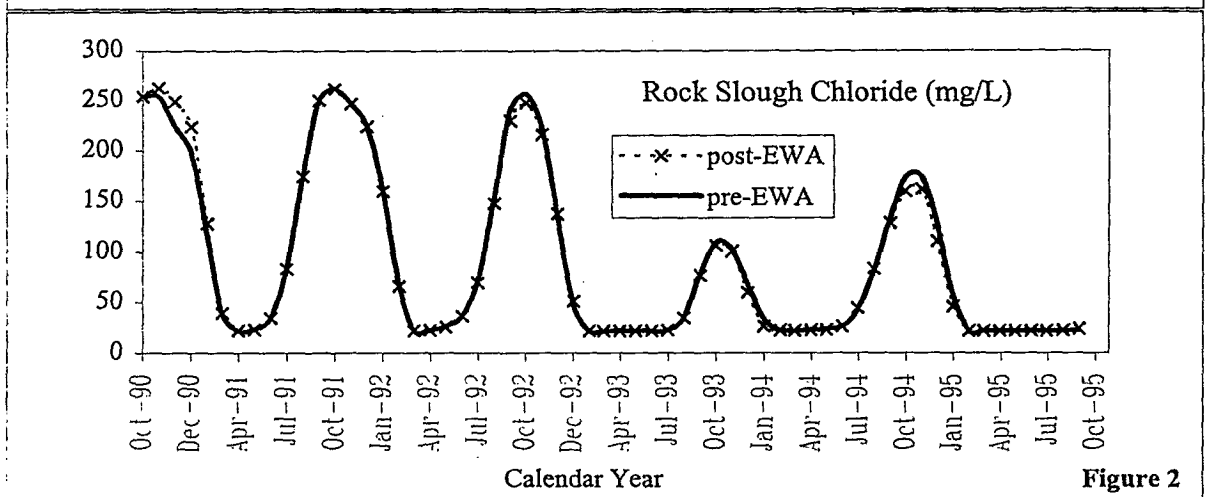


Figure 2

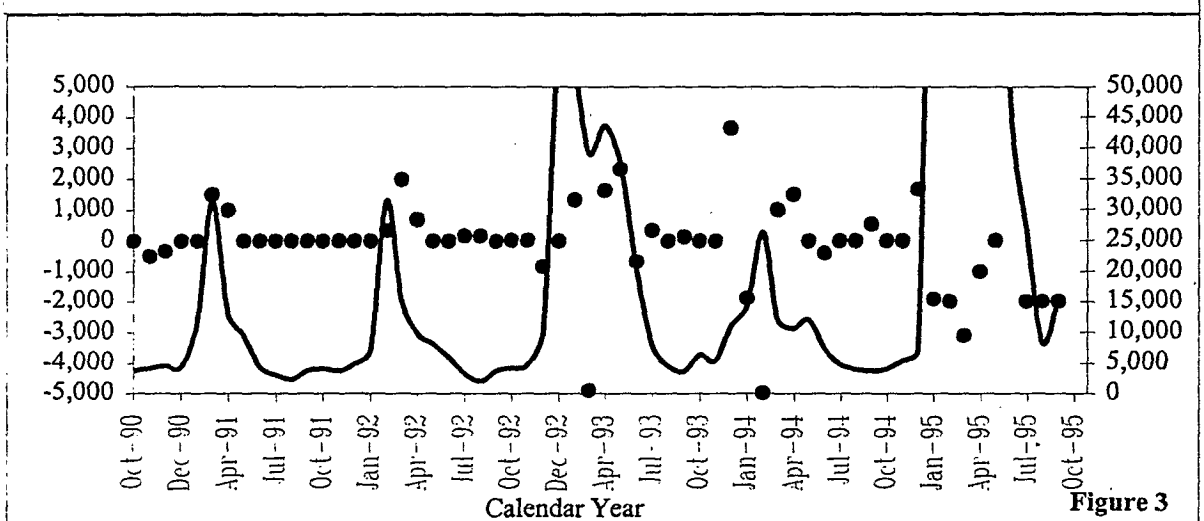


Figure 3

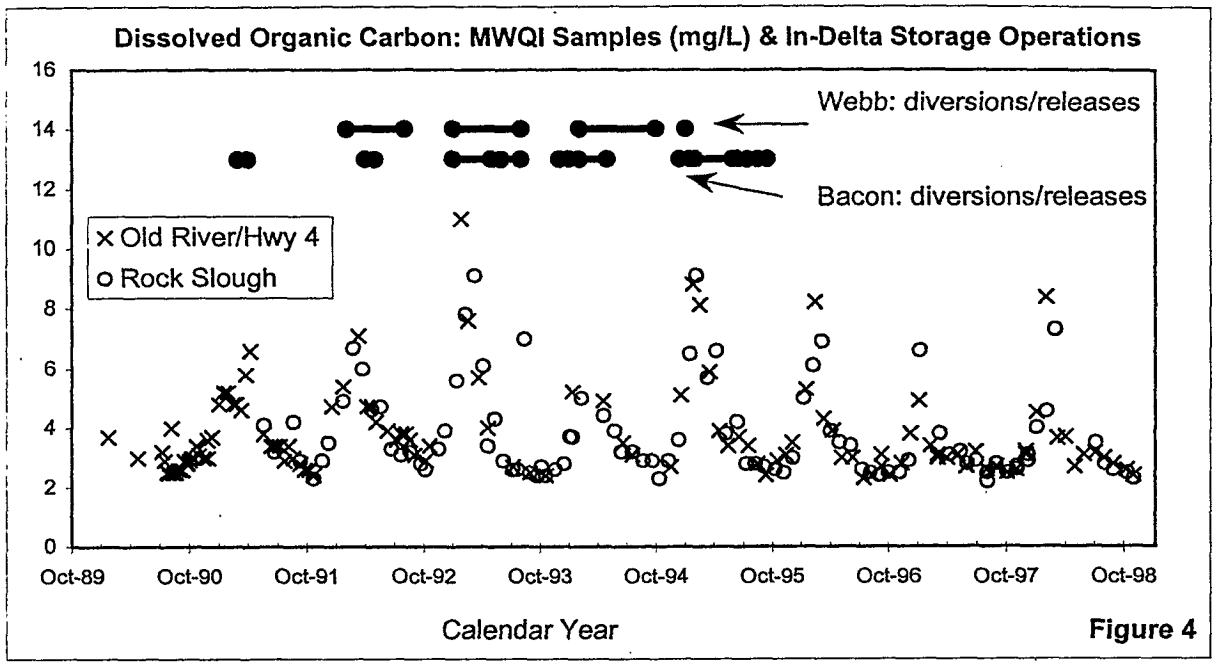


Figure 4

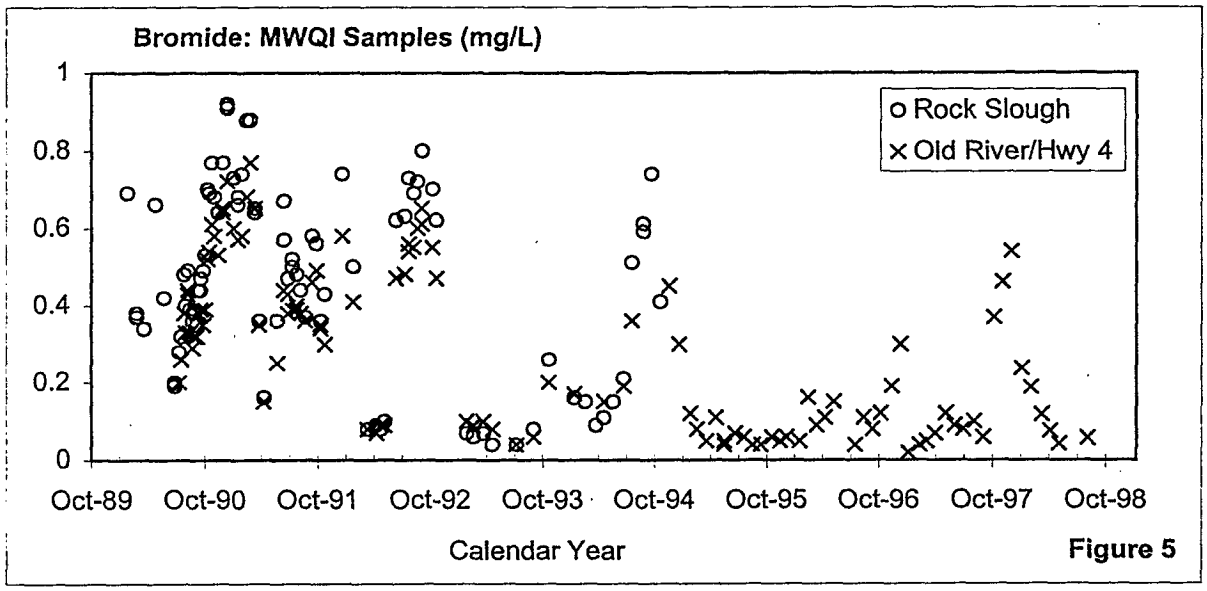
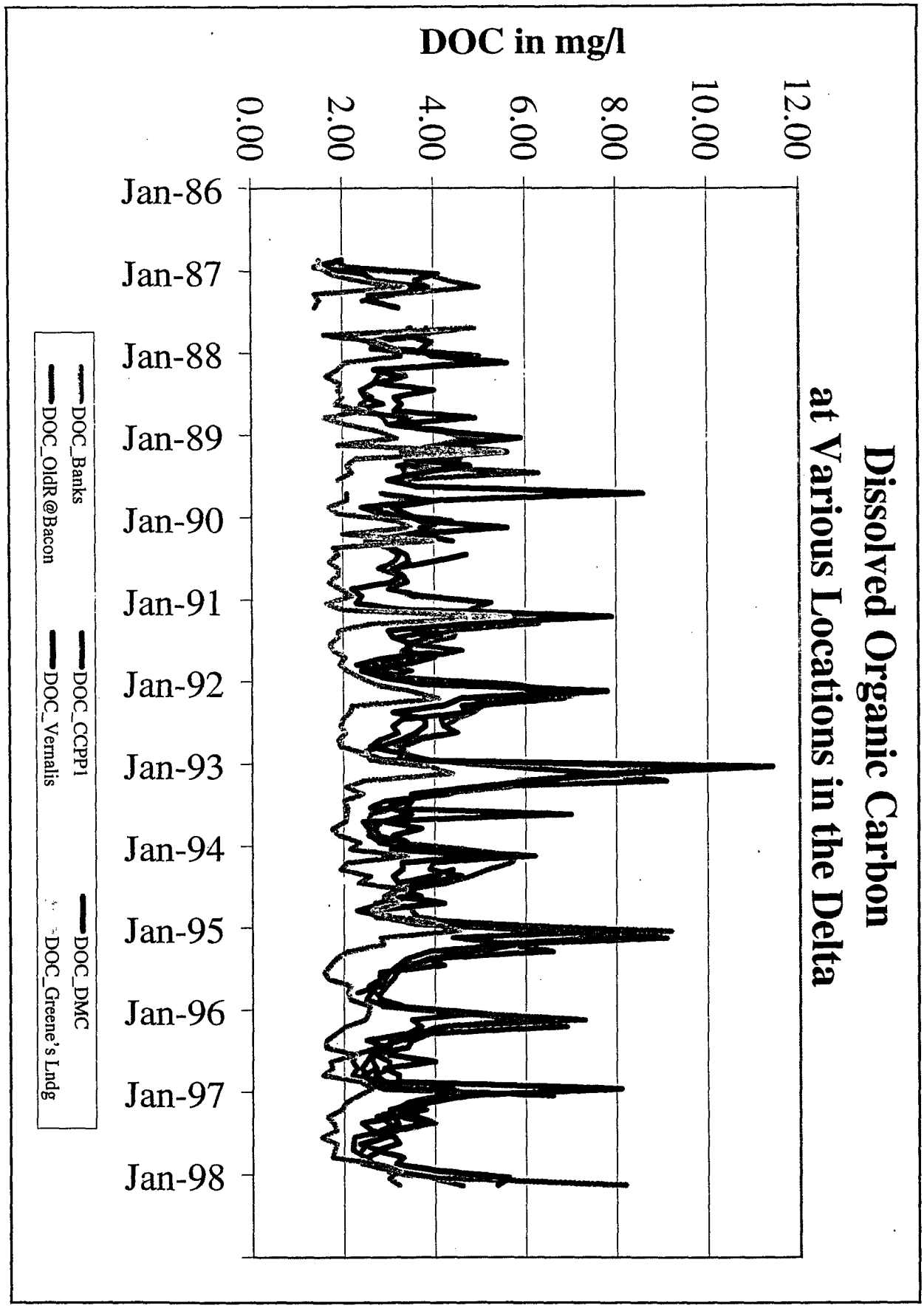


Figure 5


Dissolved Organic Carbon
at Various Locations in the Delta
DOC in mg/l
12.00
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Jan-93
Jan-94
Jan-95
Jan-96
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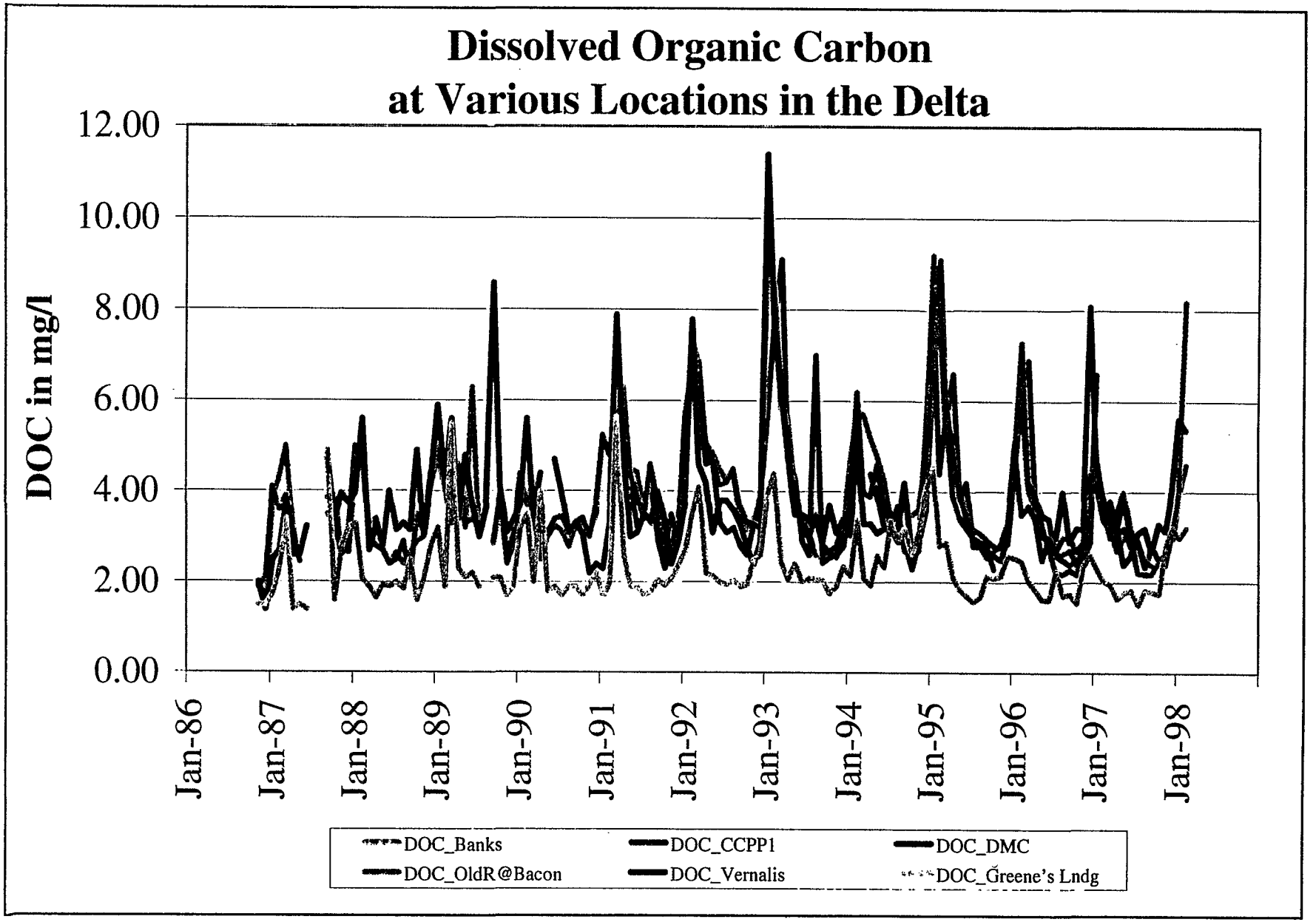
Jan-98
DOC_Banks
DOC_CCPP1
DOC_DMC
DOC_OldR@Bacon
DOC_Vernalis
DOC_Greene's Lndg



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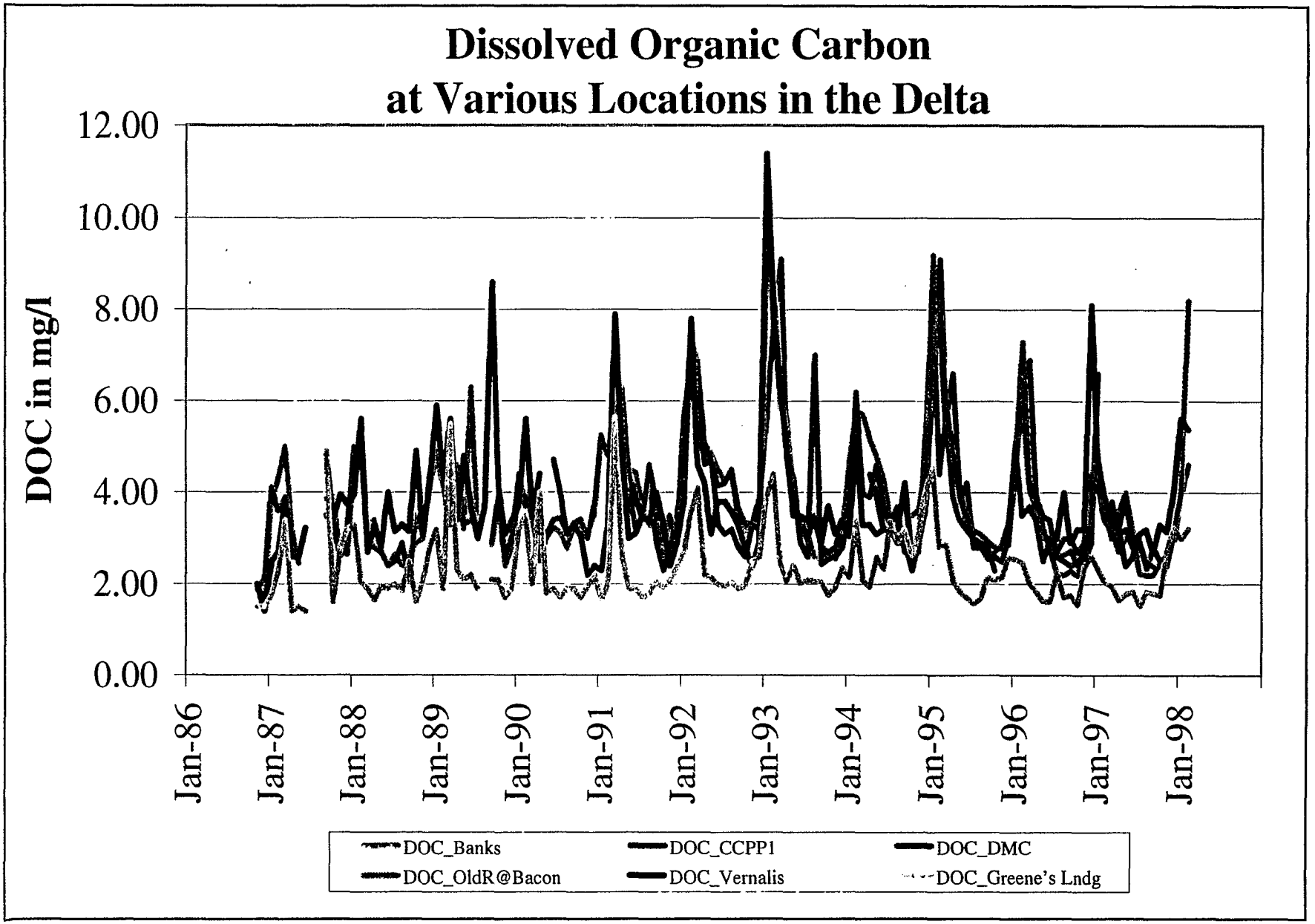

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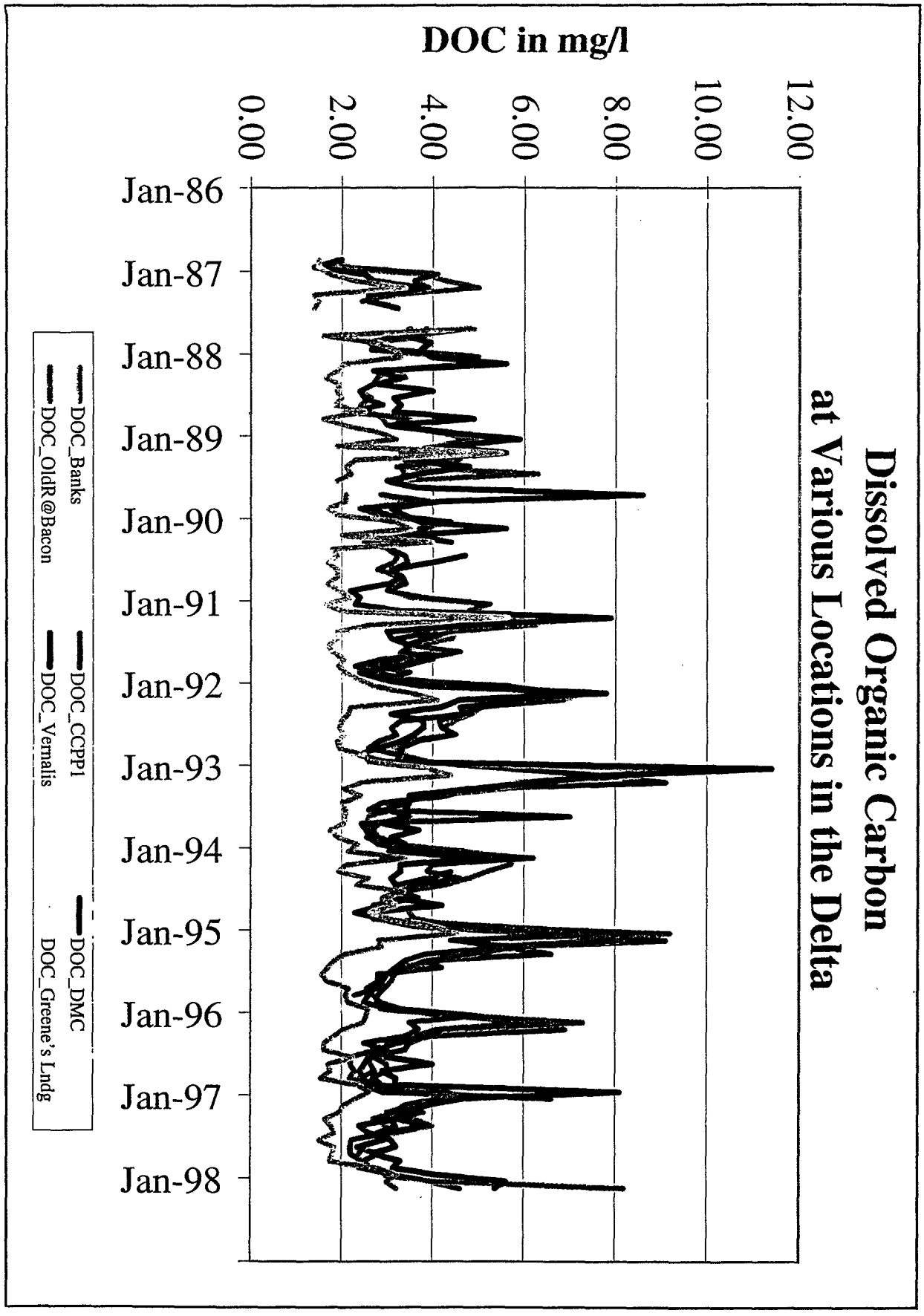
Dissolved Organic Carbon
at Various Locations in the Delta
DOC in mg/l
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
DOC_Banks
DOC_CCPP1
DOC_DMC
DOC_OldR@Bacon
DOC_Vernalis
DOC_Greene's Lndg

FISH

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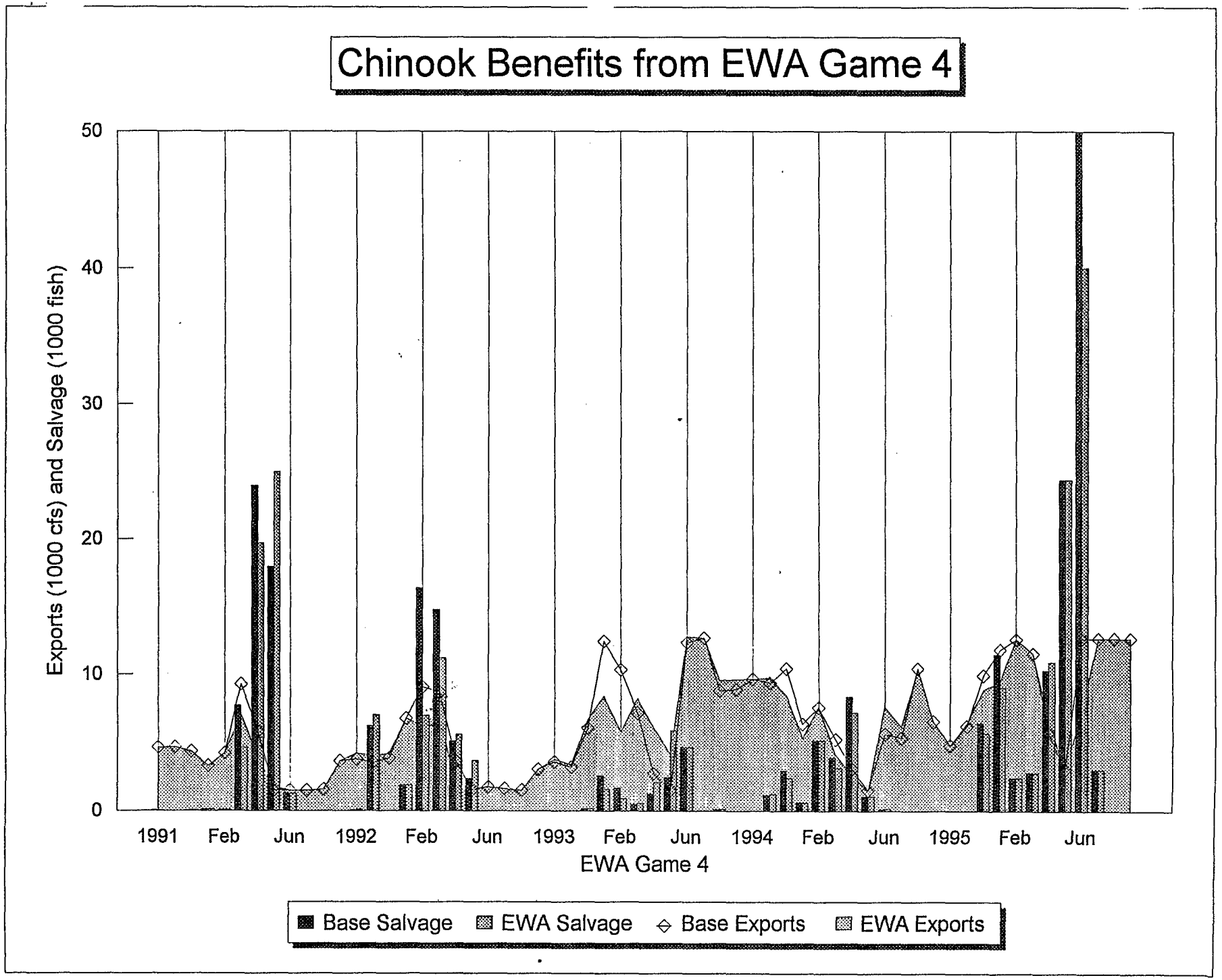
D-015972



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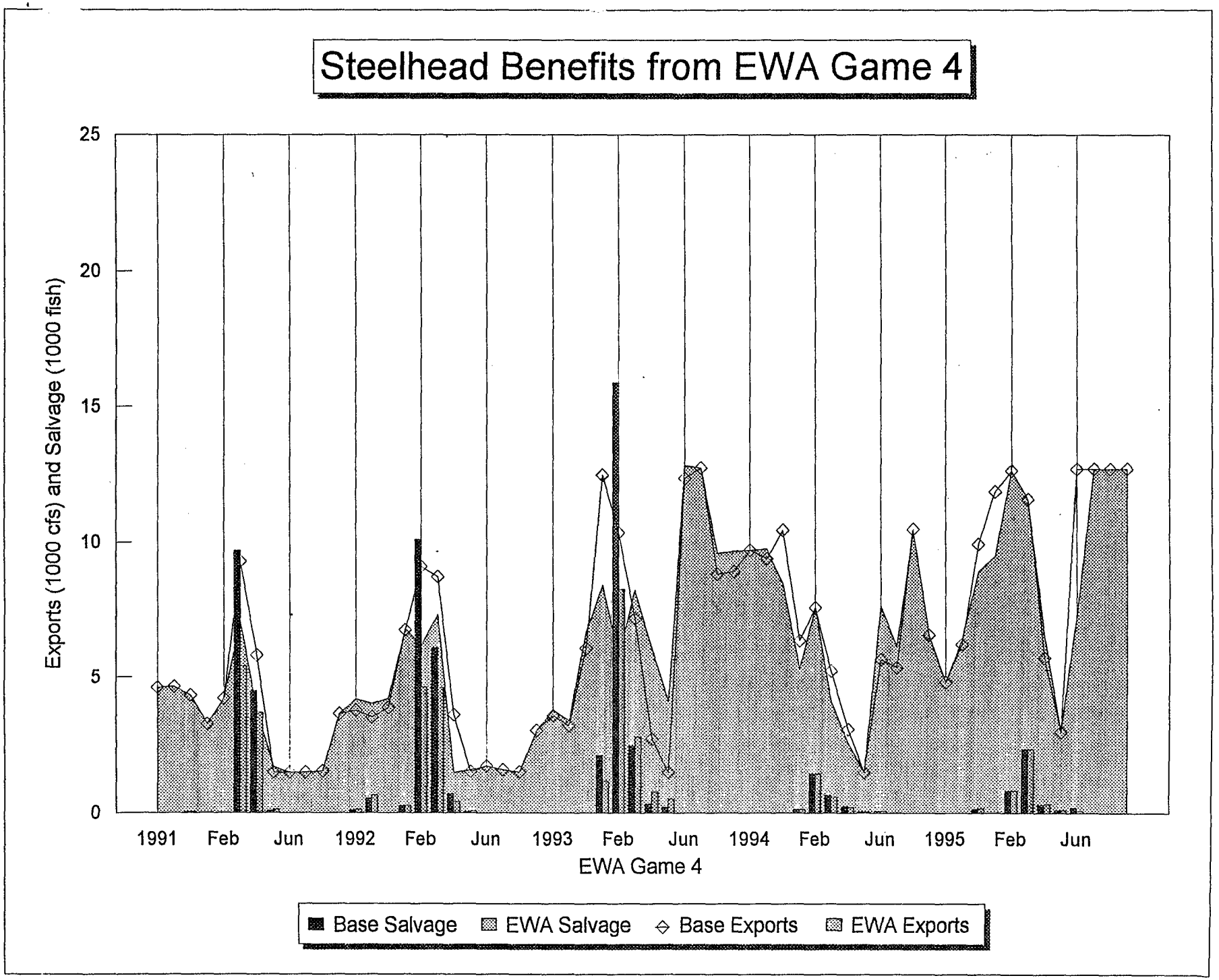

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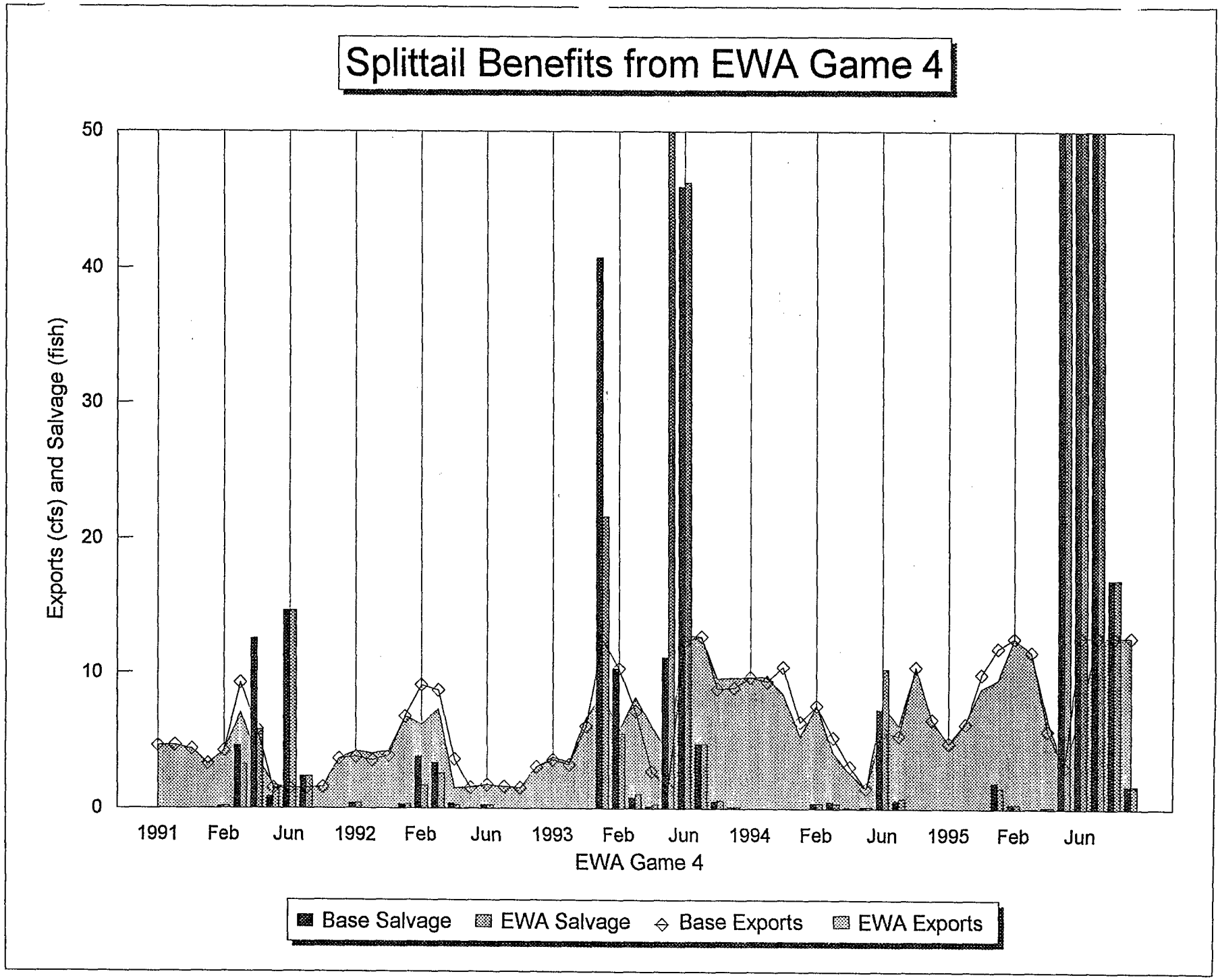

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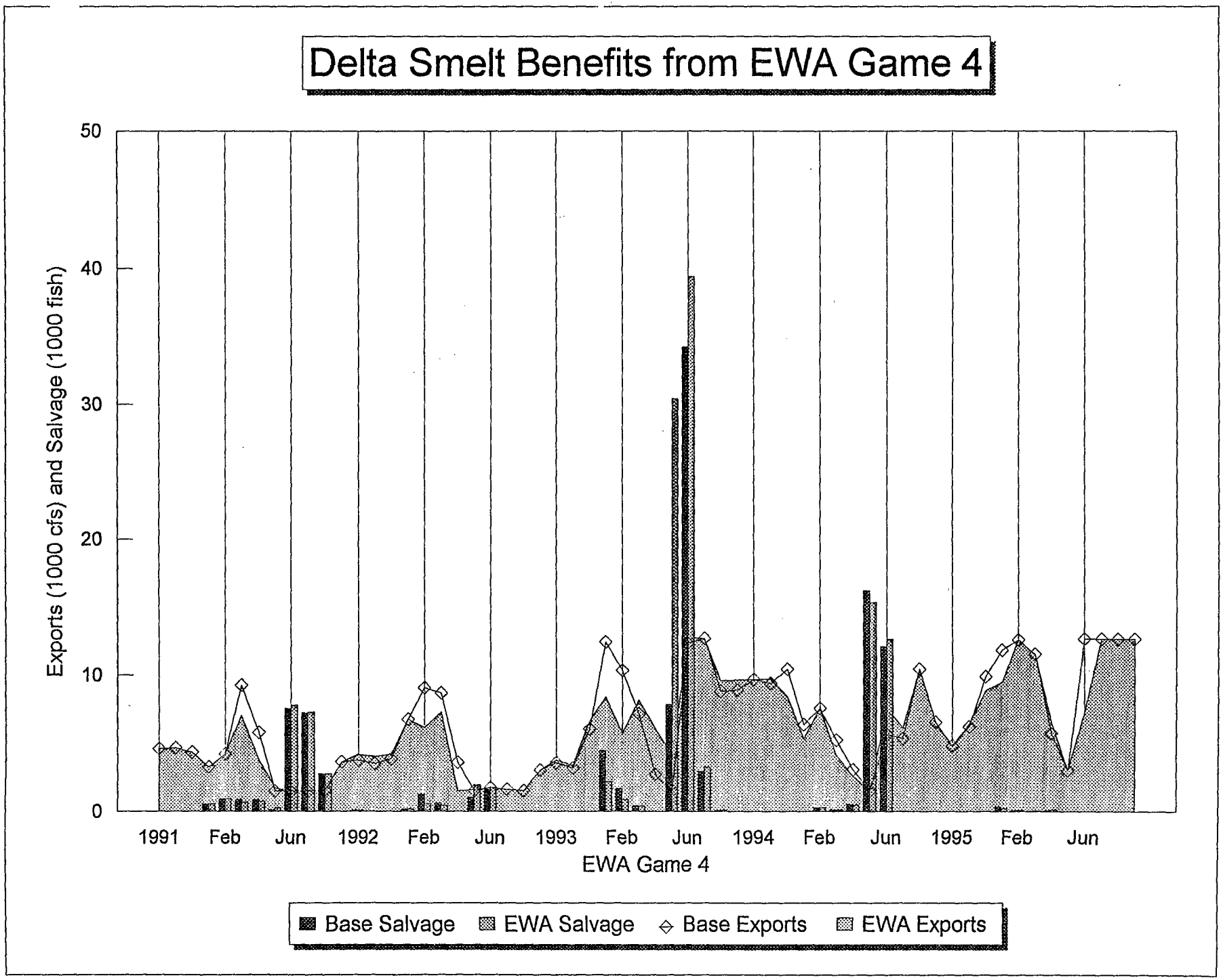

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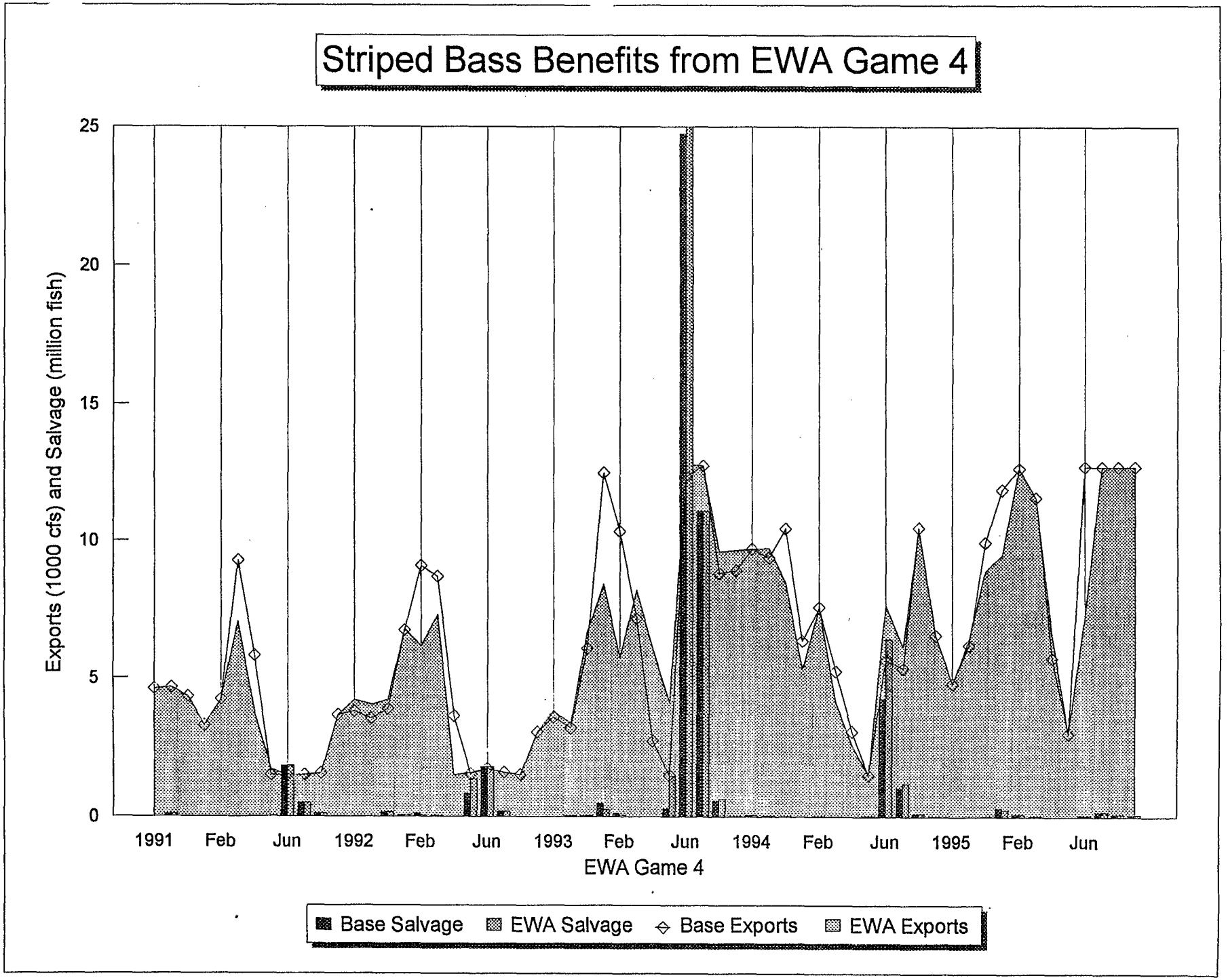

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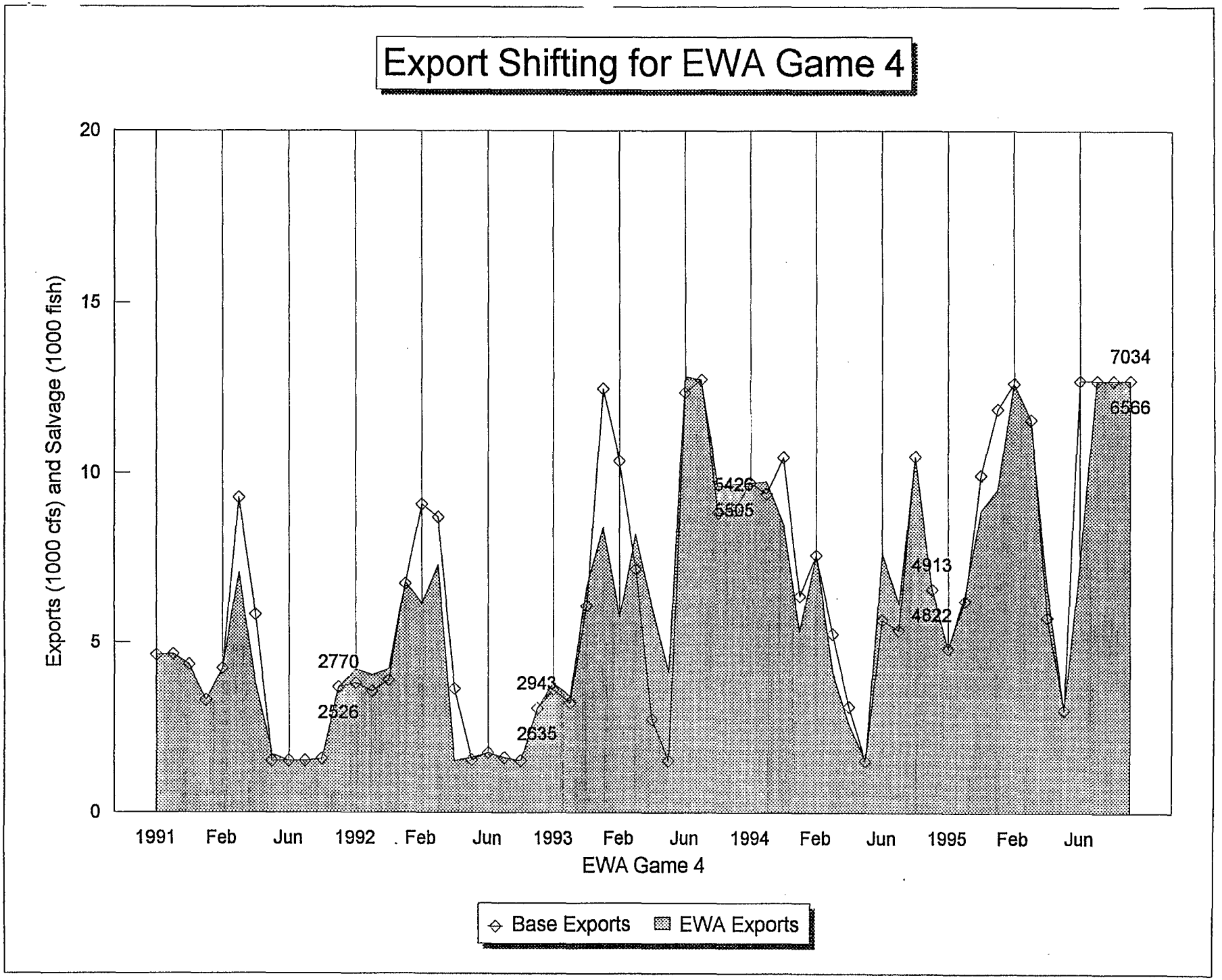

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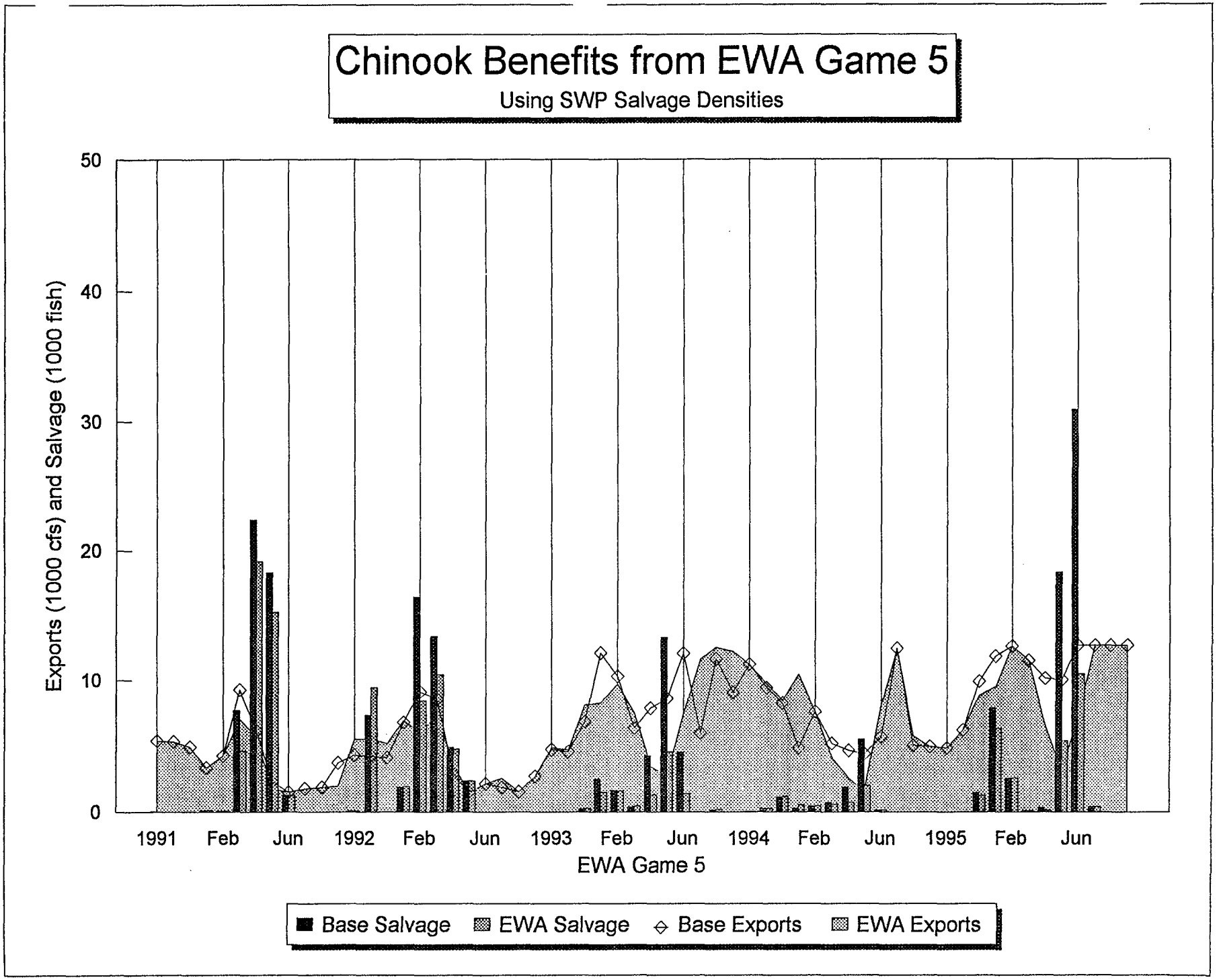

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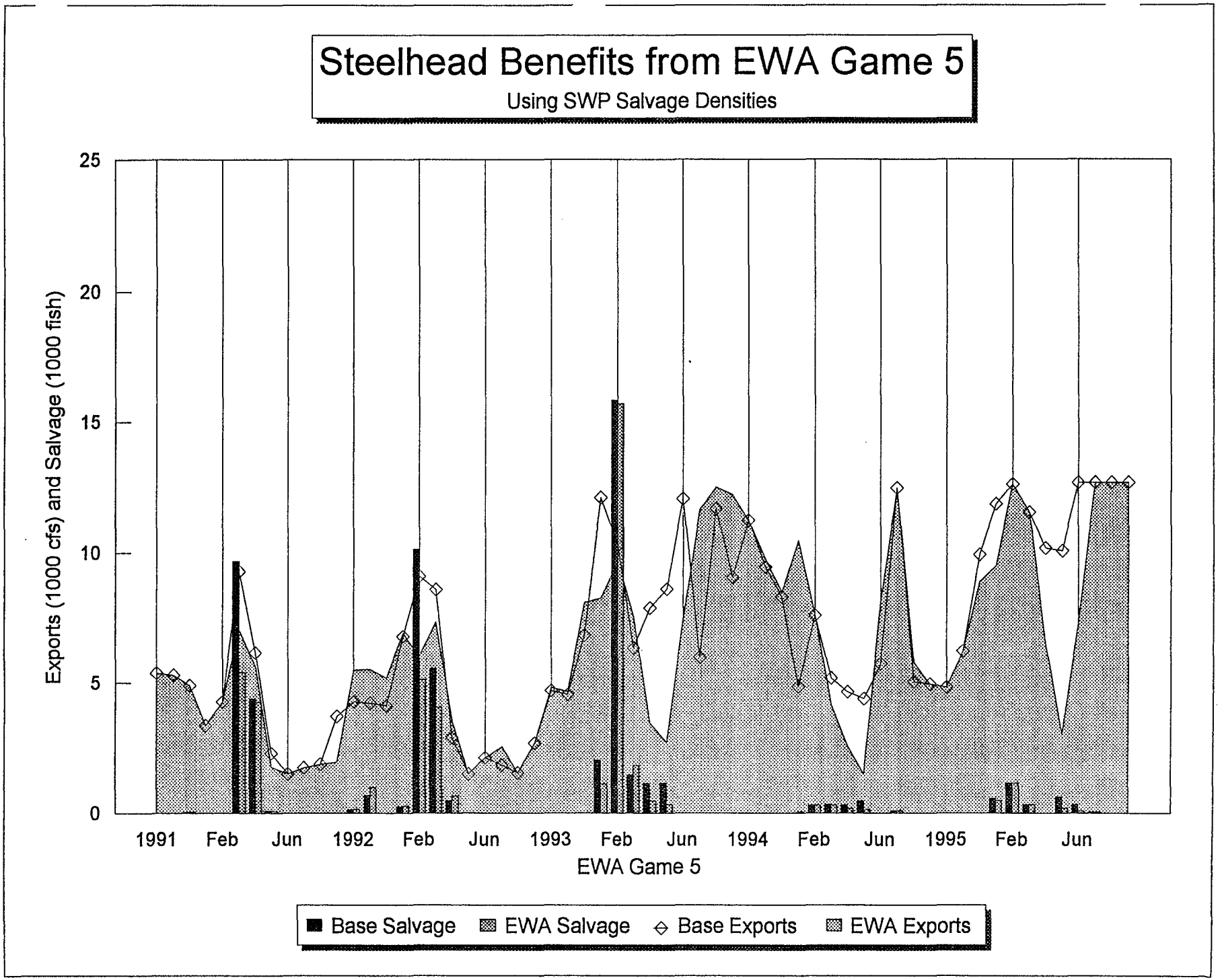

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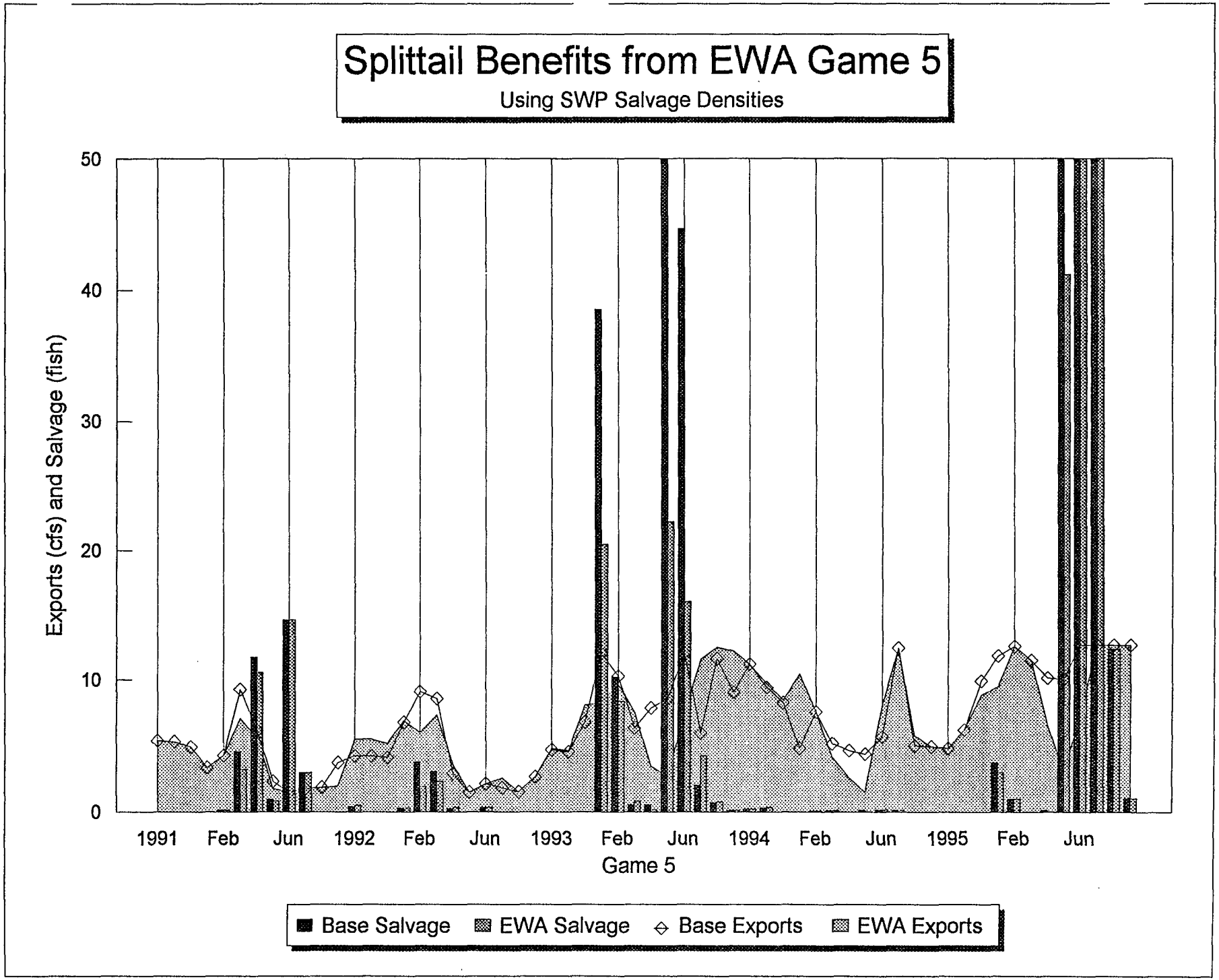

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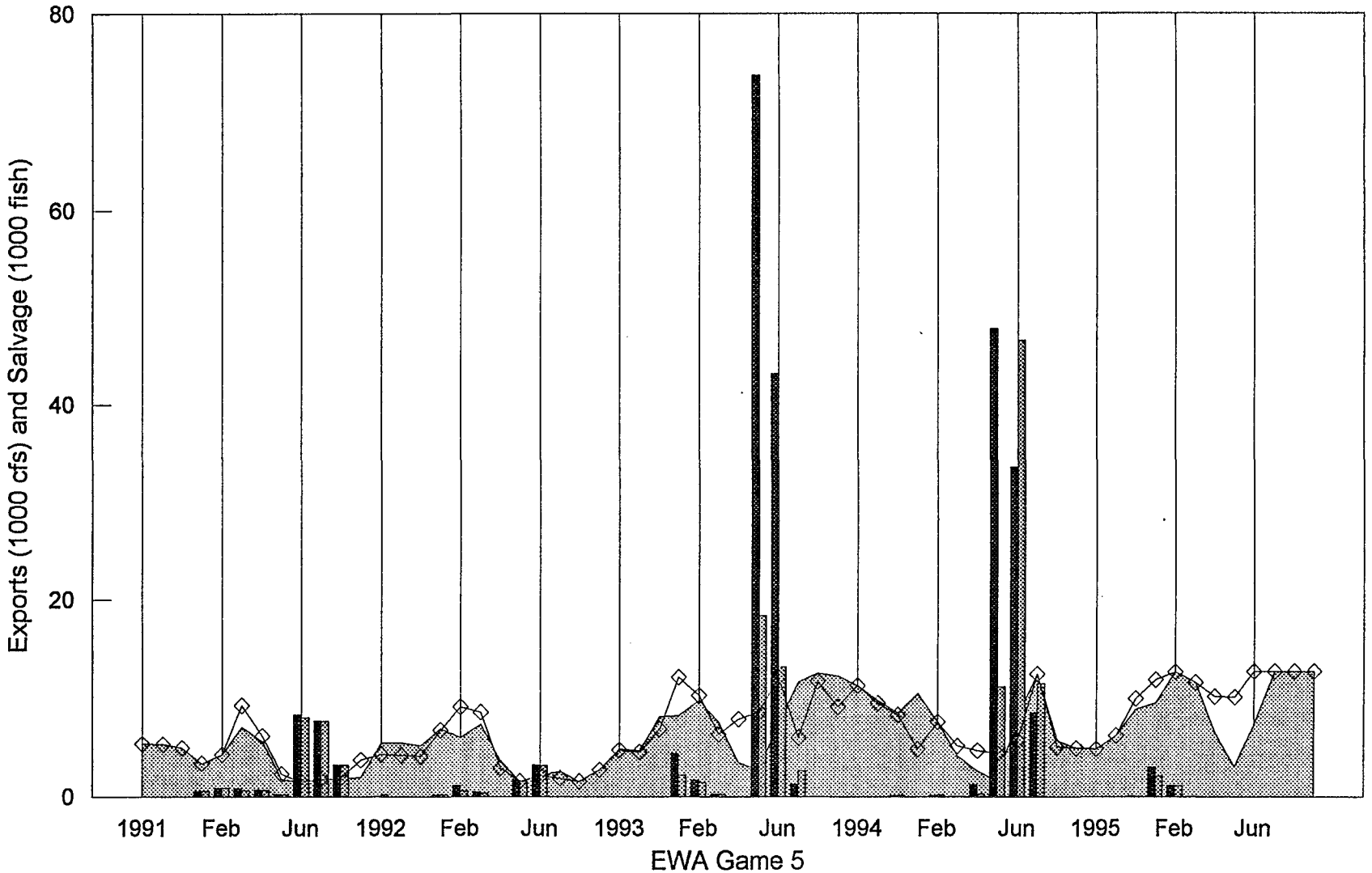
Delta Smelt Benefits from EWA Game 5

Using SWP Salvage Densities



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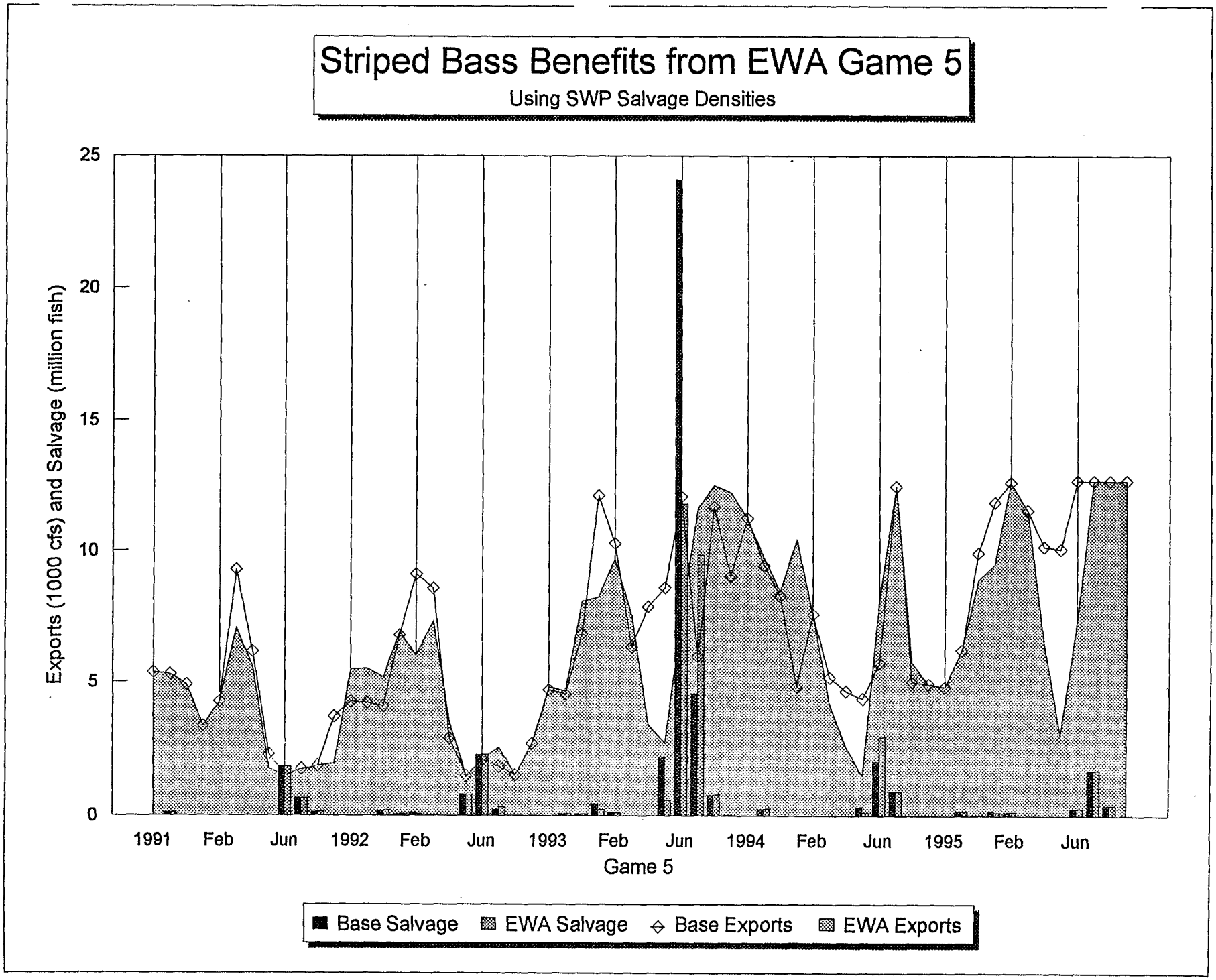

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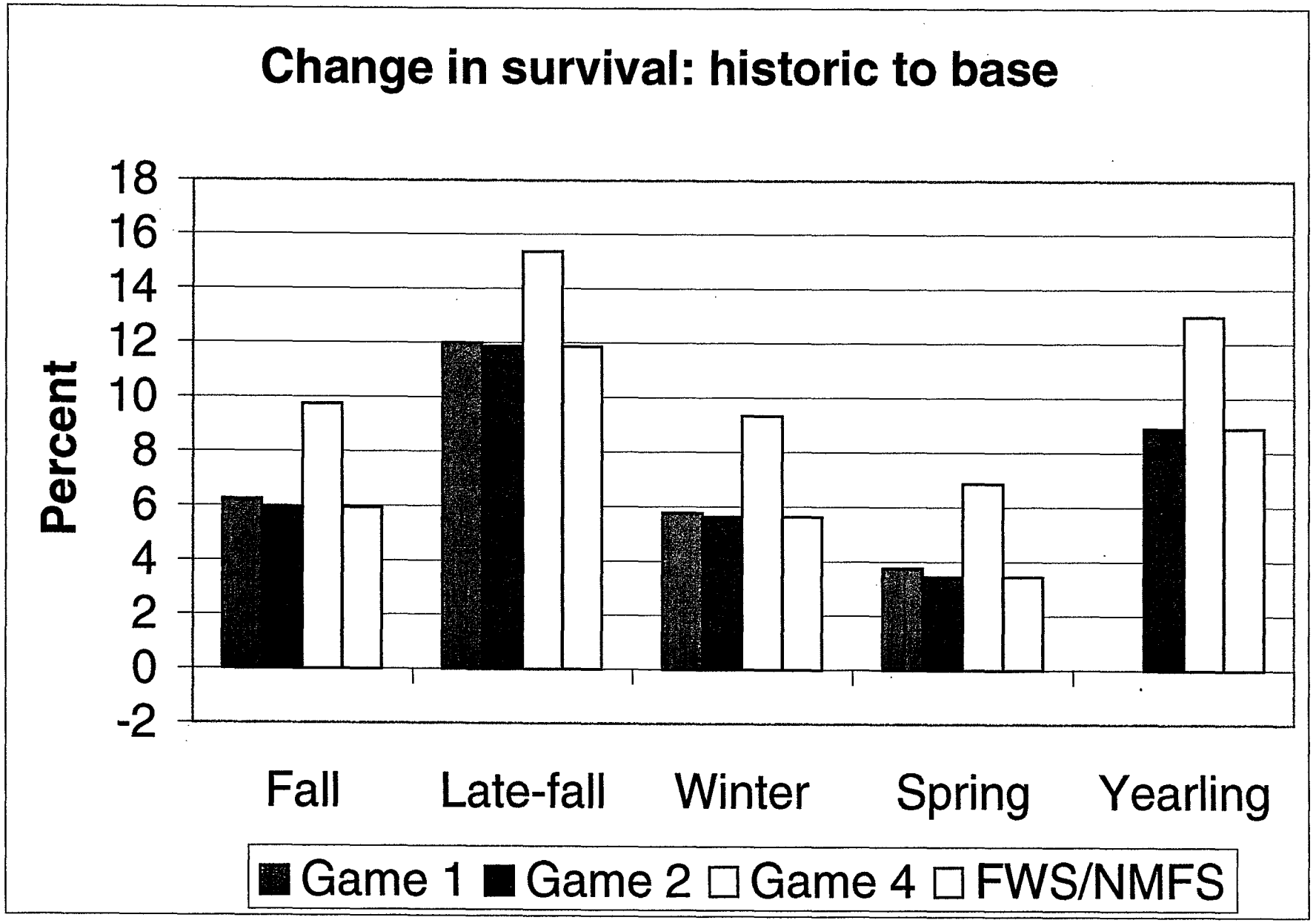

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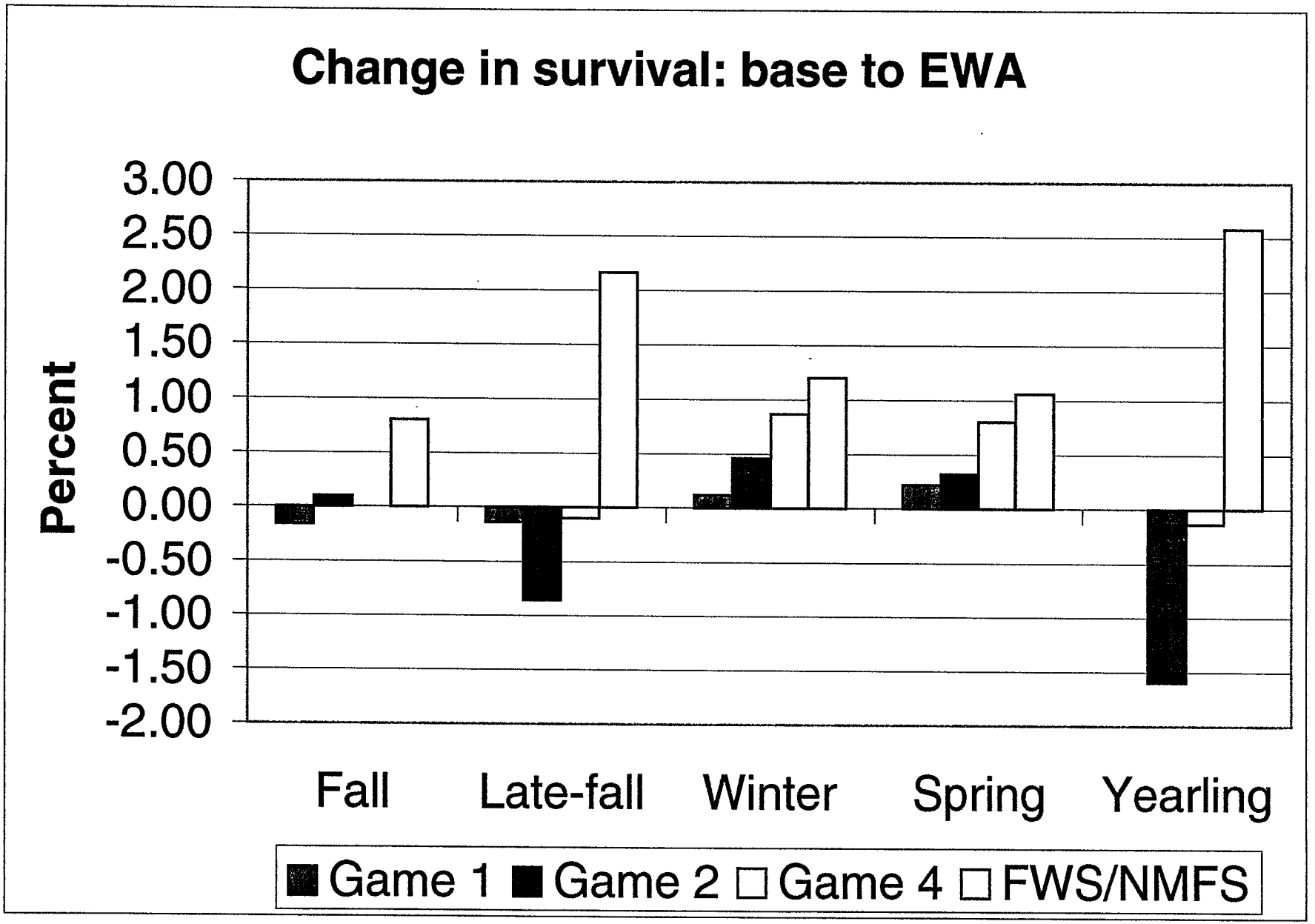

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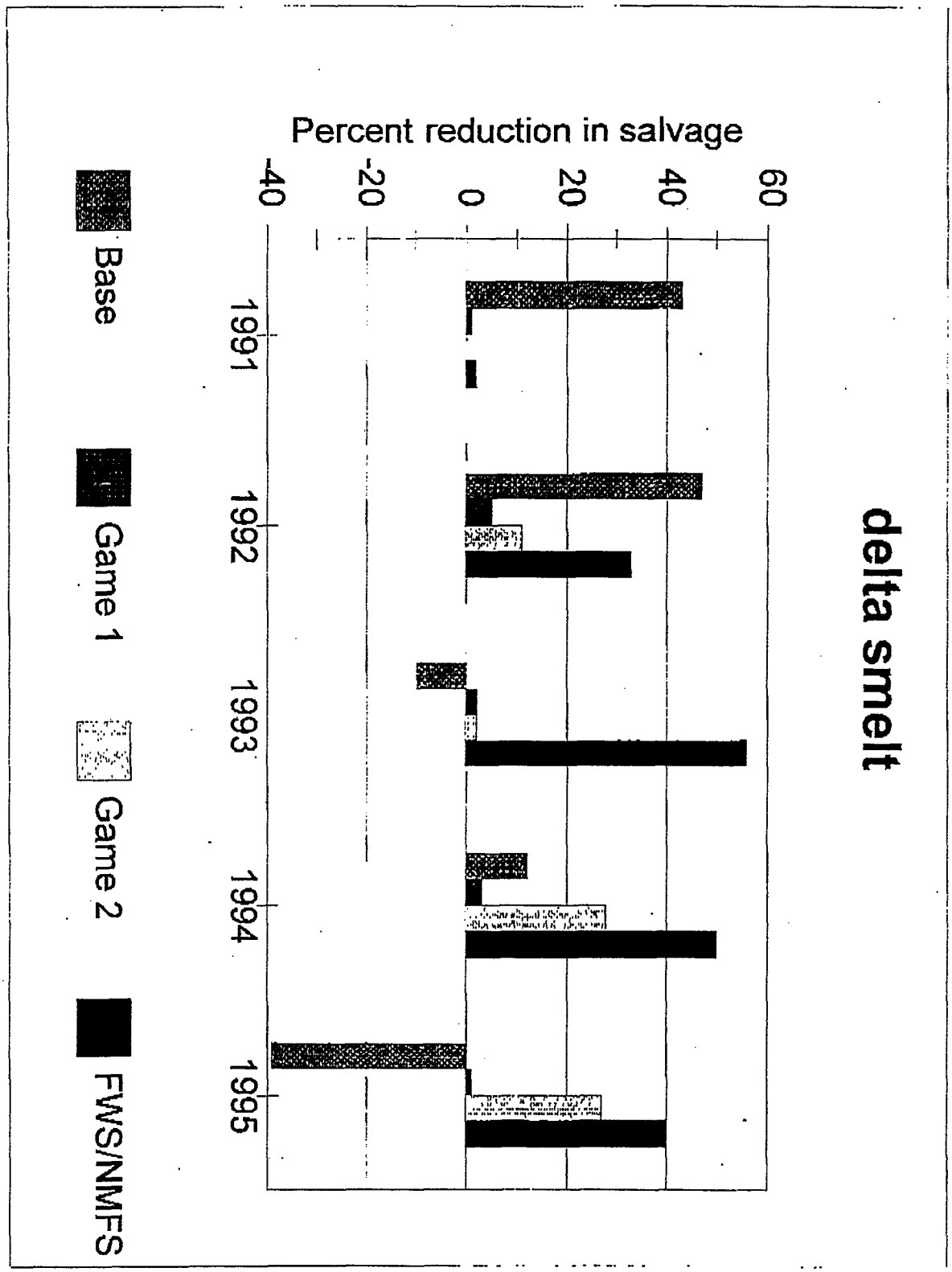
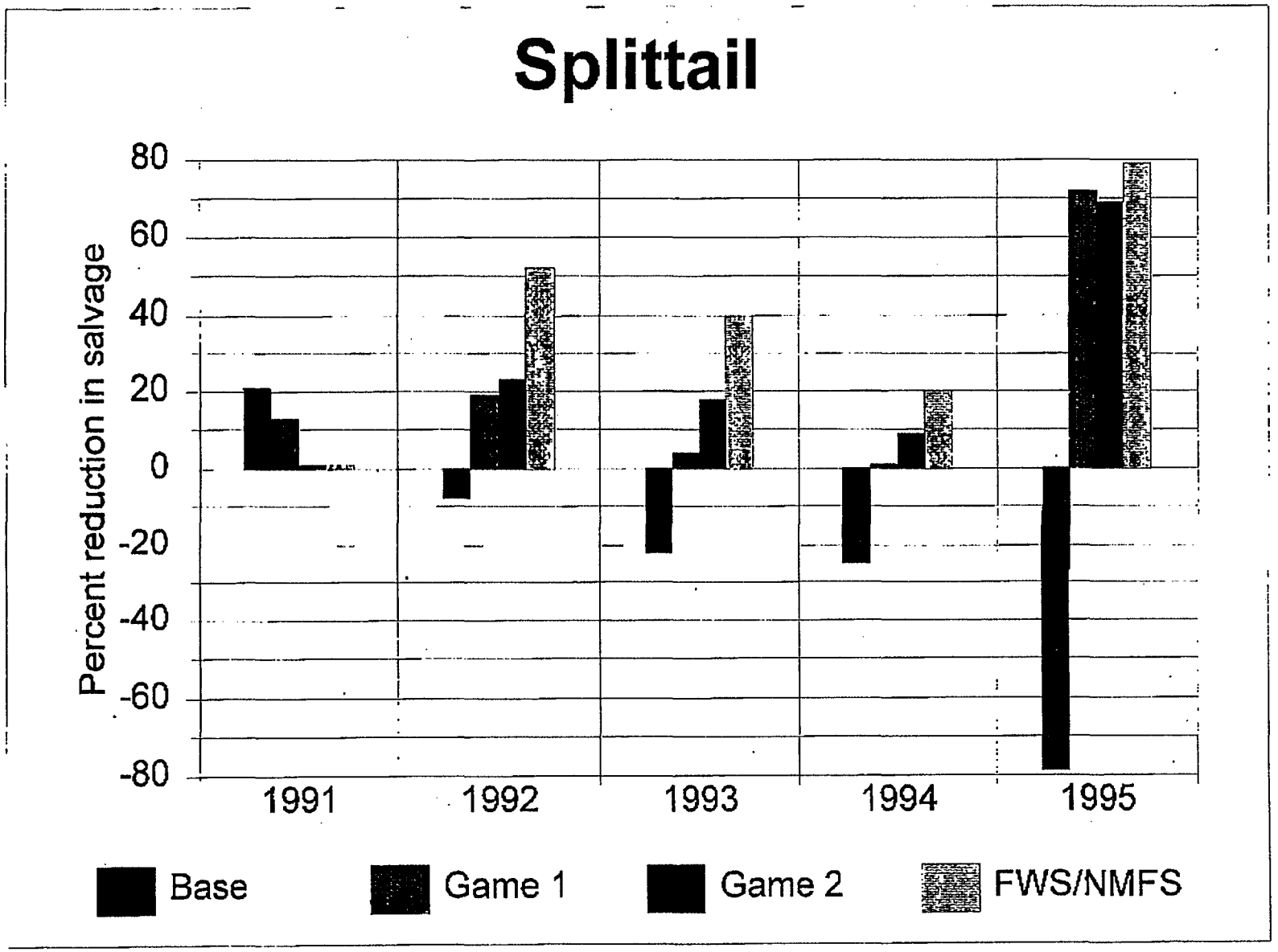
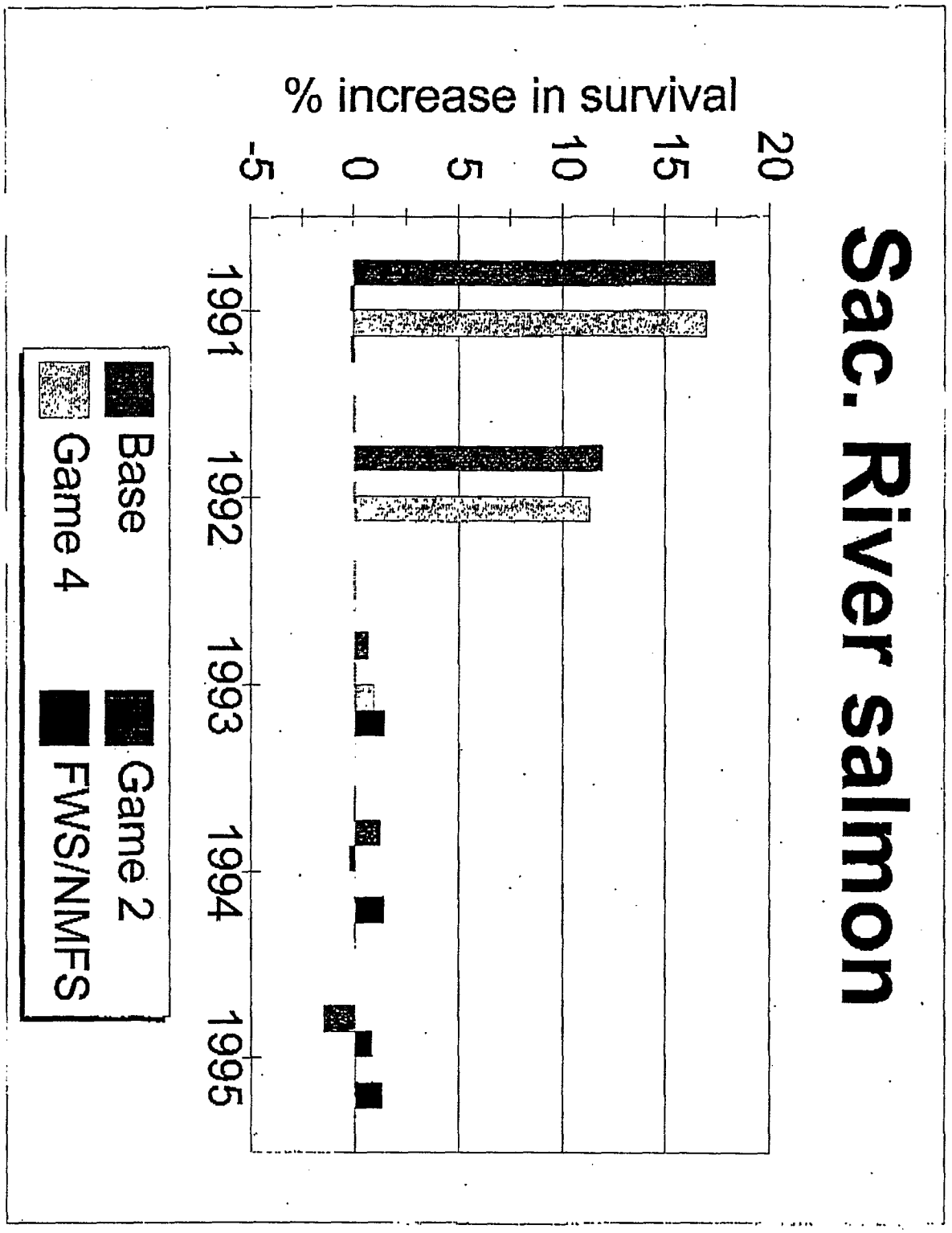
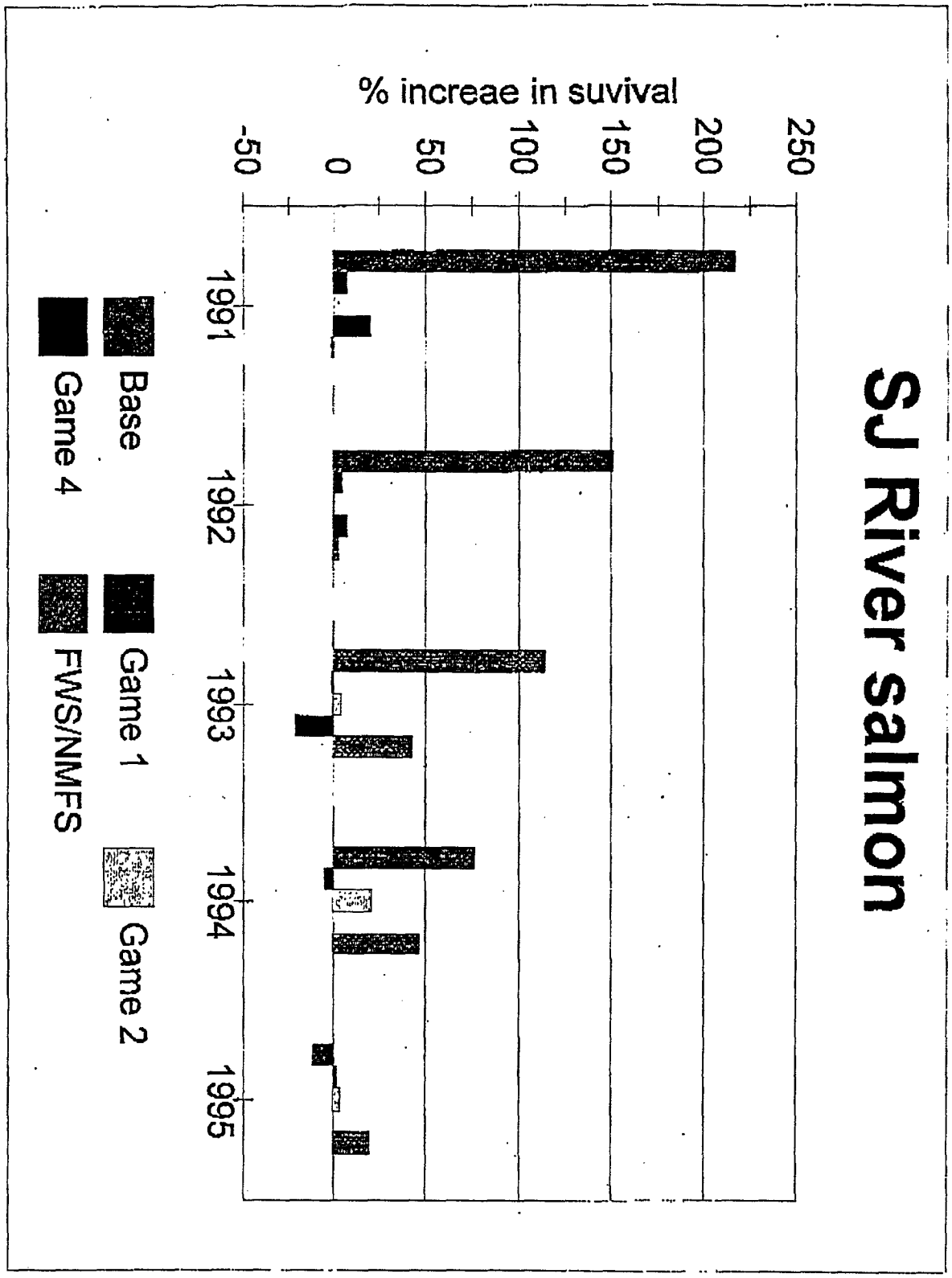

delta smelt
Percent reduction in salvage
60
40
20
0
-20
-40
1991
1992
1993
1994
1995
Base
Game 1
Game 2
FWS/NMFS


Splittail
Percent reduction in salvage
80
60
40
20
0
-20
-40
-60
-80
1991
1992
1993
1994
1995
Base
Game 1
Game 2
FWS/NMFS


Sac. River salmon
% increase in survival
20
15
10
5
0
-5
1991
1992
1993
1994
1995
Base
Game 2
Game 4
FWS/NMFS

D-015988


SJ River salmon
% increae in suvival
250
200
150
100
50
0
-50
1991
1992
1993
1994
1995
Base
Game 1
Game 2
Game 4
FWS/NMFS

Percent reduction in fish salvage for EWA Gaming and FWS/NMFS Prescriptive scenario. Base is compared to historic salvage. Games and FWS/NMFS are compared to base modelling.

1991	Historic	Base	Game 1	Game 2	FWS/NMFS
chinook	0	32	15	0	0
steelhead	0	-6	34	10	5
striped bass	0	27	-1	0	0
splittail	0	21	13	1	1
delta smelt	0	43	1	1	2

1992	Historic	Base	Game 1	Game 2	FWS/NMFS
chinook	0	-14	16	12	42
steelhead	0	-15	22	28	56
striped bass	0	9	1	1	5
splittail	0	-8	19	23	52
delta smelt	0	47	5	11	33

1993	Historic	Base	Game 1	Game 2	FWS/NMFS
chinook	0	-12	11	14	44
steelhead	0	-25	13	37	40
striped bass	0	-96	-5	-12	58
splittail	0	-22	4	18	40
delta smelt	0	-10	2	2	56

1994	Historic	Base	Game 1	Game 2	FWS/NMFS
chinook	0	4	-15	5	25
steelhead	0	-35	-14	9	25
striped bass	0	-93	9	27	37
splittail	0	-25	1	9	20
delta smelt	0	12	3	28	50

1995	Historic	Base	Game 1	Game 2	FWS/NMFS
chinook	0	-38	54	53	59
steelhead	0	-47	14	17	22
striped bass	0	-46	4	1	3
splittail	0	-79	72	69	79
delta smelt	0	-39	1	27	40

Sacto R. Salmon Survival-percent increase over base

	Historic	Base	Game 1	Game 2	FWS/NMFS	Base	Game 4
1991	0	17.4		-0.1	-0.1	17.0	0.6
1992	0	11.9		0.0	0.0	11.3	0.3
1993	0	0.6		0.0	1.4	0.9	-0.9
1994	0	1.2		-0.2	1.4		
1995	0	-1.4		0.8	1.3		

SJR Salmon Survival-percent increase over base

	Historic	Base	Game 1	Game 2	FWS/NMFS	Base	Game 4
1991	0	217.0	7.6	3.2	-1.7	201.0	20.0
1992	0	151.0	4.6	0.6	2.7	149.4	7.4
1993	0	113.7	-1.3	4.1	42.8	128.9	-22.0
1994	0	76.2	-4.8	20.6	46.8		
1995	0	-12.6	1.7	3.4	19.5		

To: DNCT - biology team
From: Jim White
Re: Comments on 3/10/99 Rules of The Game for EWA
Date: 3/21/99

These comments are intended to clarify and add to the discussion of 3/18 regarding Bruce's draft rules for adjusting the historical salvage records and scoring the actions taken during EWA games.

Sacramento salmon smolts

1. Close DCC reduces entrainment by half.

We expect that closing the DCC gates will reduce entrainment. For the purposes of the game, your estimate of 50% is close enough.

The reduction is expected to be smaller than the percent reduction in XGEO when the gates are closed (reduction from about 30 percent XGEO to about 10 percent XGEO, or 66%). Entrainment would not be expected to decline by the same amount if the survival of salmon that end up in the interior Delta through Georgiana Slough is lower with the gates closed than it would be with them open.

We need to consider survival and productivity effects as well as entrainment when we score the game. In a overly simplified calculation of survival based on change in Sacramento flow and fish splits (70:30 with the DCC gates open and 90:10 with them closed), and survival assumed to be 90% via the Sacramento River and 10-50% via the interior Delta, the improvement in survival due to DCC closure ranges from 10-24 percent, with the greatest improvement associated with the lowest interior Delta survival rate. If survival in the River were assumed to be 80% with the gates open and 90% when the gates were closed (due to the increased flow), the survival improvement due to gate closure ranges from 19 - 35 percent across the range of Delta survival rates used. The Newman-Rice model estimate that BJ mentioned was a 25 percent improvement in survival due to DCC closure, within the range estimated from my crude calculations.

I need to retract an assertion I made Thursday at the DNCT meeting. The inadvertent corruption of a fall run CWT salmon data set during manipulation of those files by DFG led to an analysis with results suggesting that at about 7000-8000 cfs export rate the survival of Sacramento salmon would be lower with the gates closed than with them open. The problems with the data set were discovered recently when the results could not be replicated. The data set has been restored and results of subsequent re-analysis sent to me Friday do not support this conclusion. Instead they indicate that emigrating Sacramento river salmon survival is 1) higher and 2) declines less rapidly with increasing exports with the gates closed than with the gates open. Sorry for confusing the already fragile discussion we were having Thursday with this

misinformation.

2. Reducing exports on a daily basis reduces entrainment proportionately.

Expect this is generally true. In addition, mortality indirectly related to exports will be reduced and survival will improve (productivity effect).

San Joaquin basin salmon smolts

1. Increasing Qwest reduces entrainment by 50% per 2000 cfs when Qwest <4000 cfs.

Probably sufficient to describe conditions in terms of San Joaquin flow and exports since Qwest will change directly in relation to changes in either Vernalis Q or exports.

2. Reducing exports on daily basis reduces entrainment proportionately.

Expect this is generally true, especially for smolts actively migrating to the ocean. For fry near the diversion points there is the same problem as for delta smelt - save them today and entrain them tomorrow. Also expect indirect losses of San Joaquin salmon are reduced (productivity effect).

3. VAMP conditions reduce entrainment 2 X proportionately.
4. HOR reduces smolt entrainment by 60%.

Obviously this is complex because these actions produce related effects. Since VAMP modifies both Vernalis flow and export rate, two types of effects are expected. Bruce describes the effect as being " 2X proportionately". I am not sure exactly what that means. Without the HOR, the VAMP export shift would reduce entrainment proportionately. But it probably would be an exaggeration to reduce historical entrainment that occurred when there was no HOR by the fraction of export rate reduction for VAMP if the HOR is presumed to be there too.

Bruce's rule says the HOR would reduce entrainment by 60%. Is this the anticipated reduction in the proportion of emigrating SJ smolts that are entrained by the CVP/SWP or the percent reduction in the number entrained? On any given day, the HOR reduces the number of smolts that migrate directly to the pumps via Old River from 60% of downstream migrants, the typical portion of SJR flow that goes into Old River, to 0%. It would be an exaggeration to say that the HOR eliminates entrainment of all salmon kept out of upper Old River, because they may be entrained after traveling down the San Joaquin and approaching the pumps from the north. Without the HOR most of the SJ smolts entrained by the CVP/SWP probably got to the pumps via Old River. So if most of the smolts among the 60% redirected by the HOR actually avoid being entrained, and the chance entrainment of the other 40% of smolts which previously migrated down the SJR does not increase radically, the percent reduction in SJ smolt

entrainment could be fairly high - perhaps much greater than 60%. Or if the probability of entrainment is high even for smolts in the SJ past Stockton, the entrainment reduction due to HOR may be much less. The maximum entrainment reduction attributable to HOR would be expected when exports are very low and flows are high.

In the game, we will want to determine first if the flows in April are so high as to preclude having the HOR installed or, if a concrete/steel barrier were constructed, closed. If the HOR is in, we could try to adjust entrainment from historical. I suggest the range of effect of the HOR on SJ smolt entrainment might be a 10-20 percent reduction with low flows and high exports up to 80-90% reduction with higher flows and low exports. The combination of lower exports and higher flows is expected to improve survival, but I don't know how describe the effect in terms of entrainment. Obviously the effects of flow and export on entrainment and survival are confounded and I don't know how well our current information (or at least my understanding of it) enables us to estimate either the combined effect or to separate the effects of each factor.

Spring run salmon yearlings

I agree there is no basis for treating the effects on these fish much differently from fall run smolts in the spring. Again, we ought to account for "productivity effects" as survival improves as exports decline, but the effect is not obviously related to changes in entrainment.

Striped bass eggs and larvae

We didn't get to this. As with other species and life stage discussions, I have a concern that we don't attribute large benefits to several different measures of environmental conditions when these measures of Delta conditions change concurrently. In this case, if exports were reduced from 8000 to 6000 cfs, and Qwest increased by 2000 cfs and X2 moved 2 km downstream as a result, the rules, as I understand them, indicate striped bass E&L entrainment would be reduced by .25 X .25 X .5 X .5, to 1.5 percent of the original rate. This seems like an overly optimistic result for this magnitude of change in Delta conditions and suggests at least some of these percentage reductions are too high. The DCC closure rule would apply only to Sacramento River spawning and would conceivably be detrimental to striped bass eggs and larvae from spawning on the San Joaquin, so even if the effect is to reduce entrainment of bass from the Sacramento side by 50%, the overall effect on entrainment would be less.

Steelhead

1. Reducing exports on daily basis reduces entrainment proportionately.

This rule is acceptable.

2. VAMP conditions reduce entrainment 2 X proportionately.

Same comments as for San Joaquin smolts.

Fish

Group:

I offer some observations regarding salinity preferences of juvenile salmon upon movement from riverine habitats into estuaries and beyond.

Buell

Baggerman, B. 1960. Salinity preference, thyroid activity and seaward migration of four species of Pacific salmon (Oncorhynchus). J. Fish. Res. Bd. Can. 17(3): 295-322.

Baggerman repeated and extended the initial work of Houston (1957) in this area, using four species of pacific salmon: pink, chum, sockeye and coho. She found that pink and chum salmon were obligate for anadromy and all fry died if held for extended periods in fresh water, whereas sockeye and coho juveniles passed through cycles of strong sea water preference and a reversion to fresh water preference if not allowed to go to sea. All test fish were placed in gradient tanks where they could choose to be in fresh or salt water. Onset of strong salt water preference corresponded directly with increases thyroid activity (now replaced by the familiar and easier to conduct ATP-ase diagnostic), which is associated with smolting. Pink fry started strong and consistent salt water preference about one month after complete resorption of the yolk sac (beginning of May). Chum salmon showed a weak preference for salt water in April after yolk sac resorption but exhibited a strong and persistent halophilic response by May. Sockeye juveniles showed a more complex response to exposure to sea water, exhibiting a preference for sea water from April through the end of August of their first year, reverting to a preference for fresh water by September. Yearling sockeye showed a strong and persistent preference for sea water from April through June, but this preference reversed by August if fish were held in fresh water. Coho juveniles exhibited very weak preference for sea water by a small proportion of test individuals during their first spring (end of May), but otherwise a consistent preference for fresh water for their first year. Coho yearlings began showing a strong and persistent preference for salt water by the end of March. When held in fresh water, this preference reversed by the end of May. Baggerman concluded that sea water preference could be used as an accurate diagnostic for "migration-disposition". She was able to alter the timing of the halophilic response (and the associated thyroid activity) through manipulation of photoperiod, having previously done the same with sticklback, which has since become a well-known phenomenon. Finally, Baggerman was able to reverse the preference for sea water by treatment with thyroid inhibitors, clearly implicating the hormone in the preference response.

Williams, I.V. 1969. Implication of water quality and salinity in the survival of Fraser River sockeye smolts. Prog. Rep. No. 22, Int. Pac. Salmon Fish. Comm. New Westminster.

Williams compiled recruitment data along with river discharge and water quality information and noted a strong influence of "some survival factor" prior to entry into salt water. Among other things, he conducted salinity preference tests on wild smolts captured at lake outlets in salt water gradients (about 2 to about 29 ppt. in 4-6 layers) for fish held previously in various salinities. Williams noted a difference in salinity "tolerance" among stocks from different lakes in the Fraser system, but he had difficulty interpreting his results. The stock closest to the mouth of the Fraser generally tolerated full strength sea water with no acclimation; stocks from lakes

further upstream required some acclimation and recovery from capture before tolerating sea water well. I suggest that the stock closer to the mouth (very close) is genetically predisposed to enter salt water soon after leaving their lake. In salt water preference tests, smolts from the lake nearest the mouth (Cultus Lake) "preferred" full strength sea water, when placed in a gradient where they could choose, within only a few (2-9) hours of being introduced into the gradient; control fish showed no spacial distribution corresponding to the salinity gradient tank or showed an opposite distribution, confirming salinity preference in the experimental group. Smolts from lakes further upstream "preferred" full strength seawater only after having been held in fresh water for a few days after capture, presumably indicating that some time needed to elapse before these fish were "ready" to make the transition. Interestingly, fish "forced" immediately after capture into sea water for holding, and then introduced into the gradient showed less preference for sea water than their counterparts held for a short time in fresh water prior to introduction into the gradient. [This may have implications for release sites for either hatchery fish or salvaged fish in the Central Valley system.] Williams interpreted his data to indicate, among other things, that it is important for survival of the various stocks of sockeye in the Fraser system to reach the estuary very near the time when acceptance of, or "preference" for, sea water occurred, and that this is genetically mediated. Both river velocity and turbidity (the lack of which retards migration of sockeye during the day) are thought to be influential factors. Once sea water "acceptance" has occurred within the fish "very little if any acclimation is necessary for survival." Premature or delayed entry can impair survival, however.

Hurley, D.A. and W.L. Woodall. 1968. Responses of young pink salmon to vertical temperature and salinity gradients. Prog. Rep. No. 19, Int. Pac. Salmon Fish. Comm. New Westminster.

Hurley and Woodall tested newly emergent pink salmon fry from a variety of stocks for both temperature and salinity "preference". They found that if pink fry were held for 2-3 months in fresh water after emergence, they died. Preference for both colder temperatures and increasing salinities occurred in an "orderly sequence" during the sea water transition period. The completion of this transition was less than one month for all stocks (a strong preference usually developed within 5-10 days) and was more rapid for later emerging fry. Salinity preference was observed to be independent of the salinity of the previous holding environment.

Tyler, R.W. 1963. Migration of juvenile salmon in Everett Bay. Report, Fish. Res. Inst., U. of Wash. Seattle.

Tyler noted that juvenile salmon emigrating from the Snohomish River into Everett Bay tended to enter saline environments quickly and migrate primarily along the north side of the estuary. This is the side away from the freshwater plume of the River, which bends south and passes primarily between "Jetty Island" and harbor facilities on the mainland. There was no correlation between the distribution of chum, coho or chinook juveniles and concentrations of spent sulfite liquor. This is consistent with observations made by others and cited by Tyler.

Conley, R.L. 1977. Distribution, relative abundance, and feeding habits of marine and juvenile anadromous fishes of Everett Bay, Washington. M.S. Thesis, U. of Wash. Seattle.

Conley observed that juvenile coho, chinook and chum salmon were most abundant in his sampling stations from May through July, during the peak of downstream migration. Chinook tended to have a more protracted migration period, but all three species moved rapidly into saline environments. Abundances were lowest for the two sites dominated by the fresh water plume (sites 3 and 4). Two large sulfite paper mills are located in the Port Gardner area, contributing effluent to the estuary, but the spent liquor concentrations are very localized and the plume tends to stay in the fresher water lens (Tyler, 1963; pers. obs.). [The Portland Harbor Study (ODFW) showed that juvenile salmon do not avoid shoreline developments, including a variety of commercial port developments and revetments, and in some cases tend to congregate in such areas; predation was found to not be a problem. Therefore, presence of port facilities is probably not a factor explaining smolt spacial distribution.] Conley's thesis did not address salinity directly, since he was primarily interested in structural habitat features, spent sulfite liquor and feeding, but the data speak for themselves.

Levings, C.D. 1982. Short term use of a low tide refuge in a sandflat by juvenile chinook Oncorhynchus tshawytscha, Fraser River estuary. Can. Tech. Rep. No. 1111, Fish. Aquat. Sci. Vancouver.

Levings documented use of depressions in the substrate of Sturgeon Bank (Fraser River estuary) as low tide refuges by chinook salmon pre-smolts (fry). Fork length ranged from 38 to over 60 mm, with modes of 42 and 54 mm for fish caught in beach seines and purse seines, respectively. Salinities ranged from 5 to 25 ppt, with higher values associated with the "refuge" except during very large ebb events when the Fraser River mixed the halocline.

Ryall, R. and C.D. Levings. 1987. Juvenile salmon utilization of rejuvenated tidal channels in the Squamish Estuary, British Columbia. Can. Manuscript Rep. N. 1904, Fish. and Aquat. Sci. West Vancouver.

Ryall and Levings documented the use of brackish (2-16 ppt) tidal channels in the Squamish Estuary by pre-smolt coho and chum salmon. Fork length of the coho ranged from 33 to 57 mm over the time period of residency (early July through mid-August). Upon smolting, the juvenile salmon left the area.

Other references, archived and difficult to obtain... I'm still trying:

Houston, A.H. 1957. Responses of juvenile chum, pink and coho salmon to sharp seawater gradients. Can. J. Zool. 35:371-383.

McInerney, J.E. 1964. Salinity preference: an orientation mechanism in salmon migration. J. Fish. Res. Bd. Can. 21(5):995-1018.

Still more references bearing on this subject, for those who are interested:

Birt, T.P., J.M. Green and W.S. Davidson. 1990. Smolting status of downstream migrating Atlantic salmon (Salmo salar) parr. Can. J. Fish. Aquat. Sci. 47(6):1136-1139.

Chernitskiy, A.G., G.V. Zabruskov, D.S. Shkurko and S.P. Gambaryan. 1995. On the nature of seaward migration of Atlantic salmon (Salmo salar) smolts through an estuary. J. Ichthyol. 35(7):52-61.

Healey, M.C. 1979. Utilization of the Nanaimo River estuary by juvenile chinook salmon, Oncorhynchus tshawytscha. Fish. Bull. 77(3):653-668.

Iwata, M. 1995. Downstream migratory behavior of salmonids and its relationship with cortisol and thyroid hormones; a reveiw. Aquacult. (Netherlands) 135:131-139.

Iwata, M., H. Ogura, S. Komatsu and K. Suzuki. 1986. Loss of seawater preference in chum salmon retained in fresh water after migration season. J. Exp. Zool. 240(3):369-376.

Iwata, M., H. Ogura, S. Komatsu, K. Suzuki, RS. Nishioka and H.A. Bern. 1985. Changes in salinity preference of chum and coho salmon during development. Aquacult. 45:380-381.

Macdonald, J.S., I.K. Birtwell and G.M. Kurzynski. 1987. Food and habitat utilization by juvenile salmonids in the Campbell River estuary. Can. J. Fish. Aquat. Sci. 44(6):1233-1246.

Mahnken, C., E. Prentice, W. Waknitz, G. Monan, C. Sims and J. Williams. 1982. The application of recent smoltification research to public hatchery releases: an assessment of size/time requirements for Columbia River hatchery coho salmon (Oncorhynchus Kisutch). Aquacult. (Netherlands) 28:251-268.

Virtanen, E., L. Soederholm-Tana, A. Soivio, L. Forsman and M. Munoa. 1991. Effect of physiological condition and smoltification status at smolt release on subsequent catches of adult salmon. Aquacult. (Netherlands) 97(2):231-257.

C:\ENTRAIN\SAL-PREF.REF

X-Sender: sgreene@cd-eso
X-Mailer: Windows Eudora Pro Version 3.0.1 (16)
Date: Mon, 22 Mar 1999 16:19:29 -0800
To: fishteam@water.ca.gov
From: Sheila Greene <sgreene@water.ca.gov>
Subject: EWA game rules - Salmon

Below are my recommendations to revise Bruce's draft tools for salmon

SACRAMENTO juveniles

1. Close DCC reduces direct entrainment from ~1% to ~0%
2. Close DCC reduces export mortality from ~12% to ~4% in the worst case and ~7% to 2.5% in the best case.
3. Reduce exports reduces direct entrainment proportionately

SAN JOAQUIN juveniles

1. Substitute San Joaquin flow and exports for QWEST in a method similar to VAMP.

I read through Jim White's analysis for Sacramento salmon and have two additional factors to incorporate.

(1) Incorporate the proportion of the interior Delta mortality attributable to exports
using USFWS juvenile survival experiments in the fall
(2) Incorporating the population level effect
applying the export interior Delta mortality to the population entering the Delta
at Sac for instance.

I used Jim analysis to this point,

"We need to consider survival and productivity effects as well as entrainment when we score the game. In a overly simplified calculation of survival based on change in Sacramento flow and fish splits (70:30 with the DCC gates open and 90:10 with them closed), and survival assumed to be 90% via the Sacramento River and 10-50% via the interior Delta,"

The "10-50% via the interior Delta" values are very close to the USFWS relationship between relative interior Delta survival and exports. I used the USFWS relationship to calculate the export interior Delta mortality of the population at Sacramento entering the Delta.

My version of the USWFS latest !!PRELIMINARY!! relative interior Delta survival (riDs) versus exports relationship is

riDs = 0.5 - (0.000335766 * exports), r2=.46, p~.07.

Exports accounts for about 46% of the change in riDs from 2000 to 12000 cfs about 93% of the times. I bumped the 46% to 43% because the significance level was 93%.

I started with 100 fish at Sacramento, split them at the Cross Channel/Georgiana Slough, set the Ryde survival to 1 and used the GS/Ryde ratio at 2,000 and 12,000 cfs exports to calculate the GS survival, calculated the number that died in the interior Delta and multiplied by 43% from USFWS equation to calculate export Delta mortality.

I have many hand made diagrams of the routes, survival rates, and mortalities varying the Cross Channel gates position, exports and starting assumed Ryde survivals. The results were

# JUVENILES	100	100	100	100	100	100	100	100
GATES	OPEN	OPEN	OPEN	OPEN	CLOSED	CLOSED	CLOSED	CLOSED
SPLIT	70/30	70/30	70/30	70/30	90/10	90/10	90/10	90/10
EXPORTS cfs	2,000	2,000	12,000	12,000	2,000	2,000	12,000	12,000
GS/RYDE RATIO	.45	.45	.1	.1	.45	.45	.1	.1
ABSOLUTE RYDE SURV	1.	.5	1	.5	1.	.5	1.	.5
GS SURV	.45	.225	.1	.05	.45	.225	.1	.05
#DIED IN INT DELTA * 43%	7	10	11.5	12.3	2.4	3.3	3.9	4.1
TOTAL #DIED IN THE DELTA & MAINSTEM (just for comparison)	16.5	58.8	27	63.5	5.5	52.75	9	54

Export mortality ranged from 7% to 12% with gates open and 2.5% to 4% with the gates closed.

Sheila Greene

FISH

Date: Mon, 7 Jun 1999 13:49:19 -0700
X-Sender: chadwick@207.212.101.2
X-Mailer: Windows Eudora Light Version 1.5.2
To: fishteam@water.ca.gov
From: Pete/Lydia Chadwick <chadwick@sonnet.com>
Subject: EWA Games and Striped Bass

Folks,

Attached are an Excel file of tabulations of striped bass entrainment in the EWA gaming data and a Word Perfect document briefly summarizing some observations about striped bass entrainment.

I was concerned that our ignoring striped bass during the EWA exercise and the fact that few protective actions taken during the period of peak bass abundance would result in drastic increases in bass entrainment. While the results are not good for striped bass, they were not consistently bad. The changes associated with development between Historic conditions and the base conditions for each game are more significant that those associated with EWEA actions.

Pete Chadwick

EWASTRIP.WPD

GAMES1~1.XLS

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Initial Analysis of Striped Bass Entrainment for Games 1, 2 and 4

Reported entrainment was tabulated by three groups of months, Oct-March, April to June, and July- September. The April-June tabulation is misleading in that most of the entrainment and most of the change occurred in June. Hence for practical purposes, the April-June tabulation actually reflects what happened in June.

Keep in mind that Game 4 reflects an early Stage 1 condition, Game 1 reflects a mid-Stage 1 condition and Game 2 reflects a late Stage 1 condition.

Entrainment for July-September 1993 seems anomalous. Totals are approximately 8.3M, 12.1M, 6.5M and 5.4M for Historic, Game 4 Base, Game 1 Base and Game 2 base, respectively. It does not seem reasonable that entrainment would increase so much early in Stage 1 and then decrease to levels well below historic ones as Stage 1 progresses.

Other entrainment numbers seem reasonably consistent.

Base/Historic Entrainment- In early Stage 1 (Game 4), base entrainment exceeded historic entrainment in about half the monthly periods. By late Stage 1 (Game 2), base entrainment exceeded historic entrainment about three fourths of the time. Presumably, those increases would have been even greater if demand was not been kept at the 1995 level in Game 2. The total number entrained was about 60% greater than historical, although this number was dominated by an exceptionally large (328%) increase in June 1993. Entrainment increased most consistency in October-March.

Outcome/ Base Entrainment- The differences between entrainment in the outcome of games and base entrainment indicates the consequences of EWA actions. In general, the differences between entrainment in the outcome of the games and the base entrainment for the games were less than 10%. There were a few notable periods when the differences were considerably greater than 10%. Overall then, EWA actions affected entrainment substantially less than the factors causing differences between historic entrainment and entrainment under base conditions for the various games.

EWA measures frequently increased striped bass entrainment, reflecting the fact that striped bass abundance was not used as a factor in deciding whether to take EWA actions in the games. There was no obvious relationship between increases and time of year.

STRIPED BASS

		Historic		
	Oct-Mar	Apr-June	July-Sept	Total
1991	149,831	2,252,514	1,234,288	3,636,633
1992	400,085	3,090,841	224,401	3,715,327
1993	628,418	8,448,577	8,257,086	17,334,081
1994	203,275	887,734	339,389	1,430,398
1995	455,945	179,906	1,692,502	2,328,353
TOTAL	1,837,554	14,859,572	11,747,666	28,444,792

		Game 1 Base		
	Oct-Mar	Apr-June	July-Sept	Total
1991	164,979	1,860,110	639,700	2,664,789
1992	407,299	2,625,066	223,161	3,255,526
1993	747,663	24,718,329	6,468,375	31,934,367
1994	274,790	2,040,321	443,719	2,758,830
1995	565,503	278,546	2,174,797	3,018,846
TOTAL	2,160,234	31,522,372	9,949,752	43,632,358

	Game 1 Outcome			
	Oct-Mar	Apr-June	July-Sept	Total
1991	208,836	1,855,593	639,700	2,704,129
1992	372,590	2,624,978	226,210	3,223,778
1993	681,480	24,661,909	8,269,346	33,612,735
1994	272,341	1,816,657	426,183	2,515,181
1995	503,968	217,090	2,191,228	2,912,286
TOTAL	2,039,215	31,176,227	11,752,667	44,968,109

GAME 1 Base / Historic			
Oct-Mar	Apr-June	July-Sept	Total
1.101101	0.825793	0.518275	0.732763
1.018031	0.849305	0.994474	0.876242
1.189754	2.925739	0.783373	1.842288
1.351814	2.298347	1.307405	1.928715
1.240288	1.548286	1.284960	1.296559
1.175603	2.121351	0.846956	1.533931

GAME 1 Outcome / Historic			
Oct-Mar	Apr-June	July-Sept	Total
1.393810	0.823788	0.518275	0.743580
0.931277	0.849276	1.008061	0.867697
1.084437	2.919061	1.001485	1.939113
1.339766	2.046398	1.255736	1.758378
1.105326	1.206686	1.294668	1.250792
1.109744	2.098057	1.000426	1.580891

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D-016004

		Game 2 Base		
	Oct-Mar	Apr-June	July-Sept	Total
1991	166,504	1,860,086	639,910	2,666,500
1992	417,398	2,745,470	230,598	3,393,466
1993	773,403	27,722,986	5,434,691	33,931,080
1994	269,184	2,042,922	443,901	2,756,007
1995	571,439	321,856	2,511,799	3,405,094
TOTAL	2,197,928	34,693,320	9,260,899	46,152,147

GAME 2 Base / Historic			
Oct-Mar	Apr-June	July-Sept	Total
1.111279	0.825782	0.518445	0.733233
1.043273	0.888260	1.027616	0.913369
1.230714	3.281379	0.658185	1.957478
1.324236	2.301277	1.307942	1.926741
1.253307	1.789023	1.484074	1.462447
1.196116	2.334746	0.788318	1.622517

	Game 2 Outcome			
	Oct-Mar	Apr-June	July-Sept	Total
1991	166,962	1,861,282	639,909	2,668,153
1992	374,488	2,745,500	230,690	3,350,678
1993	503,728	28,524,067	9,070,436	38,098,231
1994	268,175	1,336,995	409,537	2,014,707
1995	528,406	317,989	2,511,623	3,358,018
TOTAL	1,841,759	34,785,833	12,862,195	49,489,787

GAME 2 Outcome / Historic			
Oct-Mar	Apr-June	July-Sept	Total
1.114335	0.826313	0.518444	0.733688
0.936021	0.88827	1.028026	0.901853
0.801581	3.376198	1.098503	2.19788
1.319272	1.506076	1.206689	1.408494
1.158925	1.767529	1.48397	1.442229
1.002288	2.340971	1.094872	1.739854

		Game 4 Base		
	Oct-Mar	Apr-June	July-Sept	Total
1991	163,726	1,861,113	641,017	2,665,856
1992	396,434	2,628,540	223,489	3,248,463
1993	712,788	25,261,562	12,142,561	38,116,911
TOTAL	1,272,948	29,751,215	13,007,067	44,031,230

GAME 4 Base / Historic			
Oct-Mar	Apr-June	July-Sept	Total
1.092738	0.826238	0.519342	0.733056
0.990874	0.850429	0.995936	0.874341
1.134258	2.990037	1.470562	2.198958
1.080295	2.157146	1.338758	1.783649

	Game 4 Outcome			
	Oct-Mar	Apr-June	July-Sept	Total
1991	164,450	1,871,658	641,017	2,677,125
1992	333,576	3,148,950	223,486	3,706,012
1993	428,796	25,044,781	11,721,535	37,195,112
TOTAL	926,822	30,065,389	12,586,038	43,578,249

GAME 4 Outcome / Historic			
Oct-Mar	Apr-June	July-Sept	Total
1.097570	0.830920	0.519342	0.736155
0.833763	1.018800	0.995922	0.997493
0.682342	2.964379	1.419573	2.145779
0.786553	2.179926	1.295423	1.765299

D-016005

D-016005

GAME 1 Outcome / Base			
Oct-Mar	Apr-June	July-Sept	Total
1.265834	0.997572	1	1.014763
0.914783	0.999966	1.013663	0.990248
0.91148	0.997717	1.278427	1.052557
0.991088	0.890378	0.960479	0.911684
0.891185	0.779369	1.007555	0.964702
0.943979	0.989019	1.181202	1.030614

D-016006

GAME 2 Outcome / Base			
Oct-Mar	Apr-June	July-Sept	Total
1.002751	1.000643	0.999998	1.00062
0.897196	1.000011	1.000399	0.987391
0.651314	1.028896	1.668988	1.122812
0.996252	0.654452	0.922586	0.731024
0.924694	0.987985	0.99993	0.986175
0.837952	1.002667	1.388871	1.072318

GAME 4 Outcome / Base			
Oct-Mar	Apr-June	July-Sept	Total
1.004422	1.005666	1	1.004227
0.841441	1.197984	0.999987	1.140851
0.601576	0.991419	0.965326	0.975817
0.728091	1.01056	0.967631	0.989712

D-016007

Fish

Delta Smelt Adult Winter (Jan-Mar) Salvage Analysis

Introduction

One of the salvage data patterns that is consistent from year to year is the salvage of adult delta smelt sometime during the period from mid December to mid March. We looked at each of the salvage events from December 1997 to March 1996 in the Salvage Records and related the events to Delta inflow and exports as seen through Delta inflow/outflow, exports at CVP and SWP, and QWEST.

Conclusions

1. Most of the events occur at the SWP.
2. The events are usually associated with falling inflows and increasing or continuing high exports (10,000+ cfs), also characterized by declining and low (minus) QWEST. Such conditions are also indicative of rapid upstream movement of X2 into the western Delta and movement of the freshwater habitat zone of the western Delta into the central and south Delta. Adult delta smelt may be drawn in large numbers into the south Delta and toward the pumps under these conditions.
3. Salvage events can also occur at relatively high inflows if inflows are declining and exports are increasing or are continuing high.
4. Events may occur occasionally despite steady or increasing high inflows if exports are high or increasing, particularly export rates exceeding 11,000 cfs. These events are usually preceeded by a low outflow and high export event that draws the fish initially to the south Delta. Once drawn into the interior Delta, these fish appear to be vulnerable to high exports regardless of inflows.
5. At higher population levels as occurred from 1979 through 1983, adult smelt salvage events may occur under almost any circumstances, but peaks in salvage would most likely occur during or following the above described conditions.

Potential Solutions

1. Dramatically declining inflows in association with increasing or continuing high exports can be moderated by anticipating the declining inflows and reducing or at least gradually ramping up exports until inflows are stabilized at a controlled level. Declining inflows could also be ramped down more slowly as flows come under control.
2. More gradually ramping declining inflows under high and increasing exports, may reduce the attraction of adult smelt into the south Delta, thus reducing the overall potential for salvage losses later when inflows are low and exports are high.
3. Anytime fish salvage increases under high exports, exports could be reduced until an event passes. This would be especially applicable when exports are in the 11,000-15,000 cfs range.
4. Under low inflows, when QWEST falls into the negative range, high exports will often lead to a salvage event. Under these circumstance, increasing inflow or increasing the amount of inflow moving through the central Delta (by increasing San Joaquin portion,

opening DCC, or providing a Hood diversion) would potentially alleviate or preclude a salvage event. If these measures fail to solve the problem, then export reductions would be in order.

Summary of Specific Events

The following summaries include general patterns observed and rounded numbers, usually to the nearest 1,000 cfs.

1. 1/4/80-1/11/80 SWP
   a. SWP: 6,000+ cfs
   b. Outflow: falling from 50,000 to 29,000 cfs
   c. QWEST: falling from 11,000 to 2,000 cfs over several days.
   d. Ended: QWEST rose to 28,000 cfs; outflow increased to 67,000 cfs.

2. 2/25/80-3/12/80 CVP
   a. SWP at 0; CVP at 3200.
   b. Very wet: Outflow 150,000 +;
   c. QWEST 40,000+;

3. 1/9/81-3/13/81 CVP/SWP
   a. Exports: variable
   b. Outflow: initially falling from 8,000 to 3,000; variable over period.
   c. QWEST: initially falling from 1,800 to -2,400 cfs.; variable over period.
   d. Peak: 1/12-1/19; QWEST falling from 0 to -2,400; exports 10,000+; outflow falling from 7,000 to 3,000.

4. 11/26/81-11/28/81 CVP
   a. High and increasing flows and QWEST; CVP at 3100.

5. 1/16/82-3/11/82 CVP/SWP
   a. High flows
   b. Peak: 2/11-2/17; QWEST fell from 8,000 to 500; outfall fell from 46,000 to 26,000; export were steady at 10,000+.

6. 1/3/83-1/27/83 SWP
   a. Exports: 10,000+
   b. Outfall: initially falling from 100,000+ to 40,000.
   c. QWEST: initially falling from 33,000 to 10,000.
   d. Ending: when QWEST rose from 15,000 -> 66,000.

7. 2/12/83-2/16/83 SWP
   a. Exports: 10,000+
   b. Outflow: 200,000+

c. QWEST: 40,000-60,000

8. 2/24/85-3/8/85 SWP
   a. Exports: 7,000-11,000
   b. Outflow: falling from 30,000 to 0.
   c. QWEST: falling from 6,000 -> -3,000

9. 1/15/86-1/23/86 SWP
   a. Exports: 10,000
   b. Outflow: initially falling from 13,000 -> 5,000
   c. QWEST: Initially falling from 1,800 -> -2,500
   d. Ending: as QWEST increased to 0; Outflow rose from 5,000 -> 32,000; and exports fell to 6,000-8,000.

10. 2/7/86-2/14/86 SWP
   a. Exports: 6,000-7,000
   b. Outflow: falling from 70,000 to 28,000
   c. QWEST: falling from 16,000 to 1,400

11. 12/15/87-1/28/88 CVP/SWP
   a. Exports: 10,000-11,000+
   b. Outflow: falling from 20,000 to 3,000
   c. QWEST: falling from 6,000 to -4,000
   d. Peak: 12/25-12/30; after QWEST fell to -4,000 and outfall fell to 2.000
   e. Ended: Outflow rose to 10,000; QWEST rose to -1,000, under steady 10,000 exports.

12. 12/29/88-1/31/89 SWP
   a. Exports: rising from 5,000 to 11,000+
   b. Outflow: falling initially from 23,000 to 3,000, then steady at less than 4,000
   c. QWEST: falling initially from 8,000 to -3,000.
   d. Ended: Outflow rose to 12,000; QWEST rose to 3,000, and SWP fell from 6,000 to 0.

13. 2/12/90-2/17/90 SWP
   This was the first of a series of three events in Feb and Mar of 1990 with two interruptions that appeared related to small pulses of Delta inflow.
   a. Exports: 10,000+
   b. Outflow: falling initially from 9,000 to 2,000
   c. QWEST: falling initially from -500 to -4,000
   d. Ended: Outflow rose from 1,000 to 20,000; QWEST rose from -4,000 to 5,000, and continuing high exports.

14. 2/23/90-3/7/90 SWP
    a. Exports: 10,000+
    b. Outflow: falling initially from 20,000 to 2,000
    c. QWEST: falling initially from 5,000 to -4,000.
    d. Ended: Outflow rose to 12,000; QWEST rose to 1,400, with continued high exports.

15. 3/12/90-3/18/90 SWP
    Event ended in mid March despite continued poor conditions; appears adult run of smelt gradually ends about this time.
    a. Exports: 10,000+
    b. Outflow: falling initially from 12,000 to 4000
    c. QWEST: falling initially from 1,400 to -3,000.
    d. Ended: no change

16. 2/8/91-2/13/91 SWP
    This was the first of a series of four events in late winter and early spring of 1991 with three interruptions that appeared related to SWP operations and small pulses of Delta inflow.
    a. Exports: SWP at 6,000 and falling to 0.
    b. Outflow: falling initially from 24,000 to 4,000
    c. QWEST: falling initially from 11,000 to 500
    d. Ended: SWP at 0.

17. 2/20/91-2/21/91 SWP
    a. Exports: initially SWP rising to 2500
    b. Outflow: falling initially from 4,000 to 2,000
    c. QWEST: falling initially from1,500 to -600.
    d. Ended: Outflow rose to 4,000; QWEST rose to 1,500, and SWP exports fell to 800.

18. 3/3/91-3/5/91 SWP
    A short period of salvage was associated with a sharp rise in export, but ended quickly as inflow rose sharply under continuing high exports.
    a. Exports: rose from 2,000 to 10,000+
    b. Outflow: rising from 4,000 to 40,000
    c. QWEST: rising from 1,500 to 10,000
    d. Ended: with high inflow

19. 3/8/91-4/5/91 SWP
    The end of the salvage event commenced with the decline in the inflow event. Event continued despite another inflow pulse from 3/25-3/30.

a. Exports: 10,000+
b. Outflow: falling initially from 40,000 to 4,000
c. QWEST: falling initially from 10,000 to -7,000
d. Ended: no change

20. 1/16/92-1/23/92 SWP
The winter of 1992 was marked by four adult delta smelt salvage events at the SWP coinciding with periods of low inflows and high exports, and separated by pulses of inflow under continuing high exports. The first was a modest event under moderate export rates.
a. Exports: 5,000+
b. Outflow: falling initially form 4,500 to 2,400
c. QWEST: falling initially from 500 to -500
d. Ended: outflow rose to 8,000; QWEST rose to 5,000

21. 2/21/92-3/8/92 SWP
After several weeks of increasing inflow, exports, and QWEST (and few adult smelt), inflows dropped sharply in mid February under continuing high exports, sparking another salvage event, which ended with another inflow pulse.
a. Exports: 10,000+
b. Outflow: falling during the period from 43,000 to 7,000
c. QWEST: falling during the period from 4,000 to -5,500
d. Ended: outflow increased to 26,000 and QWEST increased to 1,500

22. 3/13/92-3/19/92 SWP
After a short respite, the smelt returned to the SWP facilities as inflows dropped again under continuing high exports.
a. Exports: 10,000+
b. Outflow: falling initially from 25,000 to 6,000
c. QWEST: falling initially from 1,300 to -7,000
d. Ended: Outflow rising to 29,000; QWEST rising to -1,500

23. 3/24/92-3/31/92 SWP and CVP
The fourth event occurred as the latest inflow pulse ended under continuing high export. The event and smelt run ended quietly with no marked change in conditions.
a. Exports: 10,000+
b. Outflow: falling initially from 16,000 to 2,000
c. QWEST: falling initially form -1,500 to -7,000
d. Ended: no marked change

24. 1/07/93-1/08/93 SWP
Event of winter 93 began with typical high exports and falling inflow and QWEST, eventually leading to continous events through late February.

a. Exports: 10,000+
b. Outflow: falling initially from 33,000 to 15,000
c. QWEST: falling initially from 7,000 to -4,000
d. Ended: Outflow returned to 33,000 and QWEST rose to 4,000

25. 1/15/93-2/23/93 SWP
This continuous period of adult smelt salvaged began despite rising inflows. SWP exports rose to new highs as new pumps were put to the test.
a. Exports: SWP rose from 7,000 to 10,000; total of 14,000 initially
b. Outflow: rising initially to 60,000 and then falling to 30,000 in middle of period.
c. QWEST: rising to 20,000 then falling as low as -2,000 in the middle of the period.
d. Ended: Outflow rose to 100,000+; QWEST rose to 16,000; SWP pumping went to 0.

26. 2/22/94-3/6/94 SWP and CVP
a. Exports: 4,000-5,000
b. Outflow: 34,000 falling to 13,000
c. QWEST: 7,000 falling to -700
d. Ended: QWEST rose to 300-900

27. 12/26/94-1/02/95 SWP
Small event started with declining outflows and high exports.
a. Exports: 10,000+
b. Outflow: initially falling from 12,000 to 2,000
c. QWEST: initially falling from 500 to -4,000
d. Ended: sharply rising inflows

28. 1/6/95-2/20/95 SWP
Long event occurred despite rising and high inflows, ending only with low exports. Began under low outflow, high exports, and negative QWEST. Continued despite high inflows under very high exports.
a. Exports: very high at 10,000-12,000+; 8,000+ at SWP
b. Outflow: rising from about 10,000 to 220,000
c. QWEST: initially beginning with -3,000 then rising sharply to 22,000.
d. Ended: when SWP exports fell to 800

29. 1/6/96-1/13/96 SWP
Beginning of two months of nearly continuous salvage events for adult delta smelt. This beginning event was punctuated by falling inflows and rising exports. X2 movement from Suisun Bay well into western Delta.
a. Exports: initially rising from 5,000 to 11,500
b. Outflow: initially falling from 31,000 to 7,000
c. QWEST: initially falling from 6,000 to -7,000

d. Ended: outflow rose to 10,500; QWEST rose from -7,000 to -3,000; and exports declined from 11,000 to 7,000.

30. 1/15/96-2/1/96 SWP and CVP
The second quarter of this period was punctuated by very high exports under rising inflow.
a. Exports: very high at 11,000+
b. Outflow: increasing from 6,000 to 80,000
c. QWEST: increasing from -6,000 to 18,000
d. Peak: 1/20-2/1 when exports were highest at 11,000+
e. Ended: when SWP exports fell from 7,000+ to 0.

31. 2/4/96-3/4/96 SWP and CVP
The last half of the 96 adult delta smelt salvage period was marked by increasing exports and sustain very high inflow.
a. Exports: CVP at 4,300 and SWP varying from 1,000-5,000
b. Outflows: 100,000+
c. QWEST: 30,000+
d. Ended: Exports fell to near 0.

USFWS/NMFS

D-016015

Accord + all AFRP measures	DEFT 8/5/98 Scenario	Prposed Modifications	Justification and Base Assumptions	Species and Life Stages Benefitted	Triggers and Flexibility
n/a	Positive barrier fish screen at Clifton Court Forebay; designed for 6,000 cfs at 0.20 fps screen approach velocity	Keep	Positive barrier fish screen at Clifton Court Forebay will eliminate predation in the forebay and increase fish salvage efficiencies. Approach velocity of 0.2 fps is established for delta smelt. Lower approach velocities increase opportunities for fish to escape the area of pumping plant influence and avoid the fish collection/salvage process.	All chinook salmon fry, smolts, and adults; Delta resident fish species; NOTE: Approach velocity of 0.2 fps is targeted for delta smelt adults. Delta smelt eggs and larvae are unscreenable until 20+ mm.	May be operational considerations to vary approach velocity based on fish salvage rates or hydrological conditions. (e.g. exports exceeding 6,000 cfs may be allowed up to a screen approach velocity of 0.33 fps (9900 cfs) when delta smelt are not impacted.)

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(5-7)
new actions
over full AFRP

Accord + all AFRP measures	DEFT 8/5/98 Scenario	Prposed Modifications	Justification and Base Assumptions	Species and Life Stages Benefitted	Triggers and Flexibility
n/a	Research fish screen facility at Tracy; designed for 2,500 cfs at 0.20 fps screen approach velocity	Delete this action AND Build positive barrier fish screen designed for full Tracy pumping capacity at 0.2 fps screen approach velocity at the head of the DMC or at Clifton Court Forebay with an intertie to the Tracy Pumping Plant.	Fish screen technology is currently available to complete a positive barrier fish screen at this location. Many of the proposed research objectives would be better addressed in a laboratory.	All chinook salmon fry, smolts, and adults; Delta resident fish species NOTE: Approach velocity of 0.2 fps is targeted for delta smelt adults. Delta smelt eggs and larvae are unscreenable until 20+ mm.	

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Accord + all AFRP measures	DEFT 8/5/98 Scenario	Prposed Modifications	Justification and Base Assumptions	Species and Life Stages Benefitted	Triggers and Flexibility
n/a	2,000 cfs diversion and fish screen at Hood on Sacramento River	Delete this action	Fish screen technology is currently available to complete a positive barrier fish screen at this location. USBR's hydraulic lab in Denver can address design issues. Facility may create significant impacts to upstream migrating fish (i.e. salmon adults traveling from the Delta to the Sacramento River).		
n/a	Joint Point	Keep	Additional pumping capacity at SWP can assist with the filling of Federal storage capacity in San Luis Reservoir during periods of low impact to fisheries	Potentially multiple species	Full use of JPOD consistent with standards in this proposal
n/a	Salvage all fish and truck to release location	Keep	Benefits of salvage differ among species and life stages. Delta smelt will not benefit from salvage efforts.	Juvenile salmon and steelhead; some resident Delta species.	Salvage rates can serve as an index of fisheries impacts and trigger operational changes in export rates

D-016017

D-016017

Accord + all AFRP measures	DEFT 8/5/98 Scenario	Prposed Modifications	Justification and Base Assumptions	Species and Life Stages Benefitted	Triggers and Flexibility
n/a	Old River enlargement in reach north of CCFB	Re-evaluate need in the context of new fish screens with low head pumping plant at CCFB	Dredging decreases value of aquatic habitat and may increases movement of fish towards pumping facilities	All salmon fry and juveniles; most delta resident fish species adversely affected.	
n/a	Operable flow control barriers or their equivalent in south Delta	Delete this action as proposed. Re-evaluate in the context of new export regime and new facilities	Barriers block fish passage and may increase movement of fish towards salvage facilities	All salmon fry and juveniles; most delta resident fish species adversely affected.	
n/a	Mokelumne River setback levees and dredging	Keep setback levees and delete dredging.	Setback levees will allow riparian vegetation to develop on floodplain/near shore areas and improve fisheries habitat; dredging will decrease value of aquatic habitat.	All salmon fry and juveniles; most delta resident fish species.	
1962 LOD X2 AFRP Delta Action #3	1962 LOD X2	This is the same action as in the November 20, 1997 AFRP b(2) decision.	Particularly important feature for estuarine health	Most resident Delta fish species and Bay species	none

D-016018

D-016018

Accord + all AFRP measures	DEFT 8/5/98 Scenario	Prposed Modifications	Justification and Base Assumptions	Species and Life Stages Benefitted	Triggers and Flexibility
30-day VAMP AFRP Delta Action #1	60-day VAMP	75-day VAMP from April 1 to June 15 - both flow and export components. Additional survival benefits to juvenile salmon would be realized if flows came from equal sharing across tributaries.	Impacts to San Joaquin salmon smolts will diminish under VAMP, but some losses will continue due to location of south Delta intakes. 30-day VAMP covers 45-75% of SJ salmon smolts. 60-day VAMP covers 75-90% of SJ smolts. The June period is important to SJ smolts in some years. Significant benefits to delta smelt juveniles. This action has multi-species benefits and allows for inter-annual variation in migration timing.	Spawning delta smelt; late spawning longfin smelt; late arriving winter-run salmon smolts; all Central Valley fall-run chinook salmon smolts.	Amenable to monitoring, particularly for SJ salmon smolts. The 4/1 to 6/15 time frame would be the default. Time frame could be shortened by two weeks at either end based on the absence of salmon smolts and/or delta smelt in the central Delta.
Head of Old River Barrier	Head of Old River Barrier	Head of Old River Barrier operations extended per expanded VAMP.	Substantial benefits to emigrating SJ salmon smolts.	San Joaquin fall-run salmon smolts	Same as salmon triggers for 75-day VAMP

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Accord + all AFRP measures	DEFT 8/5/98 Scenario	Prposed Modifications	Justification and Base Assumptions	Species and Life Stages Benefitted	Triggers and Flexibility
Delta Cross Channel gate closures based on real-time monitoring October - January AFRP Delta Action #6	Delta Cross Channel gate closures based on real-time monitoring October - January	Gate operations in October based on real-time monitoring and full closure of DCC gates between November 1 and January 31.	Larger Sacramento smolts are not easily detected in fisheries monitoring gear, thus DCC closure based on historical patterns of peak emigration periods.	Sacramento spring-run salmon smolts, Sacramento late fall-run salmon smolts; Sacramento winter-run salmon smolts.	DCC closure is triggered by real-time monitoring in October.
0.65 E/I ratio for October to January AFRP Delta Action #8	0.65 E/I for October 0.55 E/I for November 0.45 E/I for December - January	Additional measure to supplement Accord's E/I ratios and AFRP Delta actions: Initiated by the presence of Sacramento salmon smolts at the salvage facilities, maintain QWEST >0 through Jan. 31.	If Sacramento Basin smolts are detected at salvage facilities in south Delta, fish have been diverted significantly off-course and operational changes are necessary to improve net flow conditions for the remainder of the emigration period.	Sacramento Basin spring-run salmon smolts, Sacramento River late fall-run salmon smolts; Sacramento River winter-run salmon smolts; adult delta smelt.	Positive net flow (QWEST) is initiated by the detection of CWT Sacramento salmon (CNFH late fall-run or equivalent) at the salvage facilities: >0.5% of the upper Sacramento River CWT late fall-run salmon or >2.5% of the in-delta release CWT .

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Accord + all AFRP measures	DEFT 8/5/98 Scenario	Prposed Modifications	Justification and Base Assumptions	Species and Life Stages Benefitted	Triggers and Flexibility
0.35-0.45 E/I ratio for February 0.35 E/I ratio for March	0.25 E/I ratio for Feb and March	Replace E/I ratios for February and March with: (1) 10-day reduction in exports to 1,100 cfs (SWP/CVP combined) followed by a 4-day ramping period triggered by the presence of salmon fry at salvage facilities. (2) If the January 8 river index is <1.0 MAF, maintain QWEST at +1000; if January 8 river index is > 1.0 MAF, maintain QWEST at >0. QWEST criteria begins February 1and remains in effect until VAMP initiated.	QWEST provides baseline protection which is flow based and incorporates the generally agreed upon principal that if there is more water in the Delta, more can be safely exported. (1) In wet years salmon fry arrive in the Delta early; SJ salmon fry are particularly susceptible to losses at the south Delta pumps. The 10-14-day reduction of exports when salmon fry densities in salvage are high will allow for dispersal away from intakes and formation of habitat associations. (2) Some Sacramento smolts (spring-run, late fall run, winter-run) will be in the Central Delta and require positive downstream flows for successful emigration.	All Central Valley fall-run salmon fry; Sacramento spring-run, late fall-run, and winter-run smolts; adult delta smelt; longfin smelt.	(1) Wet years are typically when salmon fry are an issue; 10-day reduction of exports initiated by salmon fry densities in salvage. (2) In dry years (as indicated by January 8 river index), higher proportion of Sacramento Basin salmon smolts get into Central Delta and need additional flow cues to outmigrate successfully.

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D-016021

Accord + all AFRP measures	DEFT 8/5/98 Scenario	Prposed Modifications	Justification and Base Assumptions	Species and Life Stages Benefitted	Triggers and Flexibility
0.35 E/I ratio for April, May and June AFRP Delta Actions #4 and #5	0.25 E/I ratio for April, May and June	Keep Accord's E/I ratios and AFRP Delta actions as baseline flow-based protection measure after VAMP has ended.	Accord's E/I ratios provide baseline protection which incorporates the generally agreed upon principal that if there is more water in the Delta, more can be safely exported.	All Central Valley fall-run salmon smolts, some winter-run smolts; delta smelt spawning and juveniles; striped bass.	
Outflow standards July - January: range from 3,000 to 8,000 depending on month and water year. AFRP Delta Action #7	n/a	Keep Accord's outflow standards and AFRP Delta actions when other criteria in this proposal are not controlling.	Assumes SWRCB shares responsibility for implementing standards consistent with water rights priority and watershed approach that Interior testified to in the SWRCB process. This is the basic ecological principle that applies through non-X2 controlling periods.	Multiple watershed contributions will provide important upstream benefits to steelhead and salmon for adult attraction, adult holding, spawning, incubation, rearing, and emigration while meeting minimum Delta outflows.	
0.65 E/I ratio for August - September	0.75 E/I ratio for Aug-Sept	Keep Accord's E/I ratio limits.	A larger percentage of inflow diverted may adversely effect estuarine health	Sturgeon; striped bass; late spawning delta smelt	May be limited opportunities to increase E/I ratio above 0.65.

D-016022

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Accord + all AFRP measures	DEFT 8/5/98 Scenario	Prposed Modifications	Justification and Base Assumptions	Species and Life Stages Benefitted	Triggers and Flexibility
n/a	n/a	Better flows from Eastside streams to contribute to outflow standards and X2, particularly during spring months.	Habitat restoration in eastern Delta will have significantly greater value when supported by improved Delta inflow from Eastside streams. Some areas in eastern Delta cannot be supported by SJ or Sacramento inflows.	Salmon fry and smolts originating from Mokelumne River, Calaveras River, Consumnes River and San Joaquin Basin; delta smelt; Sacramento splittail.	
n/a	Delta habitat restoration plan	Keep DEFT 8/5/98 habitat plan	Needs more definition to fully evaluate. Likely to require all habitat measures in combination with flow actions to make this a beneficial action. Can not substitute habitat actions for flow based actions (X2, QWEST).	Salmon fry and juveniles; Sacramento splittail; striped bass; most resident Delta species	n/a
n/a	n/a	Fish screening program on San Joaquin River should be consistent with goals for the Sacramento Basin.	Sacramento Basin fish screen program has more aggressive goal - There appears to be no biological reason to afford less protection to San Joaquin River salmon.	San Joaquin salmon fry and smolts; Sacramento splittail	n/a

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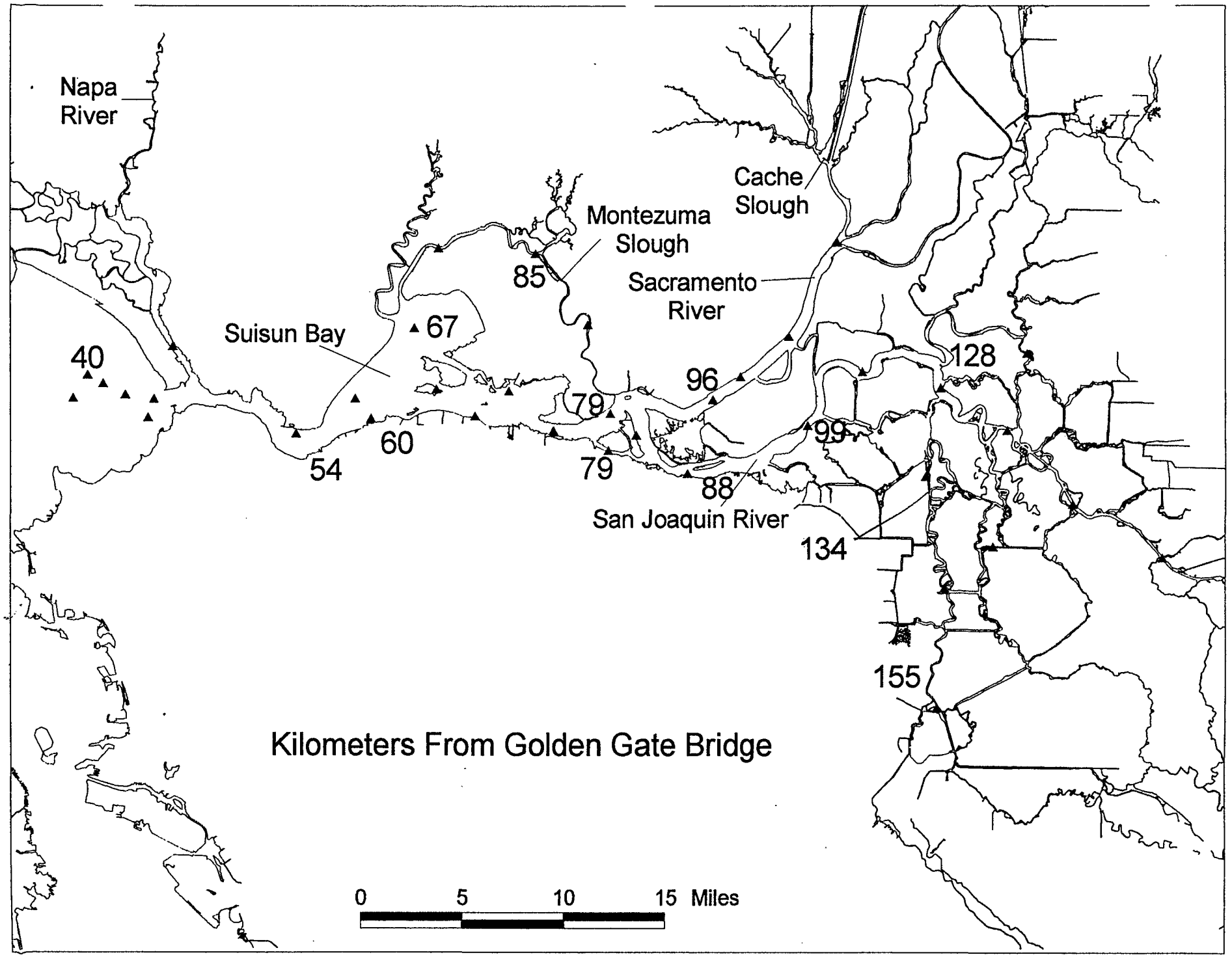

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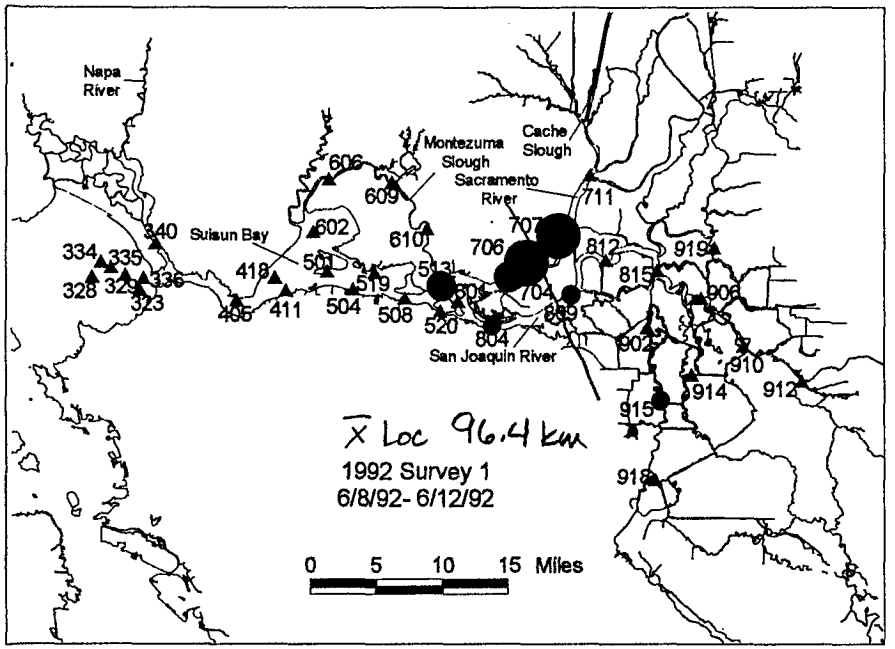
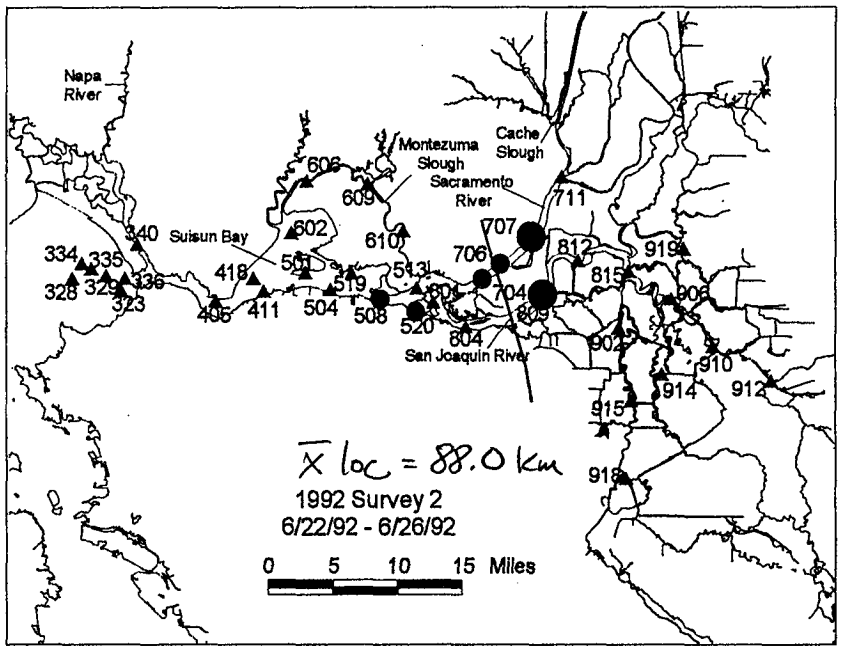
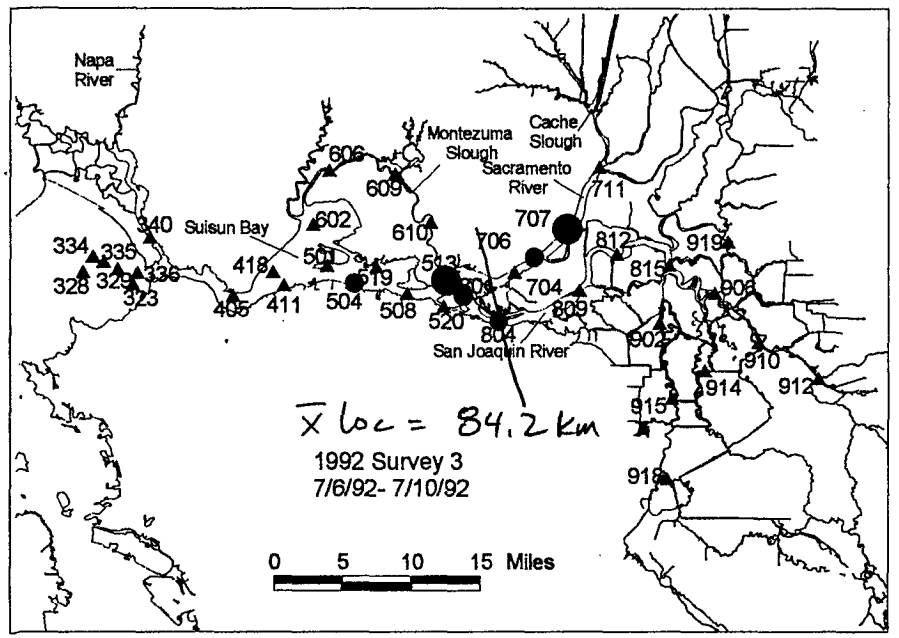
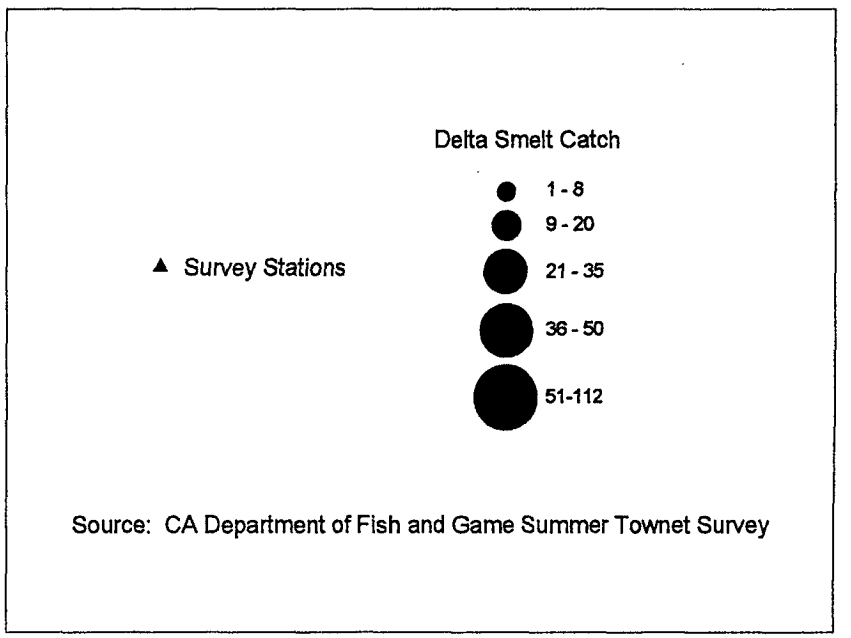
1992 Summer Tow Net Surveys









Source: CA Department of Fish and Game Summer Townet Survey

M. Sommer, PROJECT\Tnstnshist.apr

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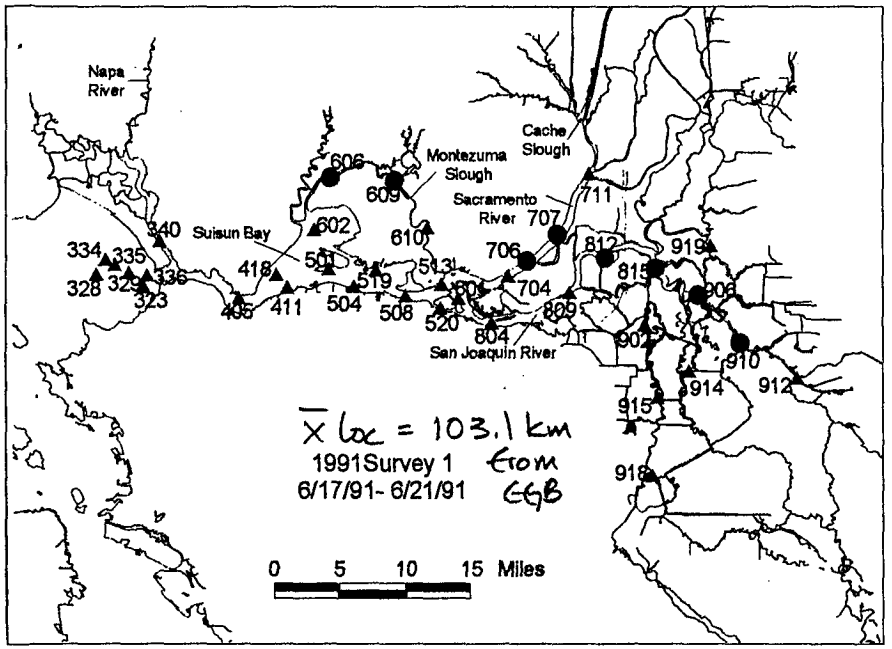
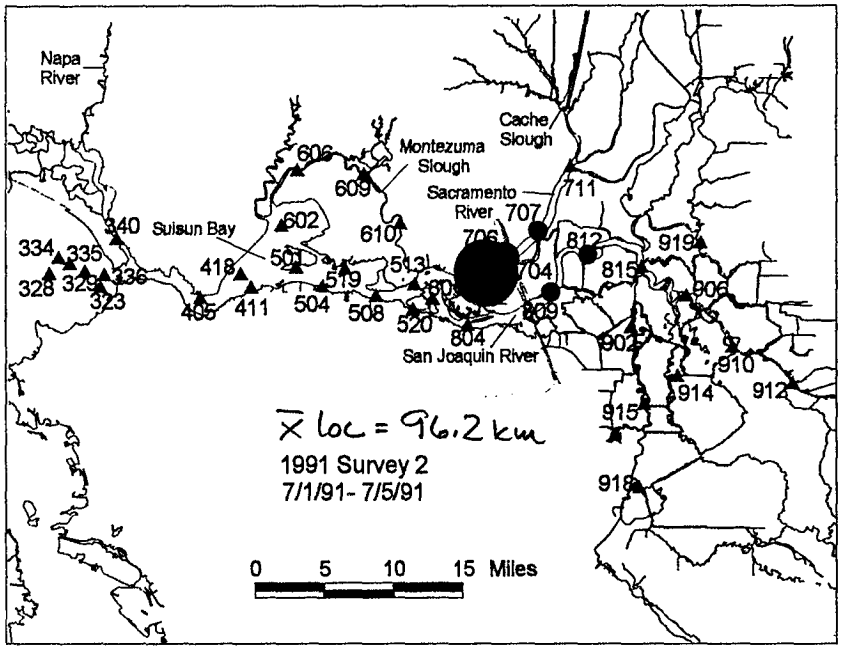
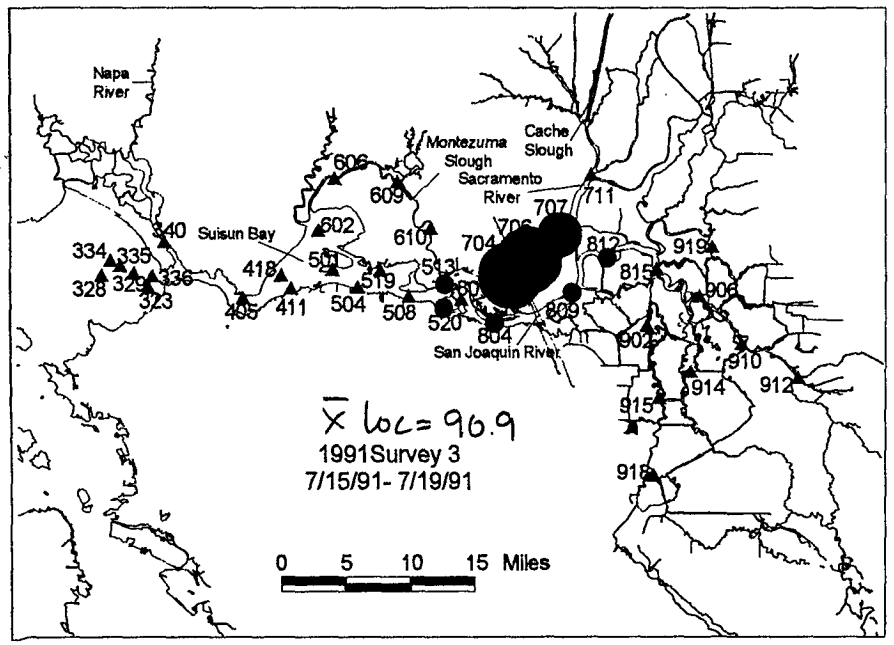
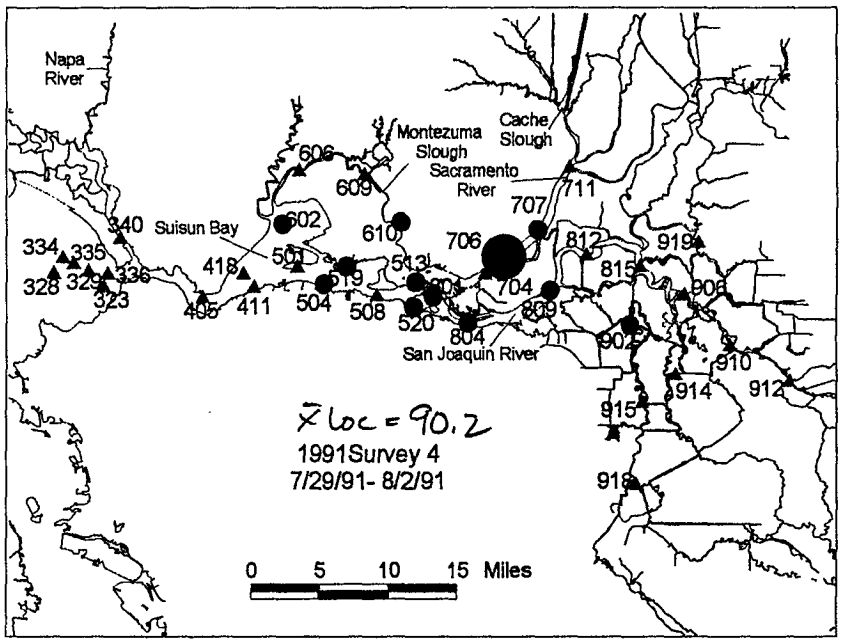
1991 Summer Tow Net Surveys









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D-016026

D-016026

A summary of a Bayesian analysis of recoveries of tagged Sacramento river chinook salmon smolts

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April 28, 1999

1. Objectives

1. to determine the degree of consistency in conclusions between alternative modeling approaches and the GLM-ridge model (Newman and Rice, IEP T.R. 59, 1997)
2. to determine if a model with fewer input variables could explain the recovery numbers as well, or perhaps better than the GLM-ridge approach.

- Ridge preferable to stepwise regression, forward selection, and backward elimination when moderate size data set compared to number of predictors of interest.

  Smaller variance, increase in bias (use cross-validation to choose ridge parameter that minimizes variance and bias combined).

- Ridge also preferable when many or most of the effects may be small.
- When (GLM-)ridge applied to Sacramento chinook, have 38 predictor variables:
  - fine for prediction
  - interpretation of $\hat{\beta}$'s tricky
  - use of the model is not easy (must make sure all input values fall within range observed in original data set).

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2. The Bayesian approach

- Consider all feasible models (or at least a large subset).

  Calculate the probability that any given model is the "best" model in the set.

- Strength of approach: uncertainty as to model choice is accounted for.

  Measures of uncertainty: posterior probabilities that each model is "best" model.

- Value of posterior probabilities:

  - Rank *each model's* relative correctness.

    If just two models are being considered, a weight of 0.99 for one model and 0.01 for the other model suggests that the second model is clearly not as reasonable as the first.

    On the other hand, if the probabilities were each 0.5, then there is no clear evidence for the superiority of either.

  - Provide a measure of the importance of *each variable* being considered.

    How often a variable shows up in models with higher posterior probabilities provides an indication of variable's "importance".

    Lack of "importance": $(\Pr(\beta_i)=0)$ equals the sum of the posterior probabilities for models that do not include a variable i.

  - Reasonable method for combining predictions from several models.

    Often preferable to forcing selection of a single "best" model, especially when two very different models may fit the data equally well.

D—016028

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3. Application to Sacramento chinook salmon data

- A total of 287 models considered. Each model was a combination of one or more covariate categories. *All the covariates considered were covariates used in the GLM-ridge model.*

- A covariate category consisted of one or more covariates; e.g., fish size is the sole variable in one category, while the logarithm of flow and a salinity measurement are two variables making up another category. No variable is in more than one category.

  A model being considered would either include all the covariates in a category or exclude all of them.

  The covariate categories were created

  - to reduce the set of all possible combinations
  - because of known correlations among covariates within a group (e.g., flow and salinity have a strong inverse relationship, the temperature variates are correlated)
  - because of relatedness in the model structure (e.g., the gate position indicators for mainstem and delta releases).

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Table 1: Covariates examined, estimated coefficients GLM-ridge model, and posterior probability that coefficient equals zero. The symbol * by coefficients indicate estimates with an approximate 95% confidence interval that does not include zero. Posterior probabilities based on equally weighted priors for all 287 models considered.

Covariate Group	GLM-ridge $\hat{\beta}$'s	$\Pr(\beta's = 0)$
Size (mm)	0.074	66.2%
log(Flow) (cfs), Salinity	0.153*, 0.269*	95.6%
Pesticide, Trend	-0.170*, -0.69	93.5%
Release Temp., Hatchery Temp., Shock	-0.278*, -0.088, 0.052	0.0%
Tide measure	-0.026	96.2%
Release site: FRH, Sac, Sloughs	-0.188*, 0.039, 0.068	
Courtland,Ryde, Mokolumne-Georgiana	0.040, 0.144*, -0.126*	6.0%
Export/Inflow: upper, delta	-0.036, -0.067	99.6%
Cross-channel gate open: upper, delta	-0.144*, 0.127	54.5%
Turbidity: mainstem, delta	-0.042, -0.034	99.9%

Table 2: Ten models with highest posterior probabilities. Model priors were uniform, 1/287, and the priors on the coefficients were centered at zero with a standard deviation of 1.65 (from Raftery, *Biometrika*, 1997). The total of the ten posterior probabilities is 93.1%.

Posterior probability	Model covariates
32.2%	Temperatures, Sites, Cross-channel Gate
23.1%	Temperatures, Sites
16.9%	Size, Temperatures, Sites
9.0%	Size, Temperatures, Sites, Cross-channel Gate
3.0%	Size, Temperatures
2.5%	Pesticide and Trend, Temperatures, Sites
2.2%	Temperatures
1.8%	Size, Temperatures, Tide, Sites
1.3%	Pesticide and Trend, Temperatures, Sites, Cross-channel Gate
1.2%	Flow and Salinity, Temperatures, Sites, Cross-channel Gate

Table 3: Coefficients for top two models, according to posterior probabilities. Ocean indicator variables' coefficients are not shown.

Site indicator is missing!

	Intercept	Chipps Indic.	Rel. Temp.	Hatch. Temp.	Shock	FRH	Sac	Slo	Crt	Ryde	Mk-G	Upper Gate	Delta Gate
$\hat{\beta}$	-6.026	1.802	-0.315	-0.014	-0.013	-0.159	0.107	0.117	0.077	0.218	-0.182	-0.163	0.20
se($\hat{\beta}$)	0.048	0.251	0.084	0.074	0.075	0.065	0.111	0.076	0.094	0.115	0.078	0.050	0.08

	Intercept	Chipps Indic.	Rel. Temp.	Hatch. Temp.	Shock	FRH	Sac	Slo	Crt	Ryde	Mk-G
$\hat{\beta}$	-6.019	1.867	-0.348	-0.004	0.025	-0.256	-0.170	0.015	-0.142	0.015	-0.218
se($\hat{\beta}$)	0.048	0.249	0.083	0.073	0.072	0.058	0.075	0.059	0.065	0.077	0.076

for signif, take 2x se($\hat{\beta}$) & subtract from coeff. Include zero? If not, it's real!

D-016030

D-016030

5. Comparison of GLM-ridge and Bayesian approaches

Similarities :

- "Significant"
  Temperature group, included in all top 10 models.
  Site indicators group, was in eight of the top ten.
  Cross-channel gate position, but a bit more ambiguous, the posterior probability of its coefficients *not* equalling zero was 45.5%, but it was included in the top model.
- "Non-significant"
  tide variable
  export/inflow measures
  turbidity measures

Differences :

- **Fish Size:**
  Slight difference: Bayesian analysis suggests fish size may affect the recovery rates ($\Pr(\beta_{size} \neq 0)$=40%), while $\hat{\beta}_{size}$ nearly zero for GLM-ridge.
- **Pesticide and Trend:**
  The Bayesian results on pesticide and trend, only 6.5% probability that the coefficients do not equal zero.
  Sharply differing with the GLM-ridge approach, which suggested moderately strong negative pesticide effect.
- **Flow and Salinity:**
  Bayesian results say no effect, while GLM-ridge had relatively large, positive $\hat{\beta}$'s.
  Not a *real contradiction* between the methods:
  when using GLM-ridge model to compare 2 flows, if reasonable levels of salinity input, then effect of flow negligible (over 4,500 to 15,000 cfs range).

At low flows (up to 15 kcfs) flow is NOT important!

D-016031

D-016031

USFWS/NMFS

K.B. 5/6/94

D-016032

Summary for Delta EWA Operations for 1991 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
Pumping (cfs)													
Historic	3,364	3,708	5,057	4,766	4,384	9,652	7,399	2,555	1,770	2,401	3,650	4,074	3,186
DWRSIM	3301	4979	5121	3901	976	12755	4034	2160	217	124	2053	4989	2,691
Model Base	4,743	4,694	4,489	3,284	4,220	9,737	6,307	1,500	1,500	1,500	1,504	3,635	2,843
Model Final	4,740	4,694	4,489	3,284	2,858	8,372	6,737	1,500	1,500	1,500	1,504	3,635	2,704
Model Change	(2)	0	0	0	(1,362)	(1,365)	430	0	0	0	0	0	(139)
Model Limits	4,740	4,694	4,489	3,284	2,858	8,372	6,737	1,500	1,500	1,500	1,504	3,635	2,704
Monthly E/I	45%	48%	47%	37%	21%	23%	32%	11%	15%	17%	19%	36%	
SL Limits	0	0	0	0	0	0	0	0	0	0	0	0	0
Fish Limits	0	0	0	0	0	0	0	0	0	0	0	0	0
DW Export	0	0	0	0	0	0	0	0	0	0	0	0	
Outflow (cfs)													
Historic	3,498	4,558	6,425	4,013	7,420	24,626	3,787	3,998	4,169	3,479	2,696	3,884	4,385
DWRSIM	5447	3494	3496	4732	11970	23902	13978	7024	5930	4000	2992	3007	5,428
Model Req'd	3,750	3,750	3,750	4,500	7,100	7,100	7,100	7,100	7,100	4,000	3,750	3,750	3,786
Model Deficit	0	0	0	85	0	0	0	0	2,680	984	988	0	286
Model Base	4,000	4,208	4,654	4,415	11,913	31,426	13,117	9,459	4,420	3,114	2,762	3,750	5,867
Model Final	3,752	4,208	4,654	4,415	13,275	32,791	12,687	9,459	4,420	3,114	2,762	3,750	5,990
Model Change	(248)	0	(0)	0	1,362	1,365	(430)	0	0	0	0	0	124
DW Diversion	0	0	0	0	0	0	0	0	0	0	0	0	
Historic X2	89.5	86.3	84.5	87.5	86.6	69.9	90.6	87.8	87.6	89.6	95.5	88.7	
Model Base X2	88.9	86.7	86.7	86.5	80.0	66.1	72.0	76.3	84.8	90.4	91.4	88.7	
Model X2	89.5	86.8	86.8	86.5	78.2	65.2	72.0	76.3	84.8	90.4	91.4	88.7	
Change X2	0.6	0.1	0.0	0.0	-1.8	-0.9	0.0	0.0	0.0	0.0	0.0	0.0	
Historic Cl	275	244	121	133	82	24	28	103	142	188	253	317	133
Model Base Cl	239	233	181	174	49	17	17	19	47	129	244	273	122
Model Cl	248	245	186	176	45	17	17	19	48	129	244	273	129
Change Cl	9	12	5	2	-4	-0	0	0	0	0	0	0	7

D-016032

D-016033

Delta Inflows and San Luis Storage for 1991 USFWS/NMFS

Freeport (cfs)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
DWRSIM-Hist	1133	574	-2517	-1284	4031	6296	6313	2104	-544	-1650	-2503	-1091	
Historic	7,620	7,723	10,818	8,984	8,133	25,755	10,879	7,332	8,930	9,514	9,515	9,969	7,573
DWRSIM	8753	8297	8301	7700	12164	32051	17192	9436	8386	7864	7012	8878	8,207
Model Base	9,003	8,297	8,301	7,700	12,164	32,051	17,192	9,436	8,386	7,864	7,012	8,857	8,222
Model Final	8,753	8,297	8,301	7,700	12,164	32,051	17,192	9,436	8,386	7,864	7,012	8,857	8,206
Model Change	-250	0	0	0	0	0	0	0	0	0	0	0	-15
Model Excess	0	0	0	0	0	0	107	0	0	0	0	0	6
Vernalis (cfs)													
DWRSIM-Hist	240	74	200	179	255	516	1121	779	456	132	198	493	
Historic	993	1,115	918	816	758	1,779	1,168	1,049	568	594	537	574	657
DWRSIM	1233	1189	1118	995	1013	2295	2289	1828	1024	726	735	1067	936
Model Base	1,501	1,189	1,118	1,006	1,033	2,295	3,042	3,290	1,024	900	900	1,067	1,108
Model Final	1,501	1,189	1,118	1,006	1,033	2,295	3,042	3,290	1,024	900	900	1,067	1,108
Model Change	0	0	0	0	0	0	0	0	0	0	0	0	0
Model HOR	75	1,225	1,188	1,094	1,088	1,826	152	165	1,030	979	979	1,133	660
San Luis (TAF)													
Historic	340	342	484	611	695	1,199	1,537	1,431	1,085	726	569	654	
DWRSIM	304	386	508	624	567	1204	1243	1143	870	585	431	519	
EWA Adjust													
Model Base	506	679	836	893	917	1,345	1,433	1,213	850	457	170	161	
Model Final	505	679	836	892	841	1,185	1,299	1,080	716	323	36	27	
Model Change	(0)	(0)	(0)	(0)	(76)	(159)	(134)	(134)	(134)	(134)	(134)	(134)	
EWA Credits	0	0	0	0	0	11	26	0	0	0	0	0	37
EWA Uses	0	0	0	0	76	95	0	0	0	0	0	0	171
EWA Balance	(0)	(0)	(0)	(0)	(76)	(159)	(134)	(134)	(134)	(134)	(134)	(134)	0
Model Demand	151	107	115	142	227	166	290	304	457	475	371	227	3,048
DWR Demand	266	187	151	91	75	108	159	206	248	246	240	192	2,169

D—016033

Delta Channel Flows for 1991 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
DCC & Georgiana													
Historic	4,323	4,353	5,260	4,722	4,473	5,184	4,747	3,515	3,935	4,878	4,878	5,005	3,336
DWRSIM													
Model Base	5,125	4,447	2,374	2,309	2,810	5,359	3,418	2,496	2,380	4,598	4,168	4,992	2,683
Model Final	4,996	4,447	2,374	2,309	2,810	5,359	3,418	2,496	2,380	4,598	4,168	4,992	2,676
Model Change	-129	0	0	0	0	0	0	0	0	0	0	0	-8
Rio Vista													
Historic	3,313	3,395	5,583	4,287	3,676	21,463	6,178	3,860	5,038	4,680	4,671	4,980	4,313
DWRSIM													
Model Base	3,439	3,713	5,903	5,174	10,107	28,769	13,491	6,430	5,120	2,239	1,944	3,243	5,404
Model Final	3,318	3,713	5,903	5,174	10,107	28,769	13,491	6,430	5,120	2,239	1,944	3,243	5,397
Model Change	-121	0	0	0	0	0	0	0	0	0	0	0	-7
Model Req'd	3,000	3,500	3,500	0	0	0	0	0	0	0	0	3,000	
QWEST (cfs)													
Historic	821	1,390	910	66	2,712	1,504	(1,930)	912	431	297	(666)	(174)	370
DWRSIM													
Model Base	743	560	(1,230)	(663)	1,512	2,183	(242)	3,250	(329)	1,303	1,192	770	546
Model Final	616	560	(1,230)	(663)	2,874	3,548	(672)	3,250	(329)	1,303	1,192	770	677
Model Change	(126)	(0)	(0)	0	1,362	1,365	(430)	0	0	0	0	0	131
Model Req'd	(15,000)	(15,000)	(15,000)	(15,000)	1,000	1,000	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)	

Salvage Fish Density and Triggers for 1991 USFWS/NMFS

Trigger	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	
Days	0	0	0	0	0	0	10	0	0	0	0	0	10	
Density Triggers														
Trigger (1=yes)	0	0	0	0	0	0	0	0	0	0	0	0		
Chinook	100	100	100	100	100	100	100	1000	1000	1000	1000	1000		
Steelhead	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000		
Striped Bass	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000		
Splittail	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000		
Delta smelt	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000		
Export Frac	0.5	0.5	0.5	0.5	0.5	0.66	0.5	0.5	0.5	0.5	0.5	0.5		
Historic														
Chinook	15	0	84	142	168	7,828	31,134	24,819	1,396	0	0	0	65,586	
Steelhead	0	0	69	37	47	9,541	4,561	139	0	0	0	0	14,395	
Striped Bass	5,066	75,789	31,138	17,381	12,413	8,044	27,712	11,526	2,213,276	981,503	223,528	29,257	3,636,633	
Splittail	0	0	0	109	166	4,864	15,006	818	18,523	4,615	0	0	44,101	
Delta smelt	0	0	14	732	1,142	1,529	1,571	482	15,176	13,004	3,828	0	37,477	
														Reduced from Historic
Model Baseline														
Chinook	30	0	48	101	94	8,204	20,660	14,249	1,257	0	0	0	44,643	32%
Steelhead	0	0	52	35	41	10,233	4,821	74	0	0	0	0	15,255	-6%
Striped Bass	6,684	104,021	25,806	12,299	10,552	7,142	20,544	13,422	1,826,120	498,898	118,414	22,598	2,666,500	27%
Splittail	0	0	0	78	146	4,870	12,038	700	14,613	2,348	0	0	34,791	21%
Delta smelt	0	0	10	544	902	892	856	124	7,638	7,277	3,058	0	21,301	43%
														Reduced from Baseline
Model Final														
Chinook	30	0	48	101	86	7,052	21,800	14,249	1,257	0	0	0	44,622	0%
Steelhead	0	0	52	35	24	9,057	5,298	74	0	0	0	0	14,539	5%
Striped Bass	6,678	104,021	25,806	12,299	8,590	6,306	21,394	13,422	1,826,120	498,898	118,414	22,598	2,664,546	0%
Splittail	0	0	0	78	124	4,287	12,371	700	14,613	2,348	0	0	34,521	1%
Delta smelt	0	0	10	544	613	714	929	124	7,639	7,277	3,058	0	20,908	2%
Pumping (cfs)														
Historic	3,364	3,708	5,057	4,766	4,384	9,652	7,399	2,555	1,770	2,401	3,650	4,074	3,184 (TAF)	
Model Base	4,743	4,694	4,489	3,284	4,220	9,737	6,307	1,500	1,500	1,500	1,504	3,635	2,840 (TAF)	
Model Final	4,740	4,694	4,489	3,284	2,858	8,372	6,737	1,500	1,500	1,500	1,504	3,635	2,704 (TAF)	
Model change	(2)	0	0	0	(1,362)	(1,365)	430	0	0	0	0	0	(136)(TAF)	

D-016035

D-016035

Genera h Evaluation Parameters for 1991 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Vernalis Flow Ratio (>1 is good)												
Base/Historic	1.5	1.1	1.2	1.2	1.4	1.3	2.6	3.1	1.8	1.5	1.7	1.9
Final/Historic	1.5	1.1	1.2	1.2	1.4	1.3	2.6	3.1	1.8	1.5	1.7	1.9
Vernalis/Export Ratio (Higher is better)												
Base/Historic	1.07	0.84	1.37	1.79	1.42	1.28	3.06	5.34	2.13	2.43	4.06	2.08
Final/Historic	1.07	0.84	1.37	1.79	2.09	1.49	2.86	5.34	2.13	2.43	4.06	2.08

Sacramento Salmon Survival for 1991 USFWS/NMFS

Out-Migration %	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Fall	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.65	0.18	0.00	0.00	0.00	1.0
Late-fall		0.25	0.50	0.25									1.0
Winter			0.10	0.25	0.35	0.25	0.05						1.0
Spring			0.01	0.06	0.17	0.28	0.25	0.16	0.07				1.0
Spring Yearlings	0.05	0.35	0.40	0.13	0.05	0.02							1.0

														Historic Relative Survival	
Historic															
DCC fraction	0.57	0.56	0.49	0.52	0.55	0.19	0.43	0.48	0.44	0.51	0.51	0.50	Fall	0.719	
Central Survival	0.39	0.38	0.33	0.34	0.35	0.18	0.25	0.41	0.44	0.42	0.38	0.36	Late-fall	0.663	
Total Survival	0.65	0.65	0.68	0.65	0.64	0.84	0.67	0.72	0.75	0.70	0.68	0.68	Winter	0.700	
													Spring	0.728	
													Yearling	0.664	
															Change from Historic
Model Base															
DCC fraction	0.60	0.54	0.29	0.31	0.22	0.16	0.20	0.28	0.32	0.67	0.68	0.61	Fall	0.844	17.4%
Central Survival	0.34	0.34	0.35	0.39	0.36	0.17	0.29	0.45	0.45	0.45	0.45	0.38	Late-fall	0.770	16.1%
Survival	0.61	0.64	0.81	0.81	0.86	0.87	0.86	0.85	0.83	0.63	0.62	0.62	Winter	0.846	20.8%
													Spring	0.854	17.4%
													Yearling	0.746	12.4%
															Change from Base
Model Adjusted															
DCC fraction	0.60	0.54	0.29	0.31	0.22	0.16	0.20	0.28	0.32	0.67	0.68	0.61	Fall	0.844	-0.1%
Central Survival	0.34	0.34	0.35	0.39	0.40	0.22	0.27	0.45	0.45	0.45	0.45	0.38	Late-fall	0.770	0.0%
Survival	0.60	0.64	0.81	0.81	0.87	0.88	0.85	0.85	0.83	0.63	0.62	0.62	Winter	0.851	0.6%
													Spring	0.857	0.3%
													Yearling	0.747	0.1%

Sacramento relative survival = 1
Central Delta relative survival = 0.5 - 0.0000336* Exports (cfs)
Monthly relative survival = sacramento fraction + DCC fraction * Central Delta relative survival
Population survival = monthly relative survival * migration portion

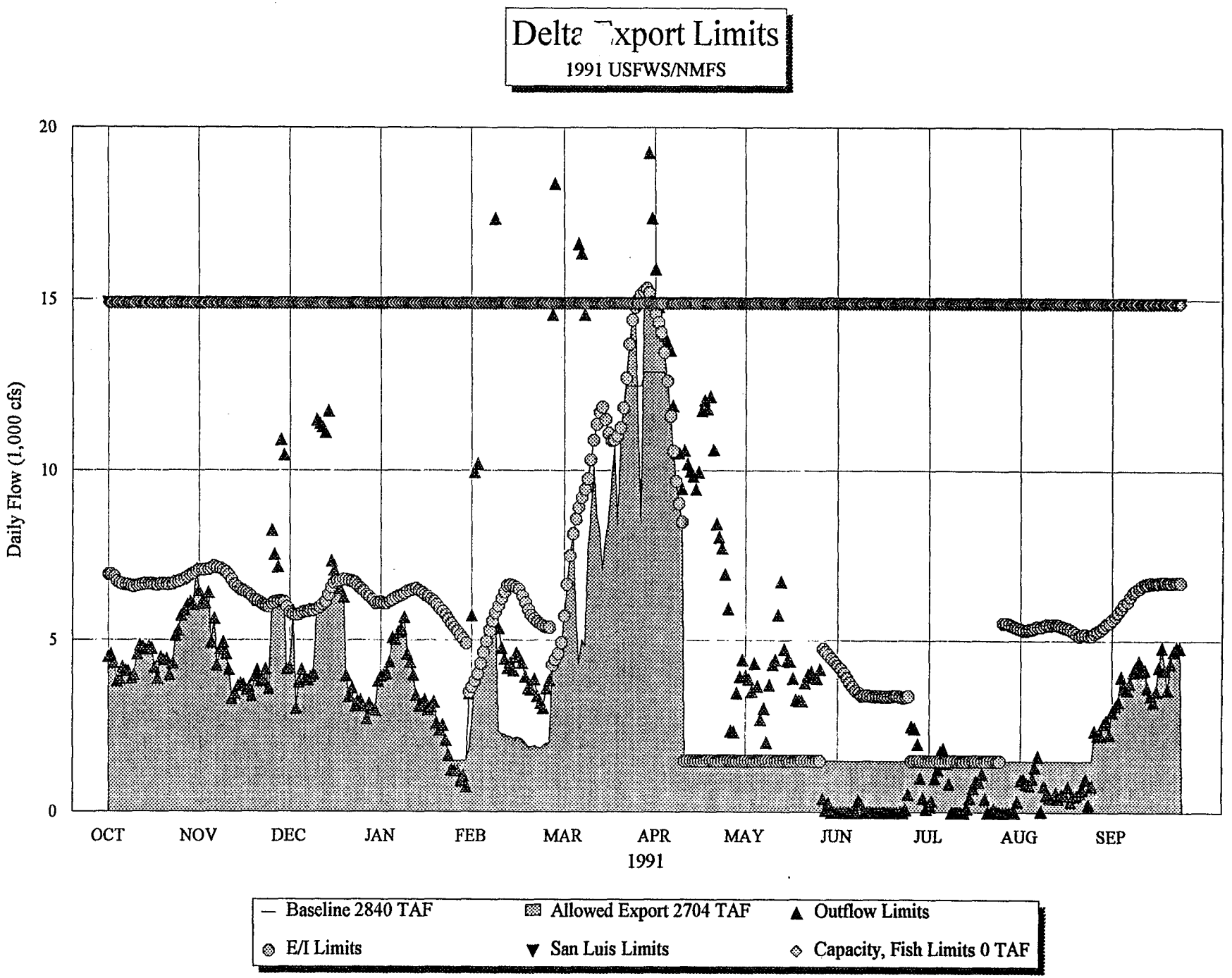
D-016036
D-016036

San Joaquin Salmon Survival for 1991 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Out-Migration %	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.48	0.07	0.00	0.00	0.00	1.0
Historic													
Flow survival	0.02	0.02	0.02	0.02	0.02	0.04	0.02	0.02	0.01	0.01	0.01	0.01	
Export Survival	0.78	0.75	0.66	0.68	0.71	0.36	0.51	0.83	0.88	0.84	0.76	0.73	
Survival	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.014
Model Base													
Flow survival	0.03	0.02	0.02	0.02	0.02	0.05	0.06	0.07	0.02	0.02	0.02	0.02	
Export Survival	0.68	0.69	0.70	0.78	0.72	0.35	0.58	0.90	0.90	0.90	0.90	0.76	
Survival	0.02	0.02	0.02	0.02	0.01	0.02	0.04	0.06	0.02	0.02	0.02	0.02	0.046
											Change from Historic		217.0%
Model Adjusted													
Flow survival	0.03	0.02	0.02	0.02	0.02	0.05	0.06	0.07	0.02	0.02	0.02	0.02	
Export Survival	0.68	0.69	0.70	0.78	0.81	0.44	0.55	0.90	0.90	0.90	0.90	0.76	
Survival	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.06	0.02	0.02	0.02	0.02	0.045
											Change from Base		-1.7%

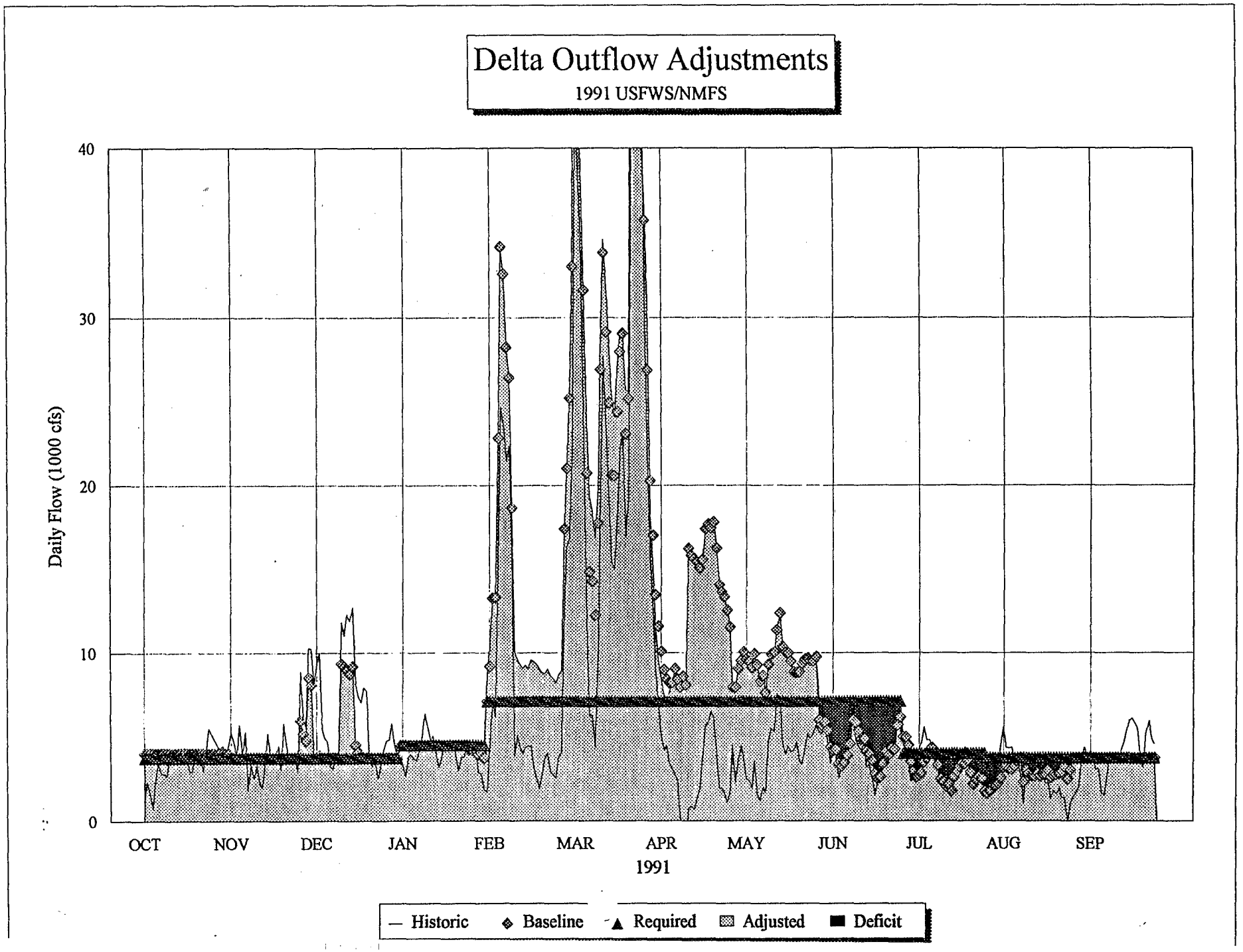
Maximum survival = 0.00002 * Vernalis Flow; 0.2 @ 10,000 cfs
Export survival factor = (15,000 - Export) / 15,000; 0.9 @ 1,500 pumping or may be a constant survival reduction
Monthly relative survival = Maximum survival * Export survival factor
Population survival = monthly relative survival * migration portion
HOR Closure may increase survival by 0.1 or some other factor

D-016037
D-016037



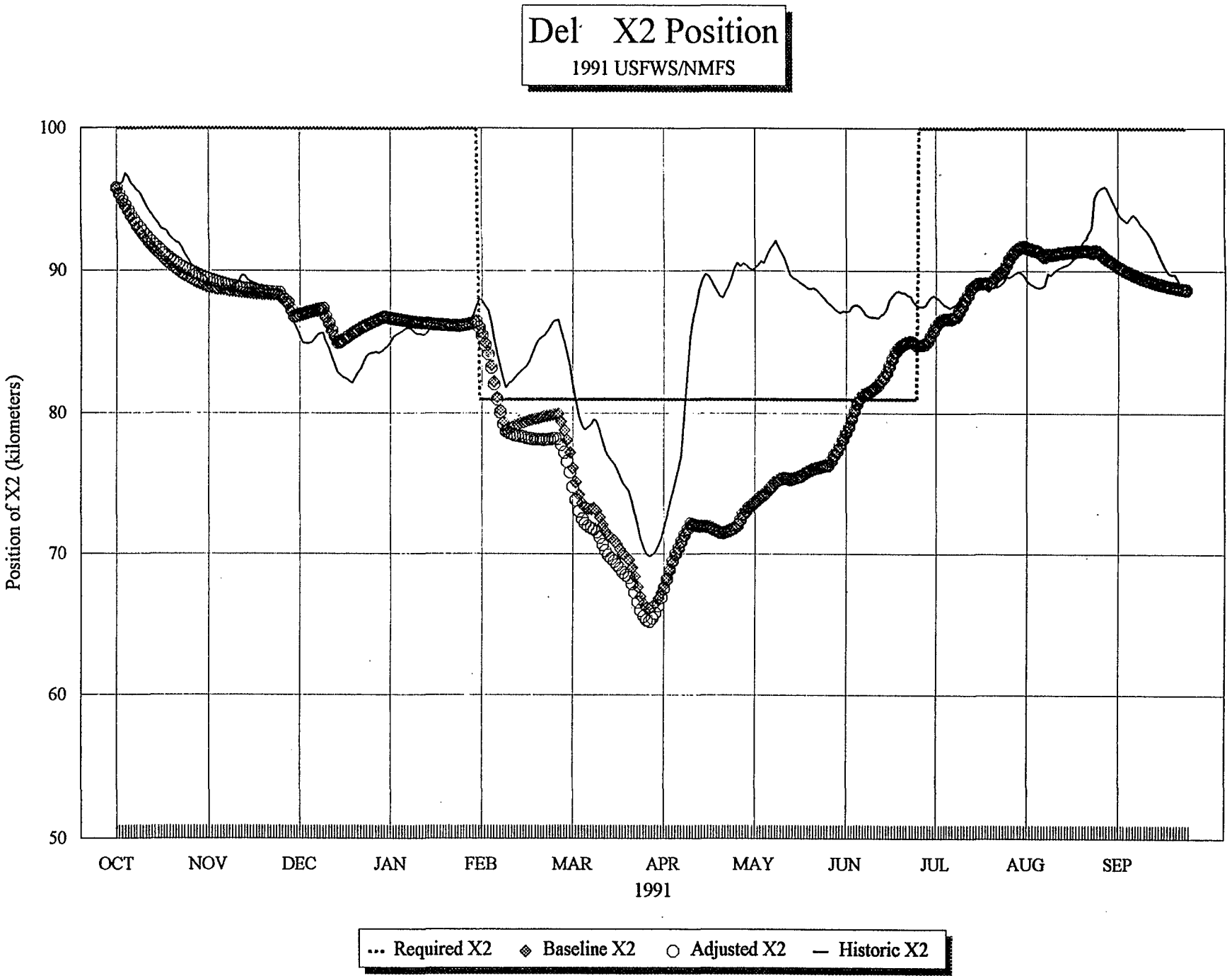
D-016038

D-016038



D-016039

D-016039



D-016040

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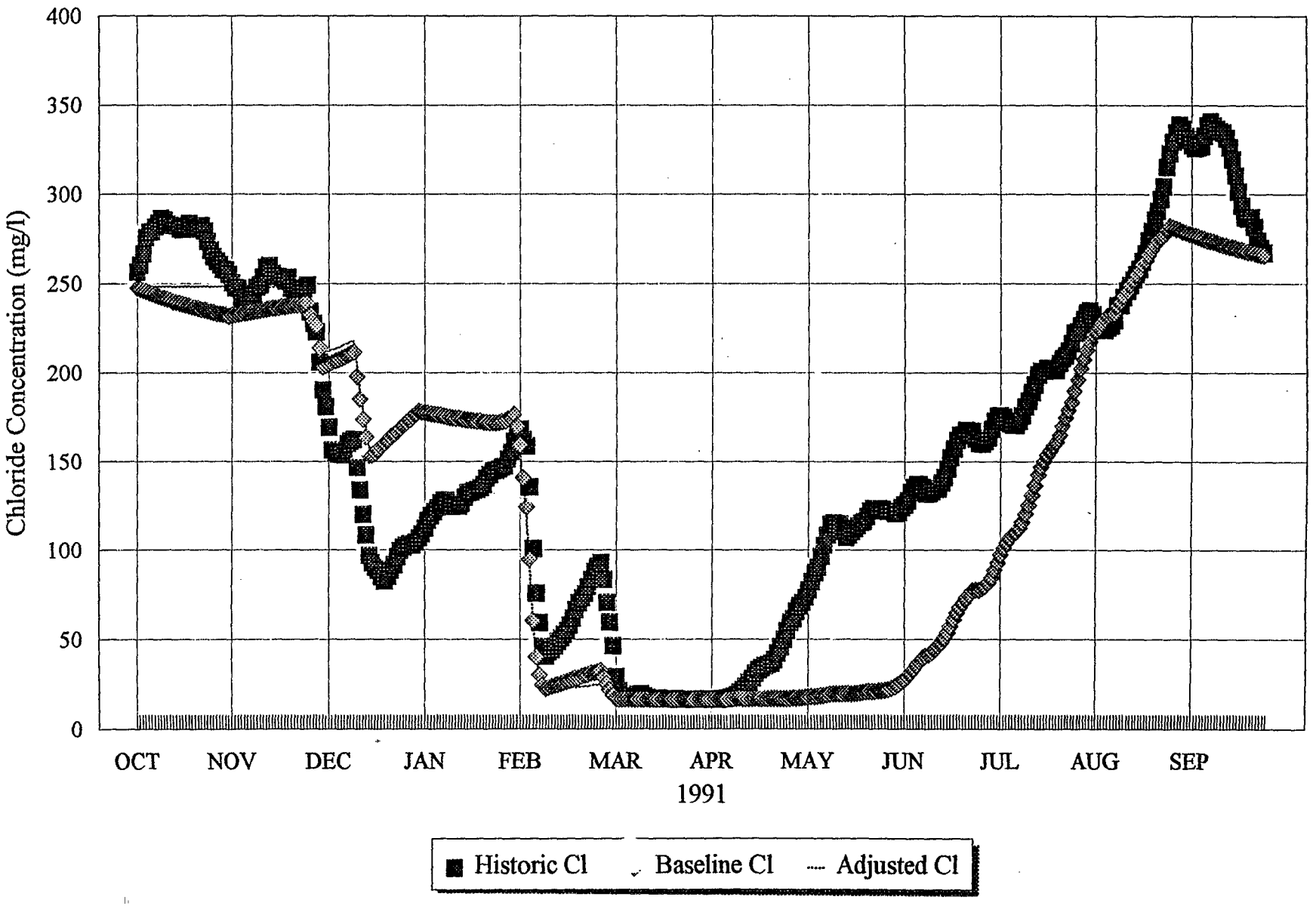
D-016041

Export Chloride

1991 USFWS/NMFS



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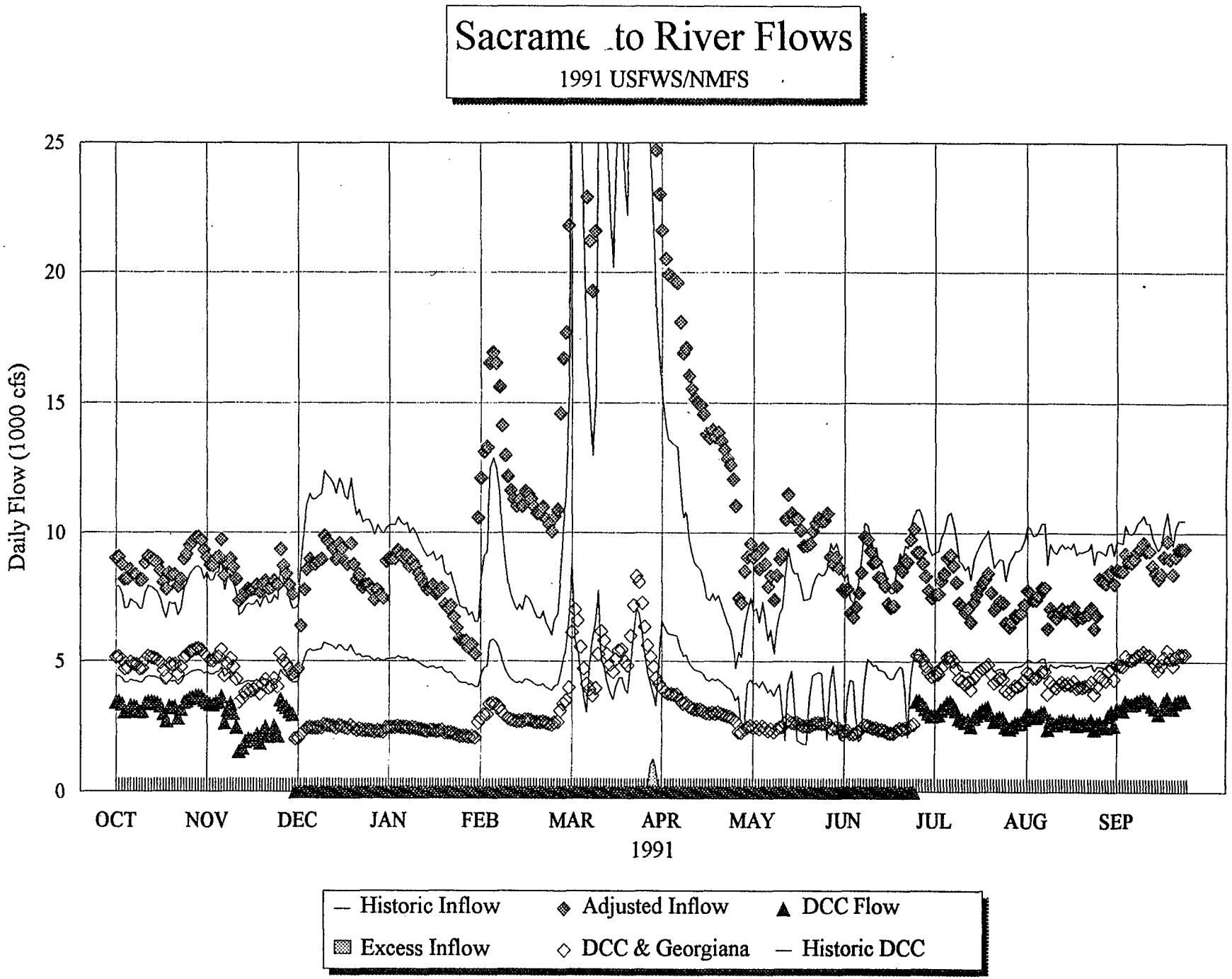

D-016042

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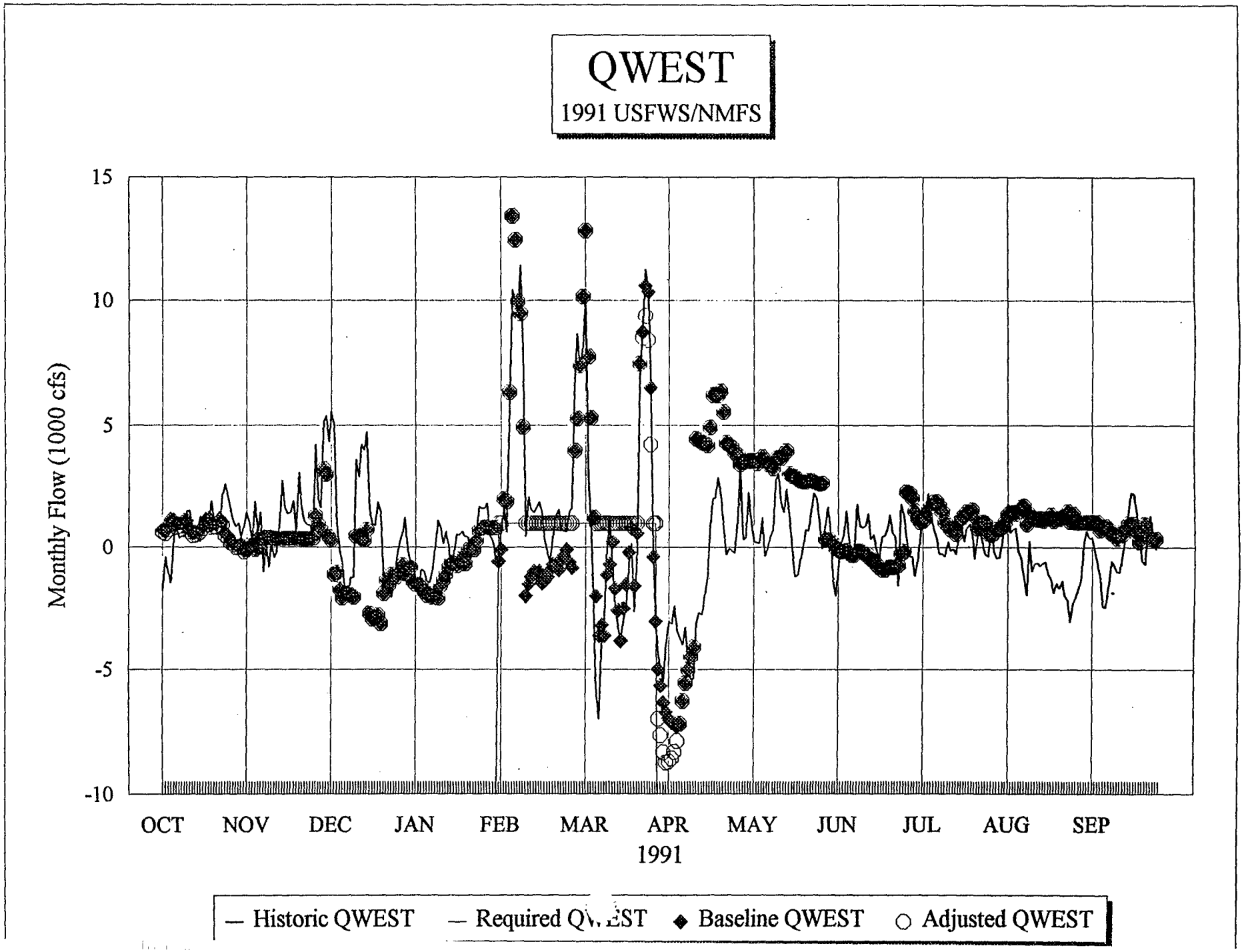

D-016043

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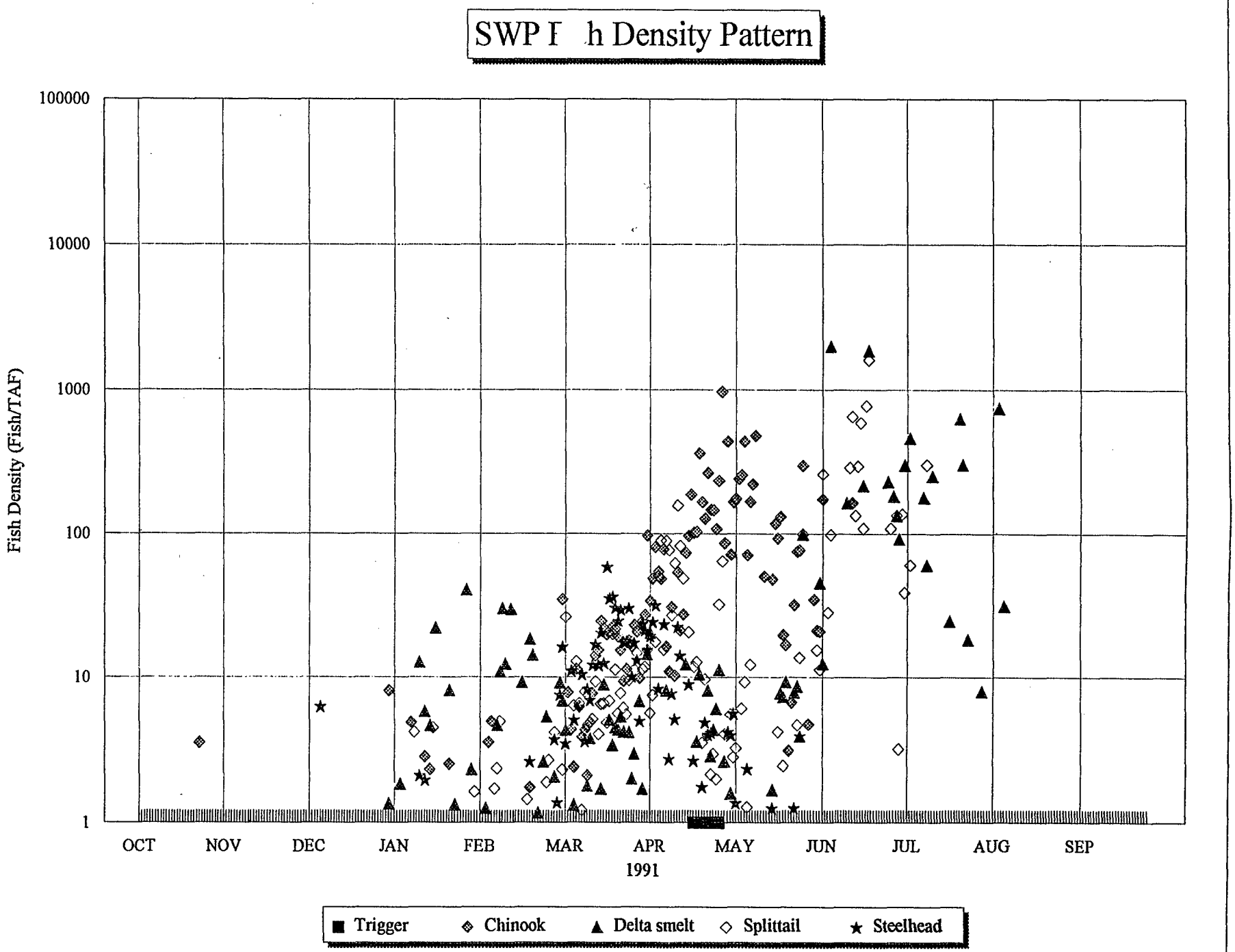
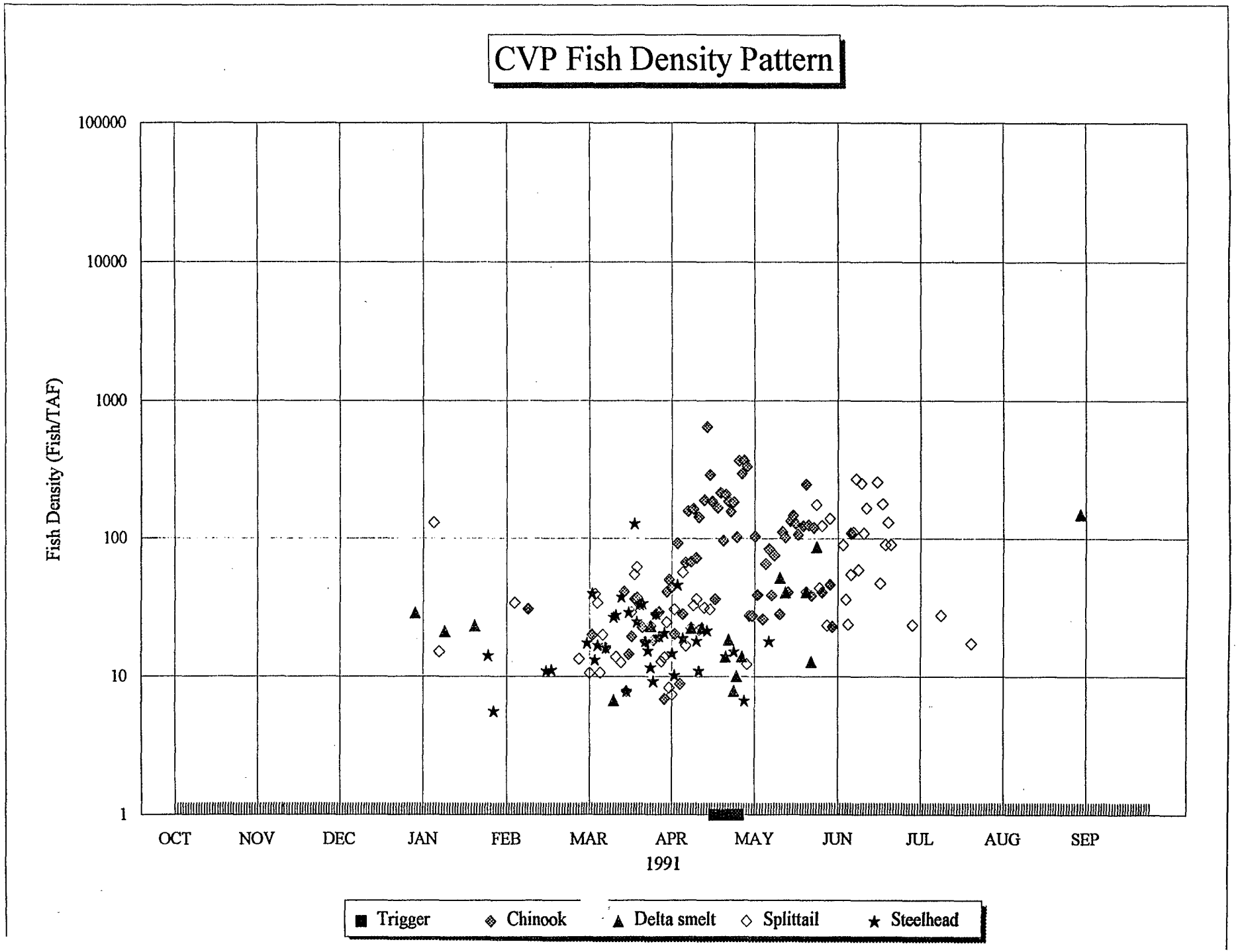


D-016044

D-016044



D-016045

D-016045

Summary for Delta EWA Operations for 1992 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
Pumping (cfs)													
Historic	5,153	3,045	3,045	6,284	5,993	10,362	2,905	1,536	1,753	1,316	2,469	4,320	2,909
DWRSIM	3,022	3,980	4,256	8,487	10,898	8,227	3,020	1,026	1,080	1,080	1,254	4,163	3,046
Model Base	3,808	3,563	3,872	6,747	10,279	8,773	3,631	1,553	1,805	1,666	1,518	3,054	3,033
Model Final	3,808	3,563	3,180	4,496	3,749	6,125	3,631	1,553	1,805	1,666	1,518	3,054	2,302
Model Change	0	0	(692)	(2,251)	(6,530)	(2,649)	0	0	0	0	0	0	(731)
Model Limits	3,808	3,563	3,180	4,496	3,749	6,125	3,631	1,553	1,805	1,666	1,518	3,054	2,302
Monthly E/I	42%	41%	37%	35%	10%	26%	23%	12%	15%	17%	20%	32%	
SL Limits	0	0	0	0	0	0	0	0	0	0	0	0	0
Fish Limits	0	0	0	0	0	0	0	0	0	0	0	0	0
DW Pass Throug	0	0	0	0	0	0	0	0	0	0	0	0	
Outflow (cfs)													
Historic	3,990	3,952	7,661	6,457	28,805	13,327	6,374	3,454	3,627	3,140	2,969	3,478	5,207
DWRSIM	5,512	3,494	3,496	4,683	28,116	15,138	10,567	7,301	6,199	4,000	2,992	3,007	5,702
Model Req'd	3,750	3,750	3,750	4,500	7,248	7,377	7,100	7,100	7,100	3,992	3,750	3,750	3,811
Model Deficit	95	0	170	0	0	0	0	0	894	395	1,485	0	183
Model Base	4,108	3,755	4,959	7,211	30,873	15,290	10,045	8,727	6,206	3,696	2,265	3,750	6,087
Model Final	4,108	3,755	5,651	9,462	37,403	17,938	10,232	8,727	6,206	3,696	2,265	3,750	6,829
Model Change	0	0	692	2,251	6,530	2,649	186	0	0	0	0	0	743
Extra DW Pumpi	0	0	0	0	0	0	0	0	0	0	0	0	
Historic X2	88.9	87.8	80.8	84.4	69.0	75.5	81.7	87.3	89.4	89.8	90.7	90.1	
Model Base X2	87.0	87.9	85.0	84.1	68.1	72.8	76.0	77.6	81.8	87.2	92.0	88.8	
Model X2	87.0	87.9	83.3	80.0	65.1	70.0	75.2	77.5	81.8	87.2	92.0	88.8	
Change X2	0.0	0.0	-1.7	-4.0	-3.0	-2.8	-0.7	-0.1	-0.0	-0.0	-0.0	-0.0	
Historic Cl	255	233	157	55	32	17	27	90	153	239	288	308	121
Model Base Cl	247	226	235	75	33	17	19	24	37	97	226	266	100
Model Cl	247	226	218	46	21	17	18	23	37	97	226	266	112
Change Cl	0	0	-17	-30	-11	-0	-1	-1	-0	-0	-0	-0	12

D-016046

D-016046

Delta Inflows and San Luis Storage for 1992 USFWS/NMFS

Freeport (cfs)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
DWRSIM-Hist	-1661	59	-2104	1071	6108	-164	2938	3070	2142	375	-2132	-1774	
Historic	9,402	6,958	9,259	10,441	26,068	20,335	9,448	6,414	8,510	8,309	8,718	9,815	8,031
DWRSIM	7,741	7,017	7,155	11,512	32,176	20,171	12,386	9,484	10,652	8,684	6,586	8,041	8,544
Model Base	7,741	7,017	7,155	11,512	32,176	20,171	12,386	9,484	10,652	8,684	6,586	8,041	8,481
Model Final	7,741	7,017	7,155	11,512	32,176	20,171	12,386	9,484	10,652	8,684	6,586	8,041	8,481
Model Change	0	0	0	0	0	0	0	0	0	0	0	0	0
Model Excess	0	0	0	0	5,823	0	0	0	0	0	0	0	351
Vernalis (cfs)													
DWRSIM-Hist	442	274	250	131	222	465	731	766	111	189	123	359	
Historic	788	1,084	895	959	2,091	1,470	1,418	892	481	447	483	635	699
DWRSIM	1,230	1,358	1,145	1,090	2,313	1,935	2,149	1,658	592	636	606	994	948
Model Base	1,232	1,358	1,145	1,090	2,313	1,935	2,827	3,051	900	900	900	1,390	1,149
Model Final	1,232	1,358	1,145	1,090	2,313	1,935	3,014	3,051	900	900	900	1,390	1,160
Model Change	0	0	0	0	0	0	186	0	0	0	0	0	11
Model HOR	62	1,249	1,147	1,177	1,648	1,538	151	189	991	986	980	1,242	685
San Luis (TAF)													
Historic	741	764	810	1,106	1,398	1,899	1,855	1,572	1,122	677	413	457	
DWRSIM													
Model Base	598	704	824	1,093	1,464	1,834	1,762	1,543	1,197	811	532	497	
Model Final	598	704	781	912	909	1,116	1,043	825	479	93	(186)	(221)	
Model Change	0	0	(42)	(181)	(556)	(718)	(718)	(718)	(718)	(718)	(718)	(718)	
EWA Credits	0	0	0	0	0	0	0	0	0	0	0	0	0
EWA Uses	0	0	42	138	375	163	0	0	0	0	0	0	718
EWA Balance	0	0	(42)	(181)	(556)	(718)	(718)	(718)	(718)	(718)	(718)	0	0
Model Demand	151	107	115	142	228	165	291	307	458	477	364	219	3,048
DWR Demand	266	187	151	91	75	108	159	206	248	246	240	192	2,169

D-016047

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Delta Channel Flows for 1992 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
DCC & Georgiana													
Historic	4,845	4,129	4,803	5,149	4,509	3,534	2,086	3,151	3,933	4,524	4,644	4,966	3,034
DWRSIM													
Model Base	4,149	3,180	2,256	2,737	5,432	3,789	2,837	2,502	2,741	4,986	3,897	4,380	2,587
Model Final	4,149	3,180	2,256	2,737	5,432	3,789	2,837	2,502	2,741	4,986	3,897	4,380	2,587
Model Change	0	0	0	0	0	0	0	0	0	0	0	0	0
Rio Vista													
Historic	4,597	2,862	4,481	5,317	22,602	17,067	7,409	3,297	4,616	3,821	4,108	4,909	5,093
DWRSIM													
Model Base	3,365	3,549	5,033	9,101	28,888	16,865	9,125	6,408	7,028	2,647	1,778	3,033	5,841
Model Final	3,365	3,549	5,033	9,101	28,888	16,865	9,125	6,408	7,028	2,647	1,778	3,033	5,841
Model Change	0	0	0	0	0	0	0	0	0	0	0	0	0
Model Req'd	3,000	3,500	3,500	0	0	0	0	0	0	0	97	3,000	
QWEST (cfs)													
Historic	(233)	1,538	3,028	719	4,661	(4,045)	(377)	1,009	303	842	186	(480)	417
DWRSIM													
Model Base	850	334	(118)	(2,010)	1,545	(1,662)	1,109	2,562	(453)	1,484	866	981	331
Model Final	850	334	574	240	8,075	986	1,295	2,562	(453)	1,484	866	981	1,074
Model Change	0	0	692	2,251	6,530	2,649	186	0	0	0	0	0	743
Model Req'd	(15,000)	(15,000)	0	0	1,000	484	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)	

D-016048

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Salvage Fish Density and Triggers for 1992 USFWS/NMFS

Trigger	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	
Days	0	0	0	0	0	0	0	0	0	0	0	0	0	
Density Triggers														
Trigger (1=yes)	0	0	0	0	0	0	0	0	0	0	0	0		
Chinook	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000		
Steelhead	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000		
Striped Bass	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000		
Splittail	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000		
Delta smelt	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000		
Export Frac	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Historic														
Chinook	114	4,101	22	1,844	14,081	15,525	3,355	3,717	0	0	0	8	42,767	
Steelhead	133	878	0	290	8,886	6,437	524	62	0	0	0	0	17,209	
Striped Bass	8,618	15,290	172,229	53,044	98,438	52,466	956	790,074	2,299,811	199,821	22,808	1,772	3,715,327	
Splittail	483	0	0	348	3,296	3,636	271	59	341	0	9	5	8,448	
Delta smelt	557	0	0	240	1,134	729	0	3,040	3,647	38	0	0	9,384	
														Reduced from Historic
Model Baseline														
Chinook	61	6,280	23	1,869	19,496	13,533	4,940	2,366	0	0	0	6	48,573	-14%
Steelhead	122	540	0	260	12,466	5,676	638	51	0	0	0	0	19,753	-15%
Striped Bass	6,850	19,544	151,261	55,194	139,185	45,364	932	857,661	1,886,877	205,881	23,278	1,439	3,393,465	9%
Splittail	383	0	0	315	4,614	3,165	346	47	276	0	5	4	9,155	-8%
Delta smelt	88	0	0	189	1,471	559	0	1,023	1,647	12	0	0	4,989	47%
														Reduced from Baseline
Model Final														
Chinook	61	6,280	12	1,196	4,054	9,320	4,940	2,366	0	0	0	6	28,235	42%
Steelhead	122	540	0	255	2,878	4,127	638	51	0	0	0	0	8,610	56%
Striped Bass	6,850	19,544	129,073	40,969	30,172	31,486	932	857,661	1,886,877	205,881	23,278	1,439	3,234,162	5%
Splittail	383	0	0	145	976	2,218	346	47	276	0	5	4	4,399	52%
Delta smelt	88	0	0	72	245	308	0	1,001	1,631	12	0	0	3,358	33%
Pumping (cfs)														
Historic	5,153	3,045	3,045	6,284	5,993	10,362	2,905	1,536	1,753	1,316	2,469	4,320	2,907 (TAF)	
Model Base	3,808	3,563	3,872	6,747	10,279	8,773	3,631	1,553	1,805	1,666	1,518	3,054	3,022 (TAF)	
Model Final	3,808	3,563	3,180	4,496	3,749	6,125	3,631	1,553	1,805	1,666	1,518	3,054	2,302 (TAF)	
Model change	0	0	(692)	(2,251)	(6,530)	(2,649)	0	0	0	0	0	0	(720)(TAF)	

D-016049

D-016049

Genera. ı Evaluation Parameters for 1992 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Vernalis Flow Ratio (>1 is good)												
Base/Historic	1.6	1.3	1.3	1.1	1.1	1.3	2.0	3.4	1.9	2.0	1.9	2.2
Final/Historic	1.6	1.3	1.3	1.1	1.1	1.3	2.1	3.4	1.9	2.0	1.9	2.2
Vernalis/Export Ratio (Higher is better)												
Base/Historic	2.11	1.07	1.01	1.06	0.64	1.56	1.59	3.38	1.82	1.59	3.03	3.10
Final/Historic	2.11	1.07	1.23	1.59	1.77	2.23	1.70	3.38	1.82	1.59	3.03	3.10

Sacramento Salmon Survival for 1992 USFWS/NMFS

Out-Migration %	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Fall	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.65	0.18	0.00	0.00	0.00	1.0
Late-fall		0.25	0.50	0.25									1.0
Winter			0.10	0.25	0.35	0.25	0.05						1.0
Spring			0.01	0.06	0.17	0.28	0.25	0.16	0.07				1.0
Spring Yearlings	0.05	0.35	0.40	0.13	0.05	0.02							1.0

														Historic Relative Survival	
Historic															
DCC fraction	0.51	0.59	0.52	0.49	0.17	0.17	0.22	0.49	0.46	0.54	0.53	0.50	Fall	0.756	
Central Survival	0.33	0.40	0.40	0.29	0.30	0.15	0.40	0.45	0.44	0.46	0.42	0.35	Late-fall	0.668	
Total Survival	0.65	0.64	0.69	0.65	0.88	0.85	0.87	0.73	0.74	0.70	0.69	0.68	Winter	0.798	
													Spring	0.821	
													Yearling	0.679	
															Change from Historic
Model Base															
DCC fraction	0.55	0.47	0.31	0.23	0.16	0.18	0.24	0.28	0.28	0.65	0.69	0.59	Fall	0.846	11.9%
Central Survival	0.37	0.38	0.37	0.27	0.15	0.21	0.38	0.45	0.44	0.44	0.45	0.40	Late-fall	0.787	17.9%
Survival	0.65	0.71	0.81	0.83	0.87	0.85	0.85	0.84	0.84	0.64	0.62	0.64	Winter	0.848	6.3%
													Spring	0.852	3.7%
													Yearling	0.771	13.4%
															Change from Base
Model Adjusted															
DCC fraction	0.55	0.47	0.31	0.23	0.16	0.18	0.24	0.28	0.28	0.65	0.69	0.59	Fall	0.846	0.0%
Central Survival	0.37	0.38	0.39	0.35	0.37	0.29	0.38	0.45	0.44	0.44	0.45	0.40	Late-fall	0.795	1.0%
Survival	0.65	0.71	0.81	0.85	0.90	0.87	0.85	0.84	0.84	0.64	0.62	0.64	Winter	0.869	2.5%
													Spring	0.863	1.4%
													Yearling	0.778	0.9%

Sacramento relative survival = 1
Central Delta relative survival = 0.5 - 0.0000336* Exports (cfs)
Monthly relative survival = sacramento fraction + DCC fraction * Central Delta relative survival
Population survival = monthly relative survival * migration portion

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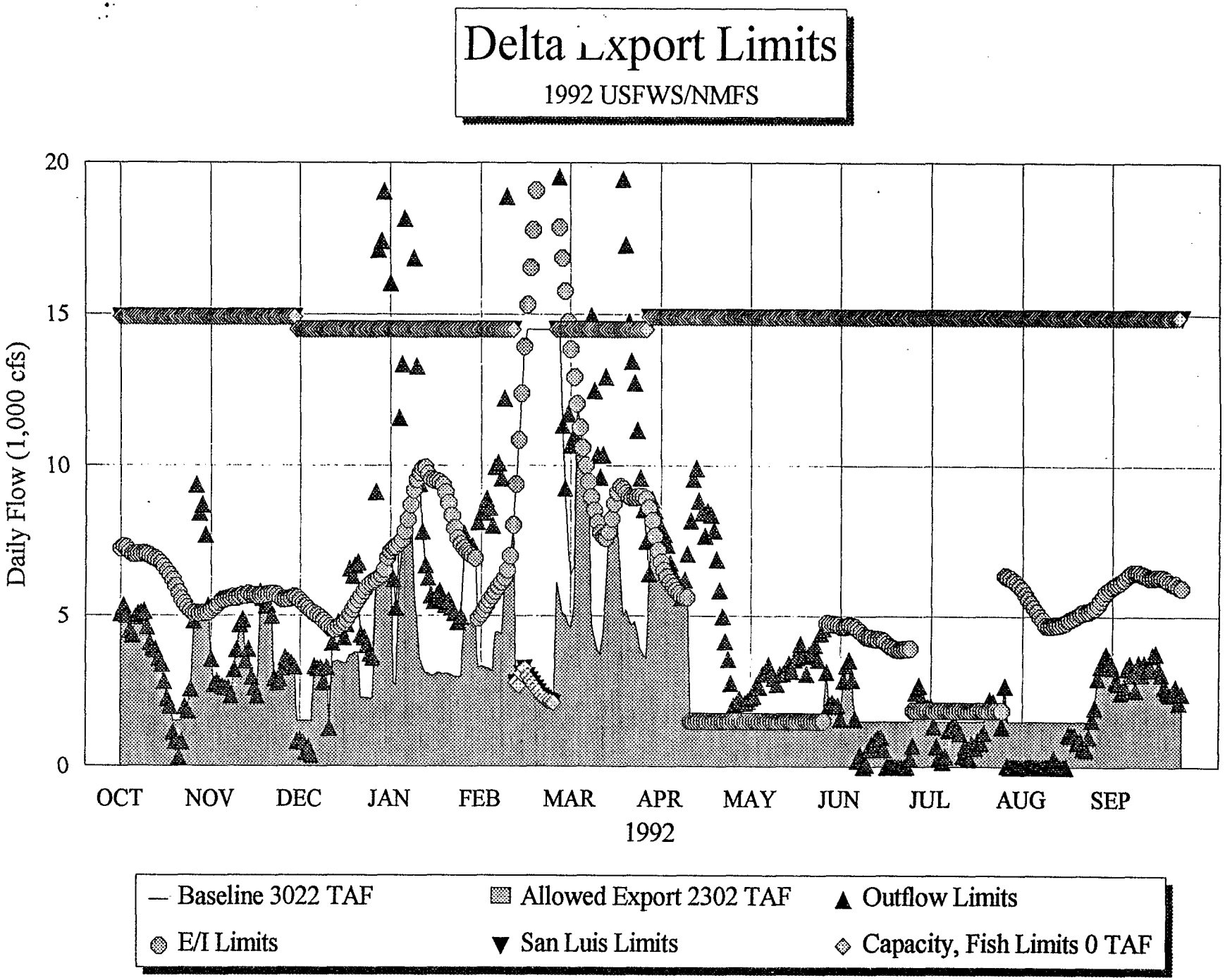
San Joaquin Salmon Survival for 1992 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Out-Migration %	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.48	0.07	0.00	0.00	0.00	1.0
Historic													
Flow survival	0.02	0.02	0.02	0.02	0.04	0.03	0.03	0.02	0.01	0.01	0.01	0.01	
Export Survival	0.66	0.80	0.80	0.58	0.60	0.31	0.81	0.90	0.88	0.91	0.84	0.71	
Survival	0.01	0.02	0.01	0.01	0.03	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.019
Model Base													
Flow survival	0.02	0.03	0.02	0.02	0.05	0.04	0.06	0.06	0.02	0.02	0.02	0.03	
Export Survival	0.75	0.76	0.74	0.55	0.31	0.42	0.76	0.90	0.88	0.89	0.90	0.80	
Survival	0.02	0.02	0.02	0.01	0.01	0.02	0.04	0.05	0.02	0.02	0.02	0.02	0.047
											Change from Historic		151.2%
Model Adjusted													
Flow survival	0.02	0.03	0.02	0.02	0.05	0.04	0.06	0.06	0.02	0.02	0.02	0.03	
Export Survival	0.75	0.76	0.79	0.70	0.75	0.59	0.76	0.90	0.88	0.89	0.90	0.80	
Survival	0.02	0.02	0.02	0.02	0.03	0.02	0.05	0.05	0.02	0.02	0.02	0.02	0.048
											Change from Base		2.7%

Maximum survival = 0.00002 * Vernalis Flow; 0.2 @ 10,000 cfs
Export survival factor = (15,000 - Export) / 15,000; 0.9 @ 1,500 pumping or may be a constant survival reduction
Monthly relative survival = Maximum survival * Export survival factor
Population survival = monthly relative survival * migration portion
HOR Closure may increase survival by 0.1 or some other factor

D-016051
D-016051



D-016052

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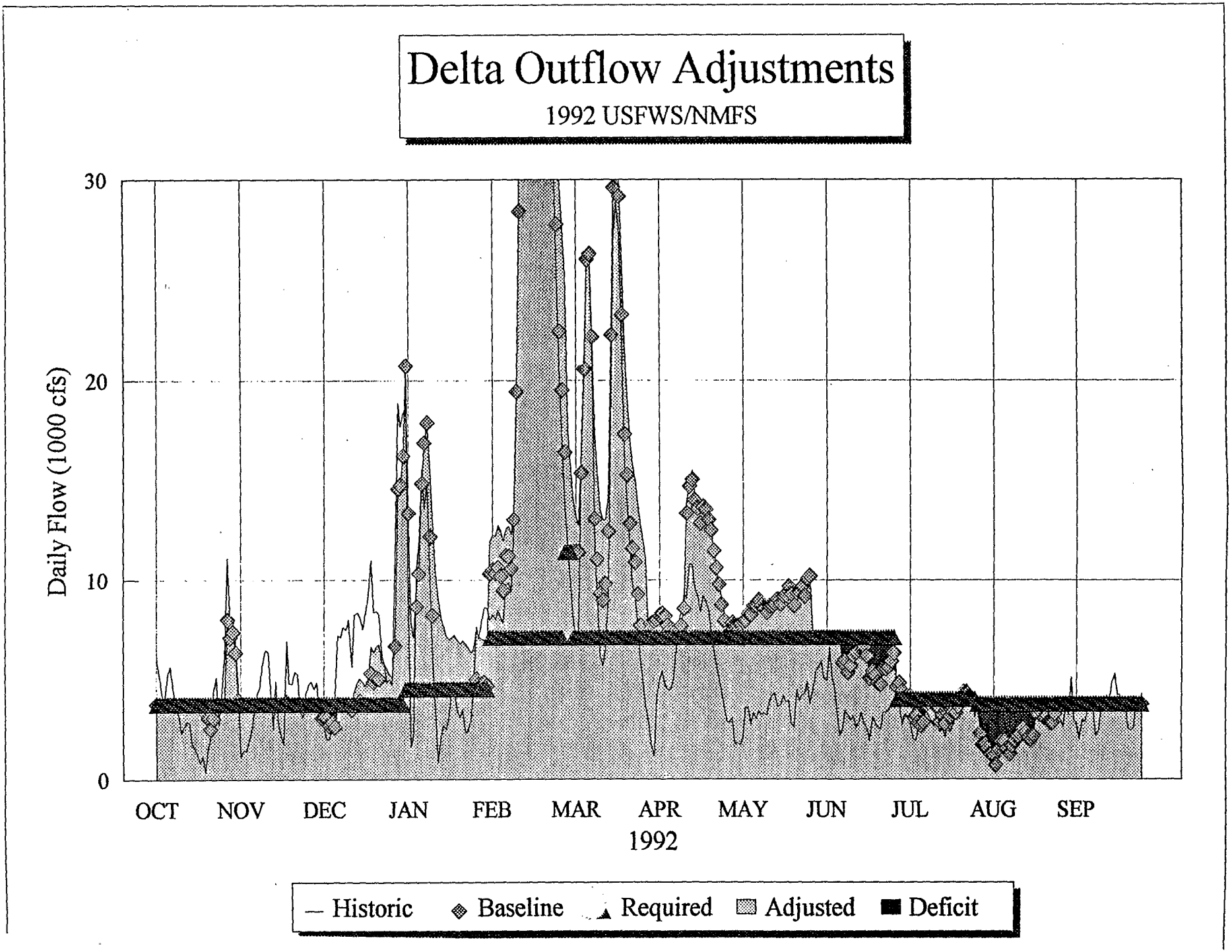

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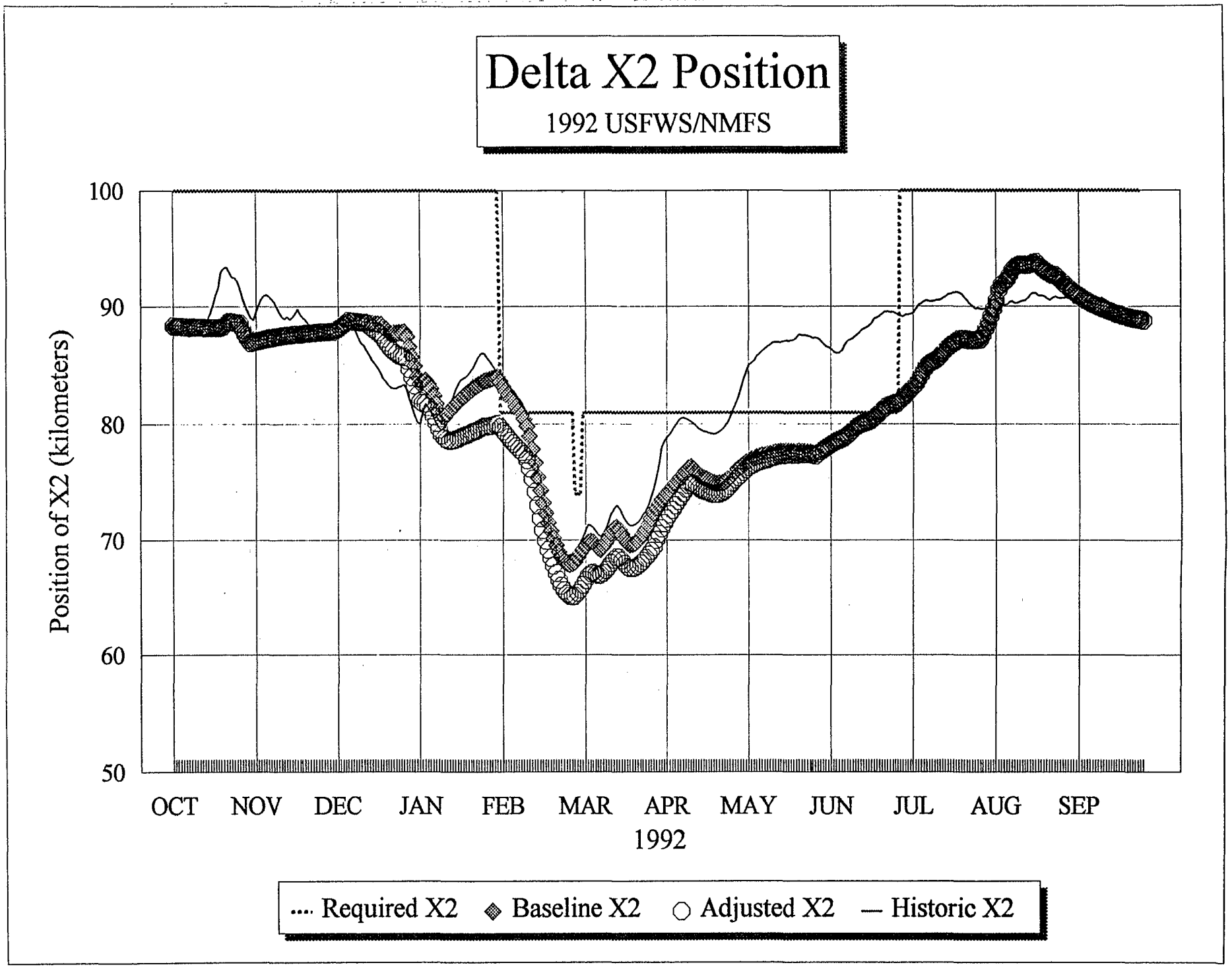

D-016054

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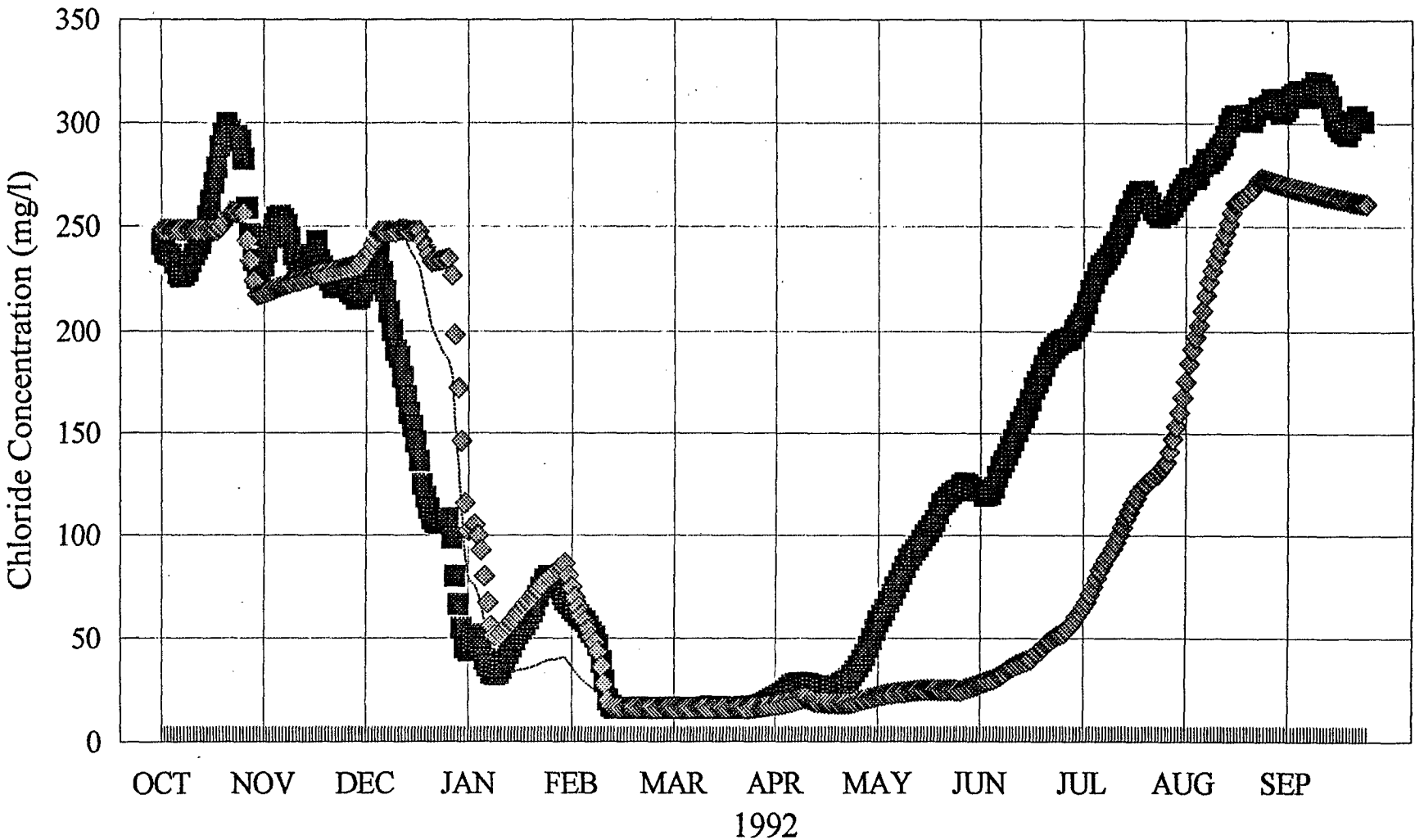
D-016055

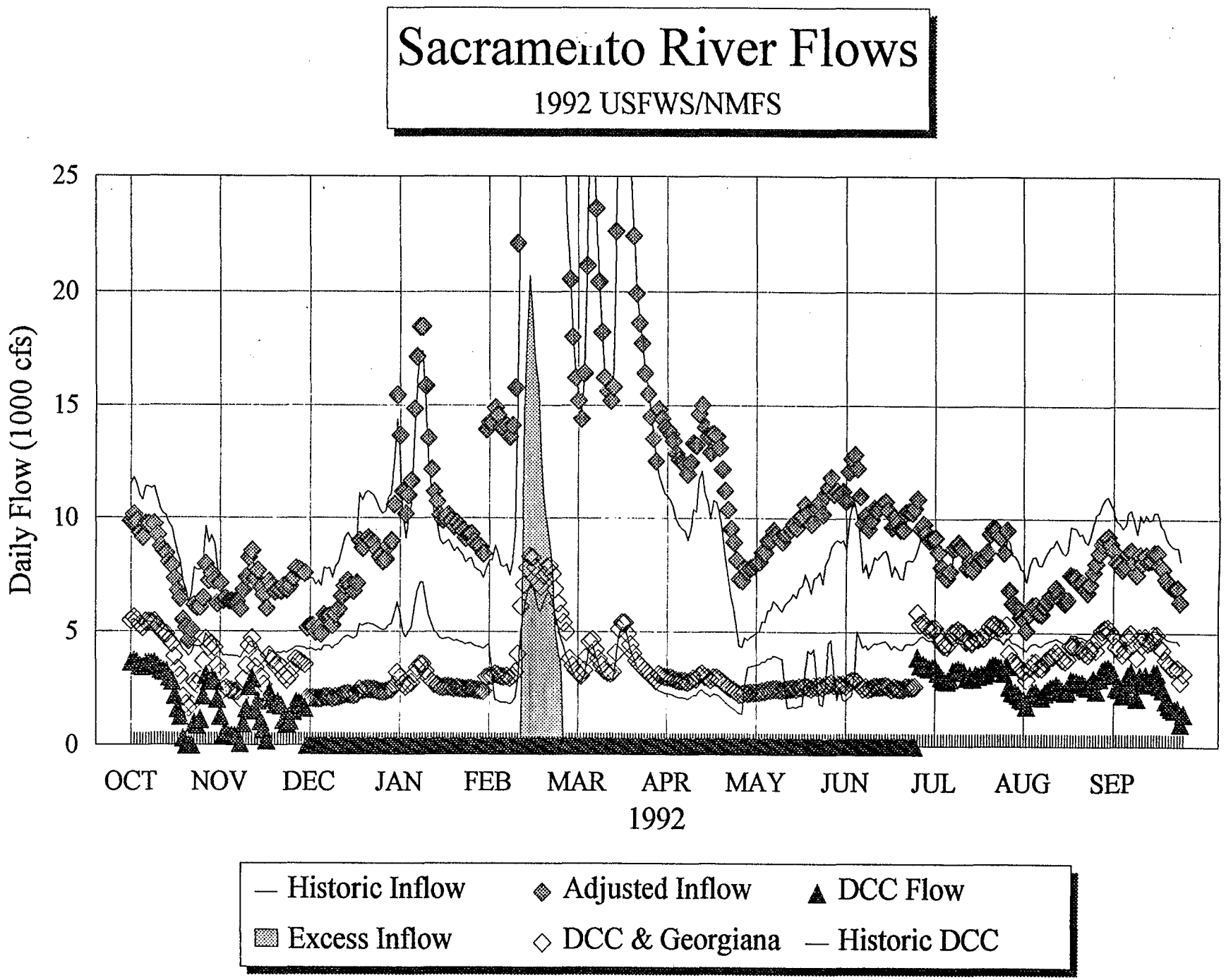
Export Chloride

1992 USFWS/NMFS



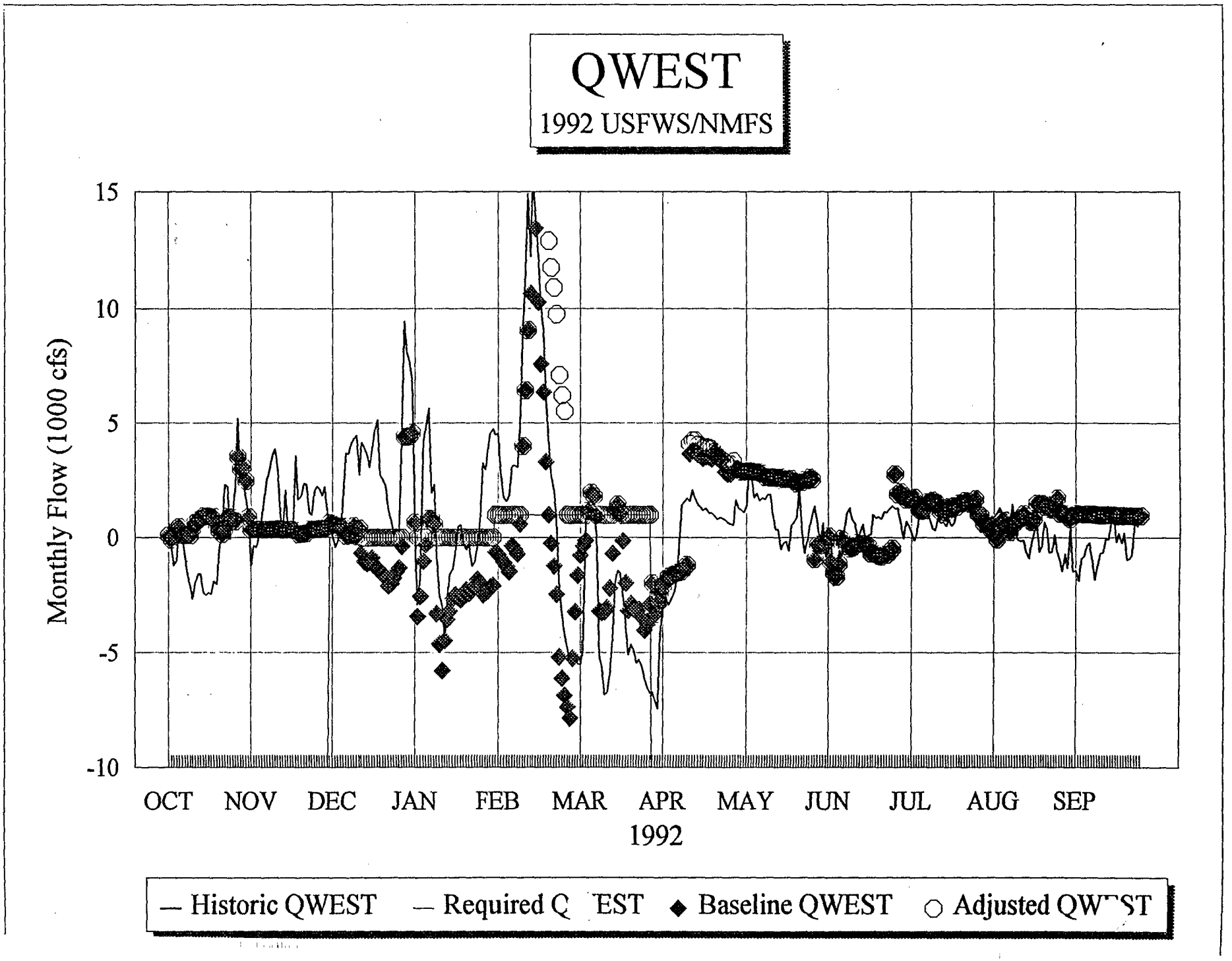
Historic Cl Baseline Cl — Adjusted Cl

D—016055



D-016056

D-016056



D-016057

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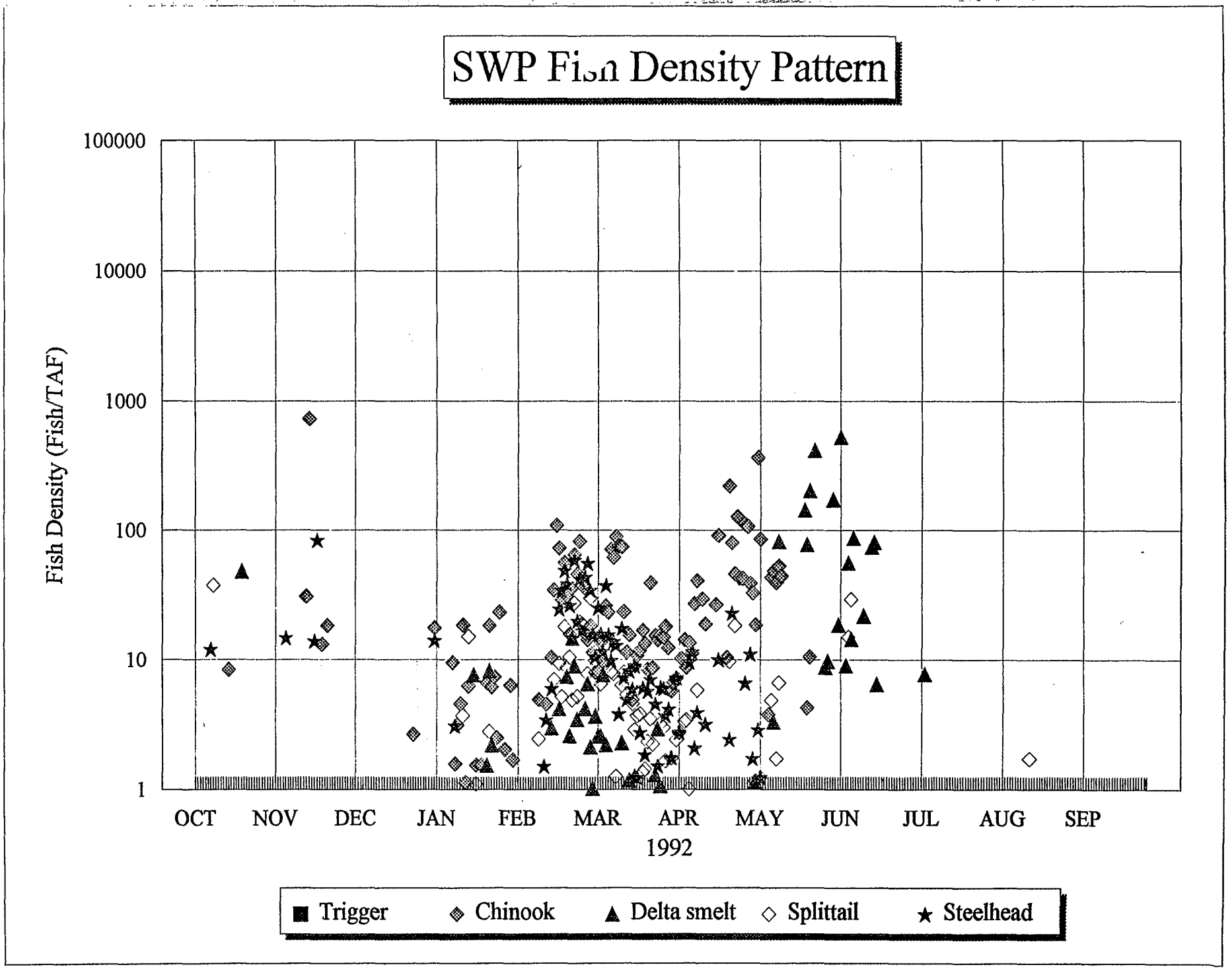
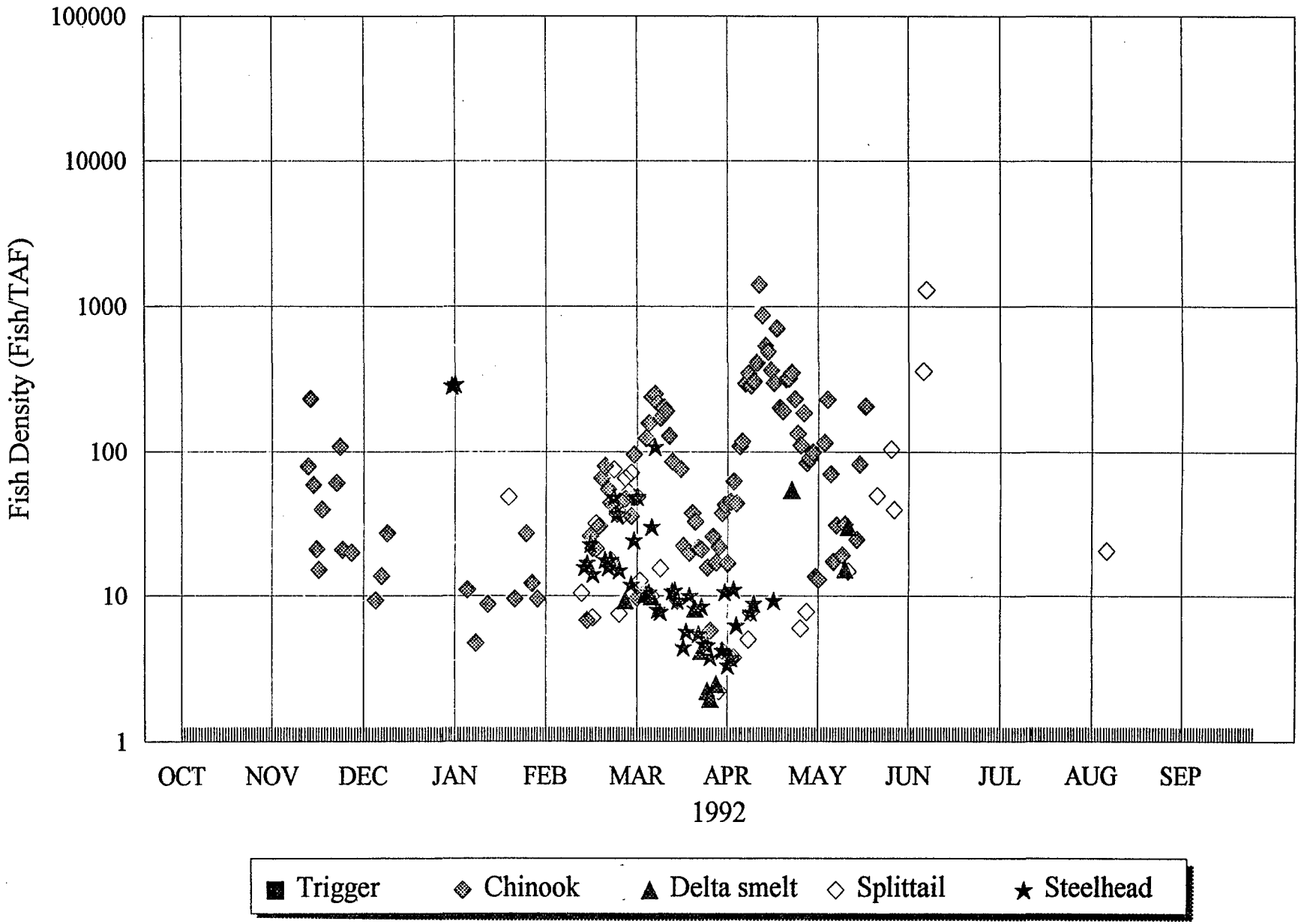


D-016058

D-016058

D-016059

CVP Fish Density Pattern



D—016059

Summary for Delta EWA Operations for 1993 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
Pumping (cfs)													
Historic	1,709	2,327	3,960	11,570	9,231	5,945	5,604	3,197	4,011	8,503	10,582	10,748	4,659
DWRSIM	4080	4847	11161	14465	14546	11128	8154	5005	12441	5487	13498	10332	6,947
Model Base	4,553	3,653	6,189	13,702	11,974	8,853	7,753	1,500	13,502	5,979	12,494	9,225	5,996
Model Final	4,787	4,328	4,911	13,179	6,715	8,090	1,500	1,500	6,952	5,979	12,494	9,225	4,806
Model Change	234	675	(1,278)	(523)	(5,259)	(763)	(6,253)	0	(6,550)	0	0	0	(1,190)
Model Limits	4,787	4,328	4,911	13,179	6,715	8,090	1,500	1,500	6,952	5,979	12,494	9,225	4,806
Monthly E/I	46%	45%	34%	20%	11%	17%	3%	4%	19%	32%	60%	58%	
SL Limits	0	0	0	0	0	0	0	0	0	0	0	0	0
Fish Limits	0	0	0	0	0	0	0	0	0	0	0	0	0
DW Pass Thro	0	0	0	0	0	0	0	0	0	0	0	0	
Outflow (cfs)													
Historic	4,411	4,162	11,631	57,917	55,049	63,994	44,356	25,345	27,244	9,617	9,599	5,462	19,114
DWRSIM	5463	3494	6114	54878	47502	32097	38203	29983	19169	8000	4000	3377	15,221
Model Req'd	3,750	3,750	3,750	6,000	27,929	7,100	10,783	7,100	7,100	8,000	4,000	3,750	5,612
Model Deficit	0	0	0	0	235	69	0	0	0	0	0	0	18
Model Base	4,289	4,778	10,007	57,212	51,612	39,789	42,650	37,584	19,311	8,000	4,490	3,755	17,103
Model Final	4,056	4,103	11,285	57,735	56,871	40,552	50,767	37,584	27,216	8,000	4,490	3,755	18,487
Model Change	(234)	(675)	1,278	523	5,259	763	8,117	0	7,905	0	0	0	1,384
Extra DW Pu	0	0	0	0	0	0	0	0	0	0	0	0	
Historic X2	86.2	87.5	83.9	60.7	56.8	54.7	60.6	65.1	67.9	75.4	77.5	83.3	
Model Base X	86.7	85.9	81.1	60.4	57.3	61.0	61.4	60.9	71.1	77.8	85.3	87.6	
Model X2	87.3	87.7	79.6	60.0	56.3	60.6	60.4	60.8	69.9	77.6	85.3	87.6	
Change X2	0.5	1.8	-1.5	-0.4	-1.0	-0.5	-1.0	-0.2	-1.3	-0.2	-0.0	-0.0	
Historic Cl	250	191	70	17	17	17	17	17	17	18	21	43	33
Model Base C	238	179	78	18	17	17	17	17	17	22	56	129	51
Model Cl	247	208	87	17	17	17	17	17	17	22	55	128	64
Change Cl	9	29	9	-0	-0	-0	-0	-0	-0	-1	-1	-1	12
DWRSIM X2	85.7	87.7	84.1	66.1	61.3	62.8	61.9	63.5	67.4	75.4	83.3	87.2	

D-016060

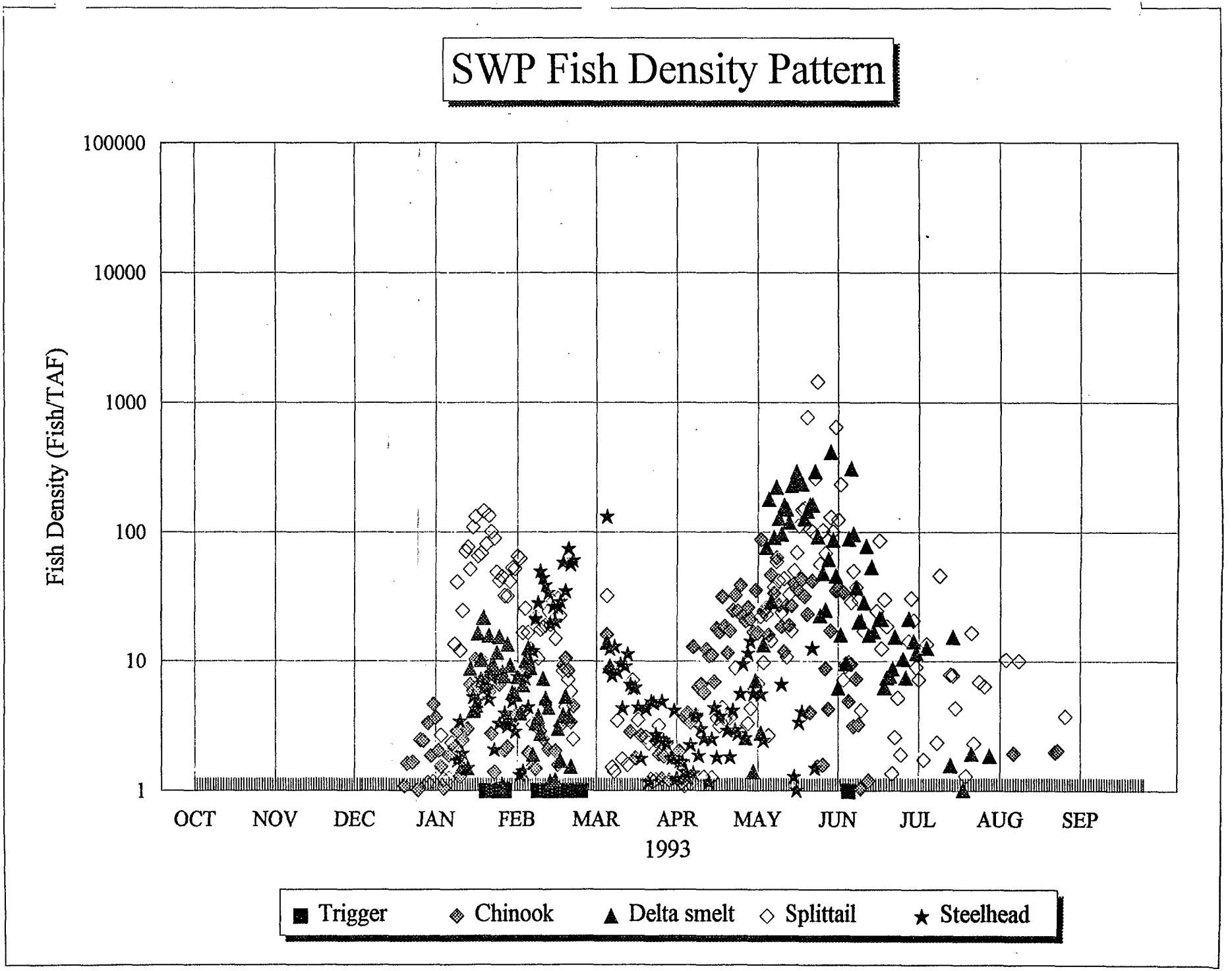
D-016060

Delta Inflows and San Luis Storage for 1993 USFWS/NMFS

Freeport (cfs)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
DWRSIM-His	2133	1451	94	-238	-1855	-22851	-2942	5471	-1677	-4646	-3090	-2560	
Historic	6,645	6,380	12,440	48,261	48,596	49,339	43,213	24,955	30,473	19,861	21,081	15,472	19,632
DWRSIM	8778	7831	12534	48023	46741	26488	40271	30426	28796	15215	17991	12912	17,859
Model Base	8,778	7,831	12,534	48,023	46,741	26,488	40,271	30,426	28,796	15,215	17,991	13,267	17,733
Model Final	8,778	7,831	12,534	48,023	46,741	26,488	40,271	30,426	28,796	15,215	17,991	13,267	17,733
Model Change	0.000	0	0	0	0	0	0	0	0	0.000	0	0	0
Model Excess	0	0	0	6,387	8,067	1,467	0	0	527	0	0	0	992
Vernalis (cfs)													
DWRSIM-His	599	503	532	1651	1060	1447	1336	1446	3166	427	-167	-695	
Historic	849	956	982	4,120	3,035	2,702	3,421	3,610	2,341	1,510	1,998	2,771	1,703
DWRSIM	1448	1459	1514	5771	4095	4149	4757	5056	5507	1937	1831	2076	2,389
Model Base	1,448	1,459	1,514	5,771	4,174	4,183	6,757	8,620	5,507	1,937	1,831	2,076	2,732
Model Final	1,448	1,459	1,514	5,771	4,174	4,183	8,620	8,620	6,862	1,937	1,831	2,076	2,926
Model Change	0	0	0	0	0	0	1,863	0	1,355	(0)	0	0	194
Model HOR	72	1,321	1,367	3,443	2,530	2,589	431	431	3,641	1,583	1,800	1,770	1,266
San Luis (TAF)													
Historic	363	381	524	1,190	1,635	1,805	1,941	1,668	1,313	1,065	1,040	1,294	
DWRSIM	152	214	706	1445	1877	2037	1944	1639	1539	895	847	921	
Model Base	312	318	462	1,012	1,257	1,461	1,348	817	715	111	119	218	
Model Final	327	373	438	956	910	1,067	582	51	(440)	(1,044)	(1,036)	(937)	
Model Change	14	54	(24)	(56)	(348)	(395)	(766)	(766)	(1,155)	(1,155)	(1,155)	(1,155)	
EWA Credits	14	40	3	0	0	0	0	0	7	0	0	0	64
EWA Uses	0	0	81	32	292	47	371	0	396	0	0	0	1,219
EWA Balance	14	54	(24)	(56)	(348)	(395)	(766)	(766)	(1,155)	(1,155)	(1,155)	(1,155)	0
Model Deman	302	213	231	284	453	332	579	609	914	949	741	454	6,096
DWR Demand	266	187	151	91	75	108	159	206	248	246	240	192	2,169

D-016061

D-016061



D-016062

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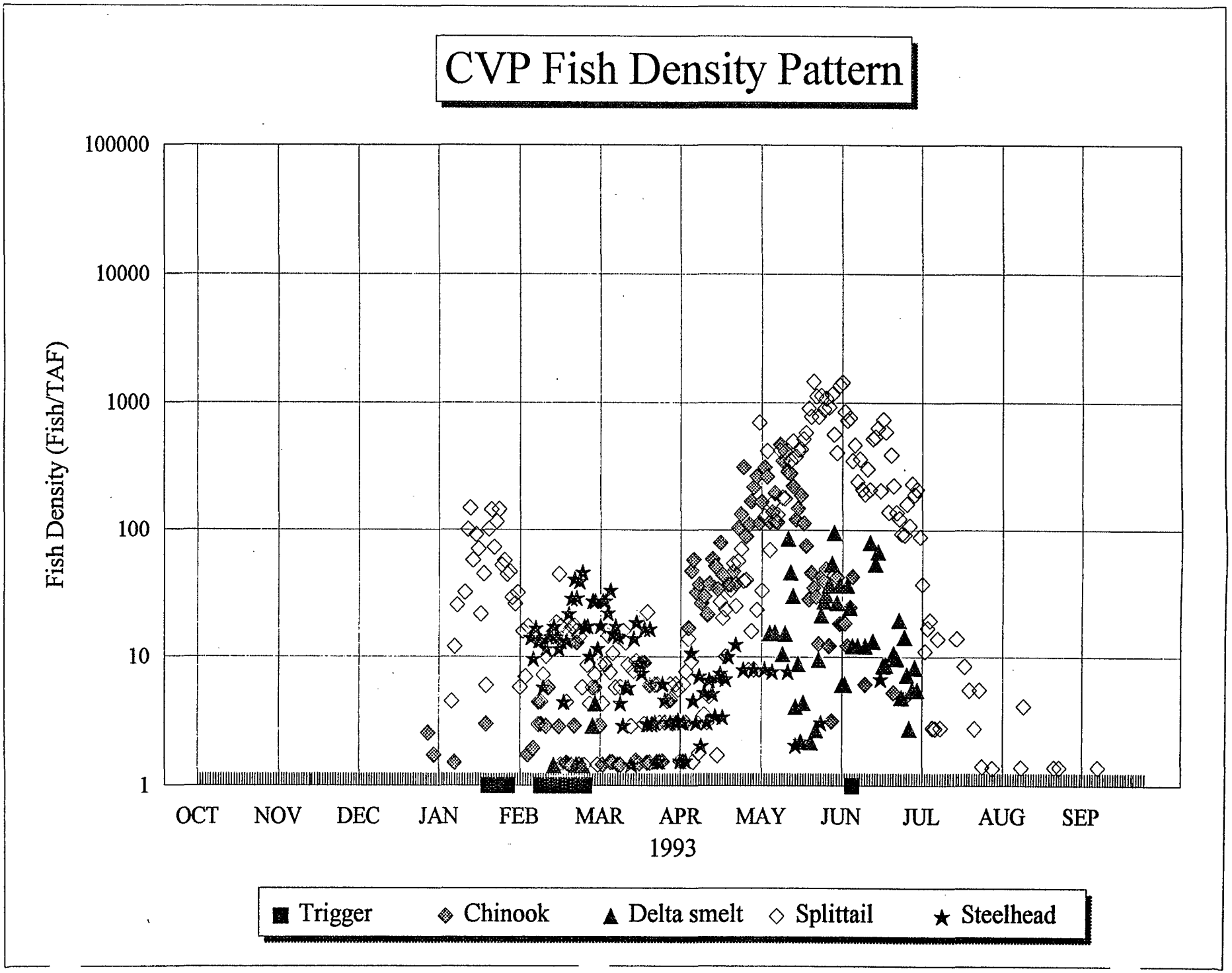

D-016063

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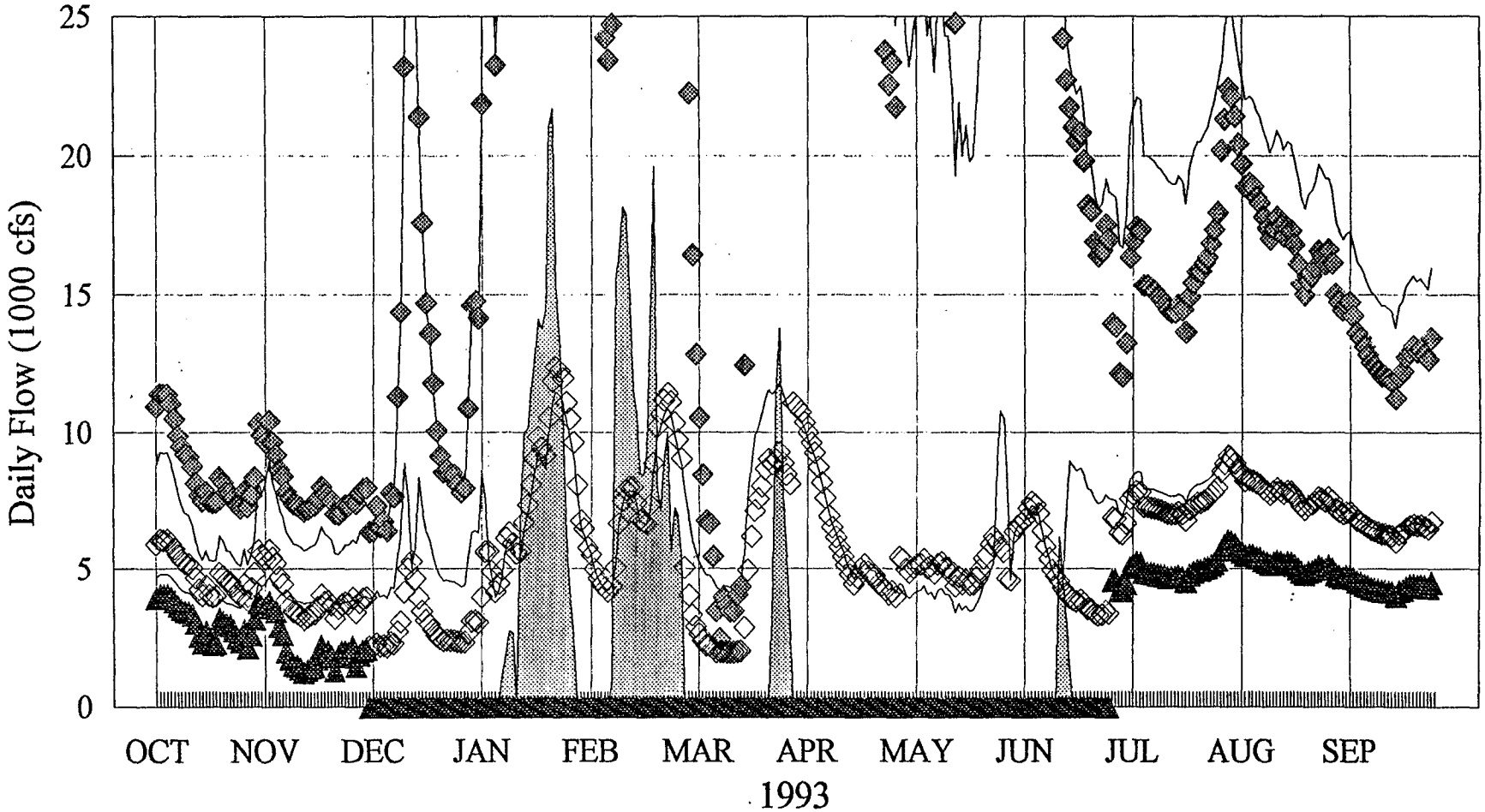
Sacramento River Flows

1993 USFWS/NMFS

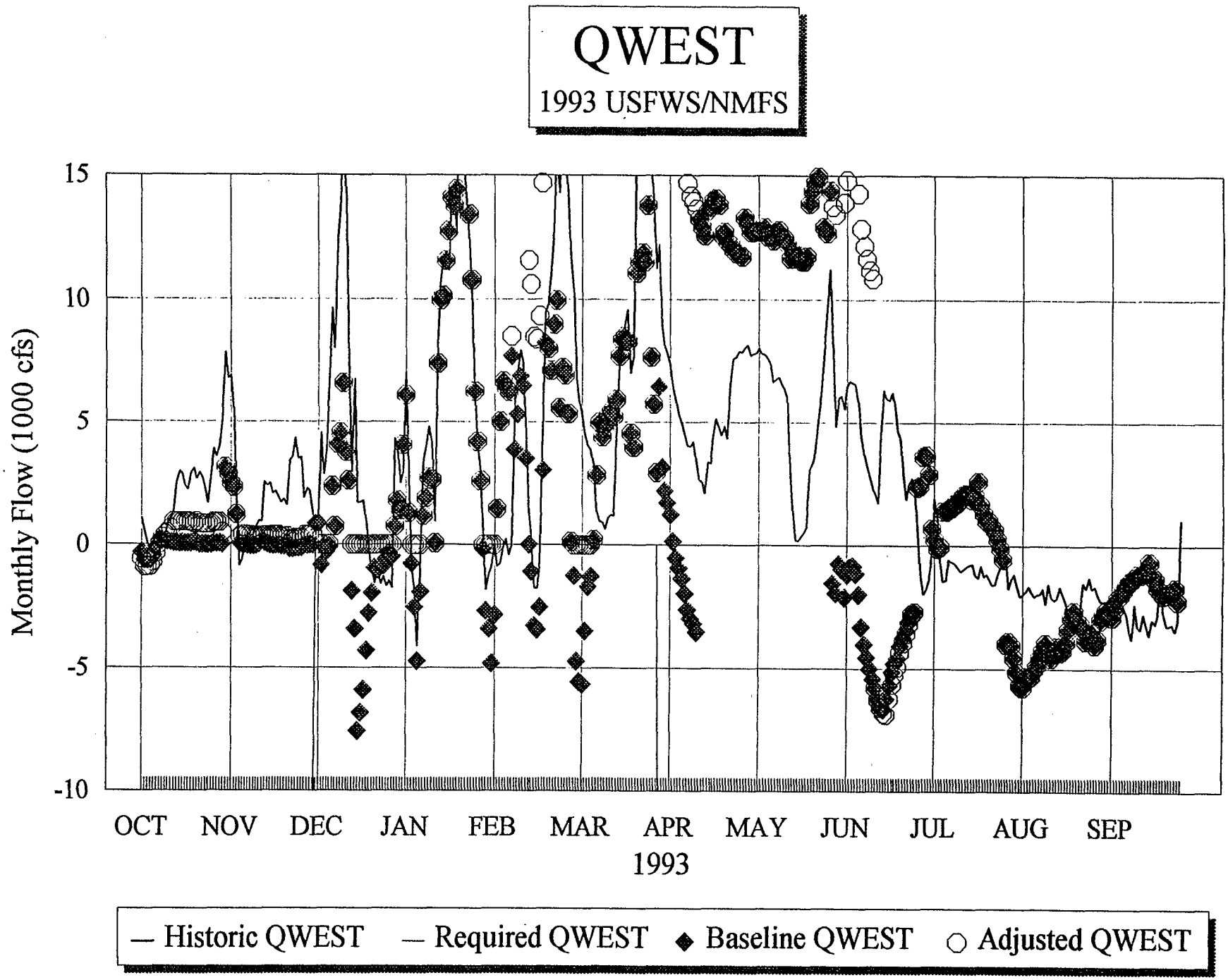


— Historic Inflow ◆ Adjusted Inflow ▲ DCC Flow

▨ Excess Inflow ◇ DCC & Georgiana — Historic DCC

D-016064

D-016064



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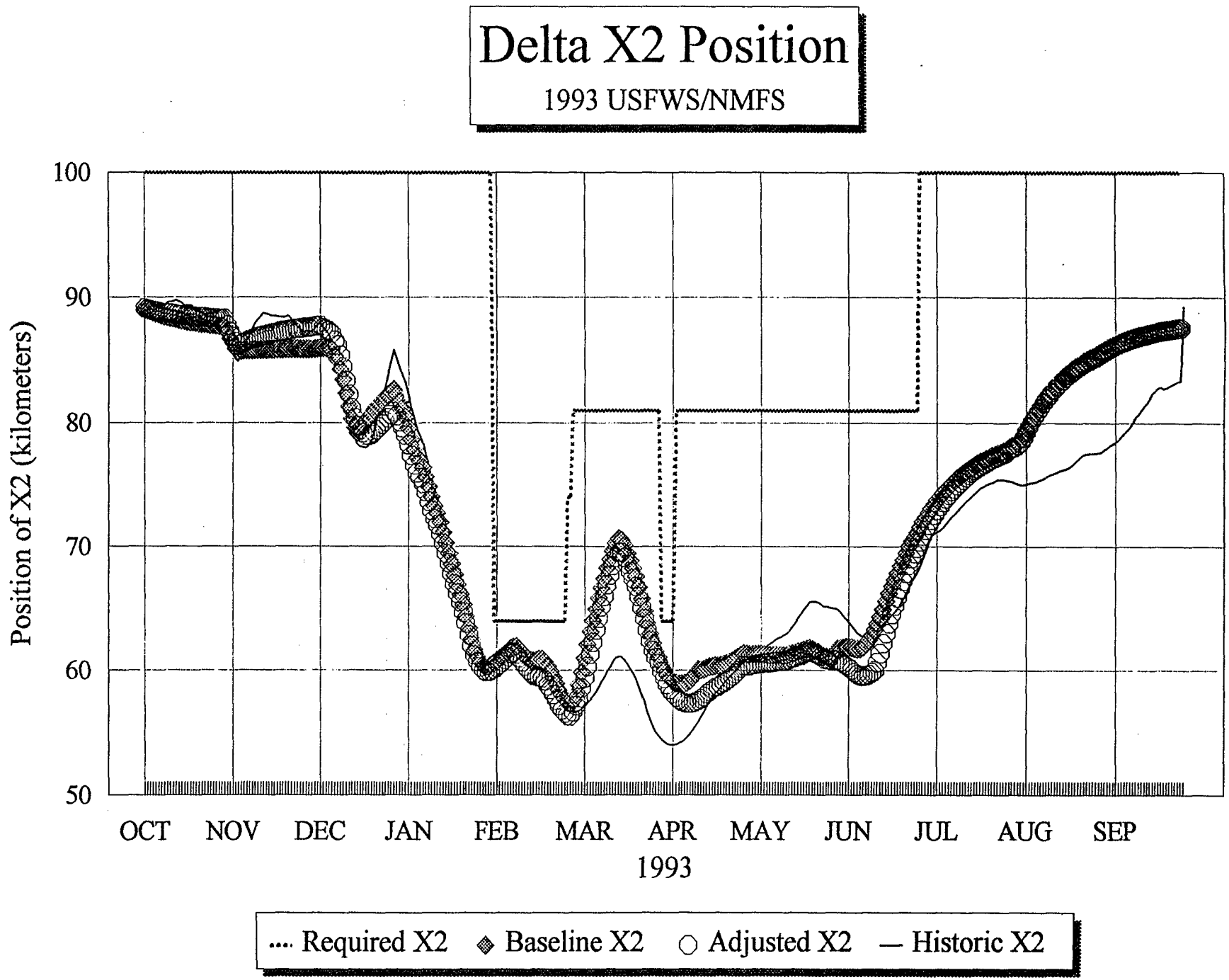

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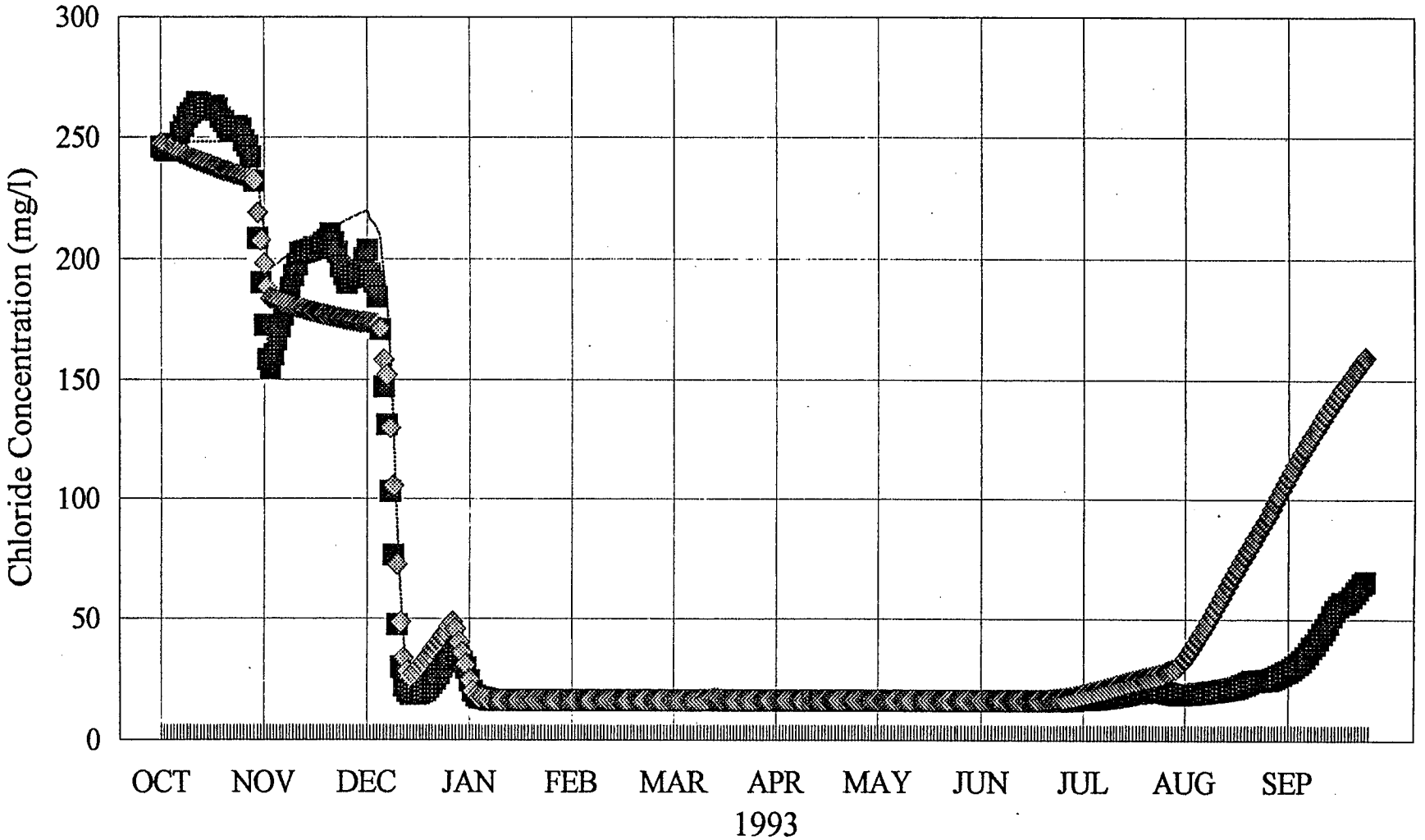
D-016067

Export Chloride

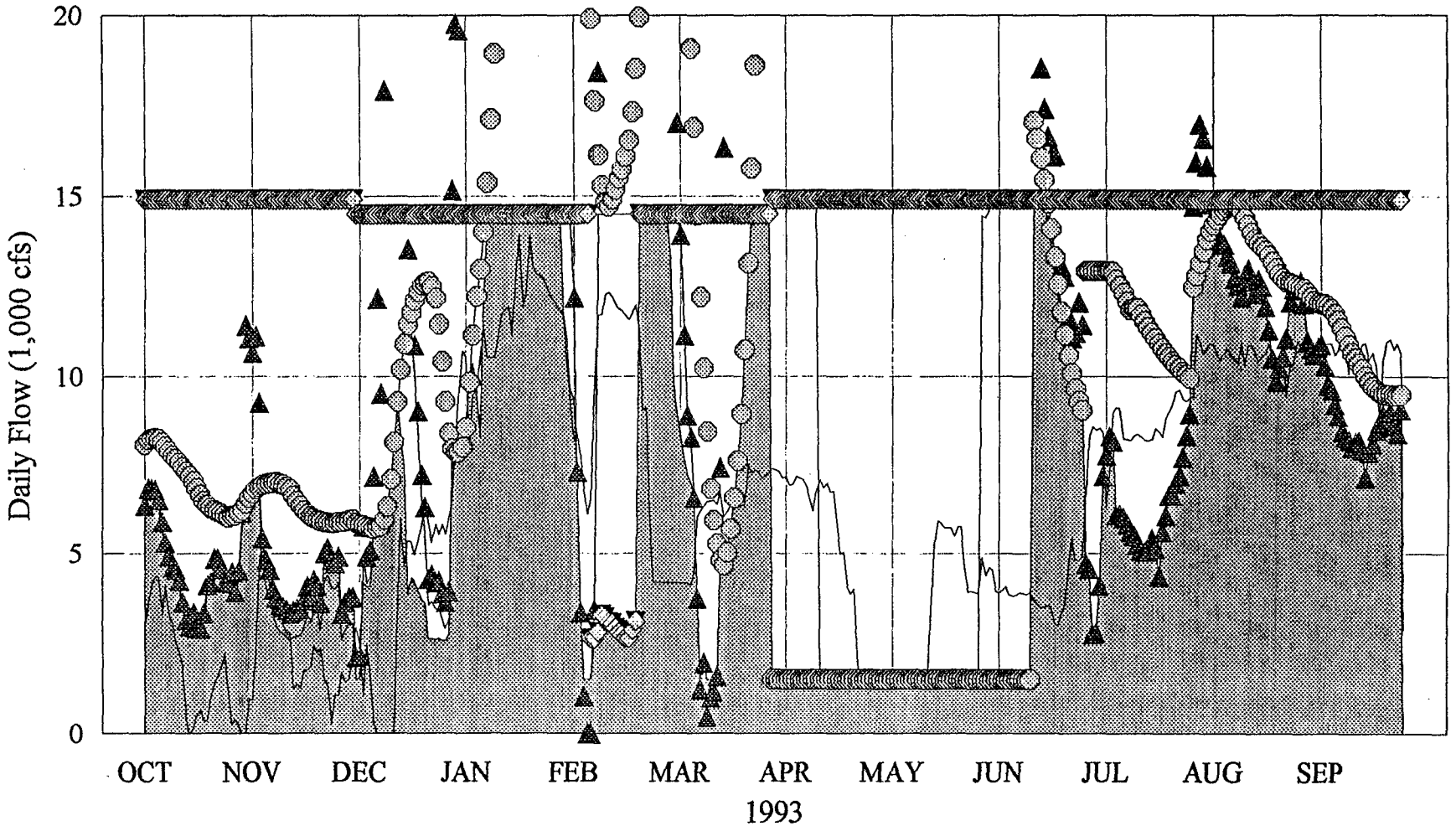
1993 USFWS/NMFS



D—016067

Delta Export Limits

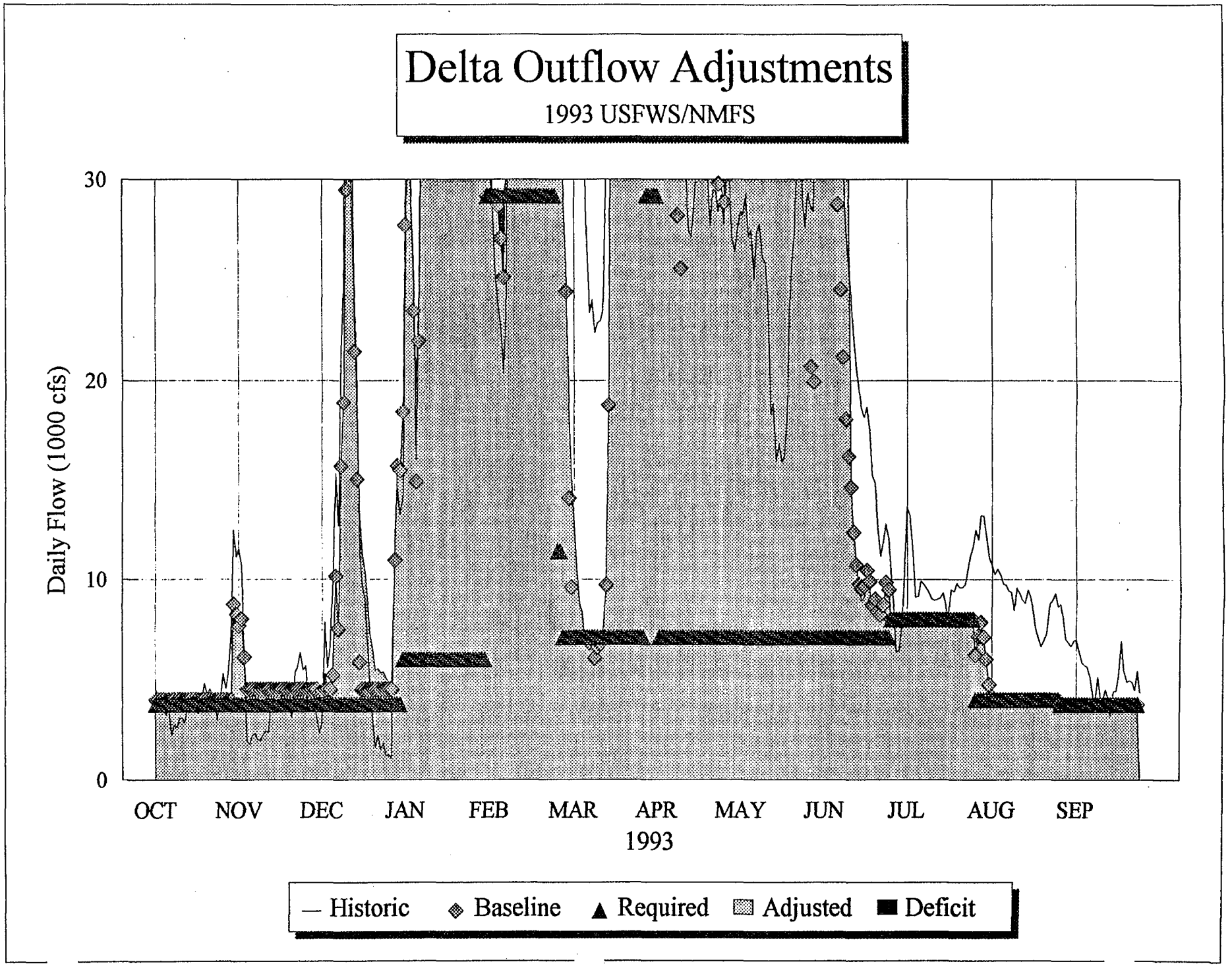
1993 USFWS/NMFS



— Baseline 5972 TAF
Allowed Export 4806 T
▲ Outflow Limits
E/I Limits
▼ San Luis Limits
◇ Capacity, Fish Limits 0
— Historic

D-016068

D-016068



D-016069

D-016069

General Fish Evaluation Parameters for 1993 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Vernalis Flow Ratio (>1 is good)												
Base/Historic	1.7	1.5	1.5	1.4	1.4	1.5	2.0	2.4	2.4	1.3	0.9	0.7
Final/Historic	1.7	1.5	1.5	1.4	1.4	1.5	2.5	2.4	2.9	1.3	0.9	0.7
Vernalis/Export Ratio (Higher is better)												
Base/Historic	0.64	0.97	0.99	1.18	1.06	1.04	1.43	5.09	0.70	1.82	0.78	0.87
Final/Historic	0.61	0.82	1.24	1.23	1.89	1.14	9.41	5.09	1.69	1.82	0.78	0.87

Sacramento Salmon Survival for 1992 Game 2

Out-Migration	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Fall	0	0	0	0	0	0	0.17	0.65	0.18	0	0	0	1
Late-fall		0.25	0.5	0.25									1
Winter			0.10	0.25	0.35	0.25	0.05						1.0
Spring			0.01	0.06	0.17	0.28	0.25	0.16	0.07				1.0
Spring Yearlings	0.05	0.35	0.40	0.13	0.05	0.02							1.0

Historic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		Historic Relative Survival
DCC fraction	0.51	0.59	0.52	0.49	0.17	0.17	0.22	0.49	0.46	0.54	0.53	0.04	Fall	0.756
Central Survival	0.33	0.40	0.40	0.29	0.30	0.15	0.40	0.45	0.44	0.46	0.42	0.35	Late-fall	0.668
Total Survival	0.65	0.64	0.69	0.65	0.88	0.85	0.87	0.73	0.74	0.70	0.69	0.97	Winter	0.798
													Spring	0.821
													Yearling	0.679

Model Base	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep			Change from Historic
DCC fraction	0.55	0.47	0.31	0.23	0.16	0.18	0.24	0.28	0.28	0.65	0.69	0.59	Fall	0.846	11.9%
Central Survival	0.37	0.38	0.37	0.27	0.15	0.21	0.38	0.45	0.44	0.44	0.45	0.40	Late-fall	0.787	17.9%
Survival	0.65	0.71	0.81	0.83	0.87	0.85	0.85	0.84	0.84	0.64	0.62	0.64	Winter	0.848	6.3%
													Spring	0.852	3.7%
													Yearling	0.771	0.134

Model Adjusted	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep			Change from Base
DCC fraction	0.56	0.53	0.31	0.23	0.16	0.18	0.24	0.28	0.28	0.65	0.68	0.60	Fall	0.846	0.0%
Central Survival	0.34	0.34	0.37	0.27	0.22	0.22	0.38	0.45	0.44	0.44	0.45	0.38	Late-fall	0.773	-1.8%
Survival	0.63	0.65	0.81	0.83	0.88	0.86	0.85	0.84	0.84	0.64	0.63	0.63	Winter	0.852	0.5%
													Spring	0.854	0.003
													Yearling	0.75	-0.027

Sacramento relative survival = 1
Central Delta relative survival = 0.5 - 0.0000336* Exports (cfs)
Monthly relative survival = sacramento fraction + DCC fraction * Central Delta relative survival
Population survival = monthly relative survival * migration portion

D-016070
D-016070

San Joaquin Salmon Survival for 1993 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Out-Migration %	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.48	0.07	0.00	0.00	0.00	1.0
Historic													
Flow survival	0.02	0.02	0.02	0.08	0.06	0.05	0.07	0.07	0.05	0.03	0.04	0.06	
Export Survival	0.89	0.84	0.74	0.23	0.38	0.60	0.63	0.79	0.73	0.43	0.29	0.28	
Survival	0.02	0.02	0.01	0.02	0.02	0.03	0.04	0.06	0.03	0.01	0.01	0.02	0.049
Model Base													
Flow survival	0.03	0.03	0.03	0.12	0.08	0.08	0.14	0.17	0.11	0.04	0.04	0.04	
Export Survival	0.70	0.76	0.59	0.09	0.20	0.41	0.48	0.90	0.10	0.60	0.17	0.38	
Survival	0.02	0.02	0.02	0.01	0.02	0.03	0.07	0.16	0.01	0.02	0.01	0.02	0.105
											Change from Histori		113.7%
Model Adjusted													
Flow survival	0.03	0.03	0.03	0.12	0.08	0.08	0.17	0.17	0.14	0.04	0.04	0.04	
Export Survival	0.68	0.71	0.67	0.12	0.55	0.46	0.90	0.90	0.54	0.60	0.17	0.38	
Survival	0.02	0.02	0.02	0.01	0.05	0.04	0.16	0.16	0.07	0.02	0.01	0.02	0.149
											Change from Base		42.8%

Maximum survival = 0.00002 * Vernalis Flow; 0.2 @ 10,000 cfs
Export survival factor = (15,000 - Export) / 15,000; 0.9 @ 1,500 pumping or may be a constant survival reduction
Monthly relative survival = Maximum survival * Export survival factor
Population survival = monthly relative survival * migration portion
HOR Closure may increase survival by 0.1 or some other factor

D-016071
D-016071

Delta Channel Flows for 1993 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
DCC & Georgiana													
Historic	4,037	3,959	5,297	7,585	7,292	7,391	6,577	4,661	6,911	7,909	8,267	6,727	4,620
DWRSIM													
Model Base	4,173	2,916	2,880	7,655	7,449	4,818	6,537	5,107	4,930	7,226	7,983	6,649	4,122
Model Final	4,873	3,917	2,880	7,655	7,449	4,818	6,537	5,107	4,930	7,226	7,983	6,649	4,225
Model Change	700	1000	0	0	0	0	0	0	0	-0.00	0	0	102.6
Rio Vista													
Historic	2,638	2,446	7,180	49,370	48,485	54,964	39,221	20,336	23,642	11,995	12,848	9,120	16,919
DWRSIM													
Model Base	4,277	4,692	10,156	50,430	47,284	35,260	36,002	24,911	23,186	6,944	9,096	5,980	15,579
Model Final	3,577	3,692	10,156	50,430	47,284	35,260	36,002	24,911	23,186	6,944	9,096	5,980	15,477
Model Change	-700	-1000	0	0	0	0	0	0	0	0.000	0	0	-103
Model Req'd	3,000	3,500	3,500	0	0	0	0	0	0	0	0	3,000	
QWEST (cfs)													
Historic	2,276	2,063	3,800	6,632	5,429	8,227	5,578	5,641	4,665	(855)	(1,924)	(2,737)	2,334
DWRSIM	-961	-2140	-4674	6633	1822	-133	2806	5041	-3813	684	-5713		
Model Base	156	185	(335)	6,235	4,004	4,299	6,775	12,854	(3,571)	1,491	(4,227)	(1,962)	1,563
Model Final	622	510	944	6,758	9,263	5,063	14,892	12,854	4,333	1,491	(4,227)	(1,962)	3,049
Model Change	466	325	1,278	523	5,259	763	8,117	0	7,905	(0)	0	0	1,486
Model Req'd	(15,000)	(15,000)	0	0	0	0	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)	

D-016072

D-016072

D-016073

Salvage Fish Density and Triggers for 1993 USFWS/NMFS

Trigger	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	
Days	0	0	0	6	18	0	0	0	1	0	0	0	25	
Density Triggers														
Trigger (1=yes)	0	0	0	0	0	0	0	0	0	0	0	0		
Chinook	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000		
Steelhead	1000	1000	1000	1000	10	1000	1000	1000	1000	1000	1000	1000		
Striped Bass	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000		
Splittail	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000		
Delta smelt	10000	10000	10000	10	10000	10000	10000	10000	10000	10000	10000	10000		
Export Frac	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Historic														
Chinook	0	0	243	2,449	1,609	451	2,883	5,056	1,446	15	148	0	14,299	
Steelhead	0	0	25	1,985	14,183	2,890	732	398	0	0	0	0	20,213	
Striped Bass	116	32,191	24,699	436,163	130,791	4,458	152	868,396	7,580,029	7,542,346	674,856	39,884	17,334,081	
Splittail	0	0	21	38,074	10,130	939	425	33,173	14,195	3,309	610	115	100,990	
Delta smelt	0	0	0	4,589	1,978	280	0	30,308	12,569	1,648	41	0	51,412	
														Reduced
Model Baseline														from Historic
Chinook	0	0	190	2,812	1,932	608	2,470	2,479	5,281	14	178	0	15,963	-12%
Steelhead	0	0	20	2,321	18,553	3,186	990	222	0	0	0	0	25,291	-25%
Striped Bass	172	57,756	51,569	507,902	151,936	4,068	260	293,038	27,429,688	4,568,160	832,205	34,326	33,931,079	-96%
Splittail	0	0	22	44,160	11,751	1,078	383	11,149	51,512	2,012	776	121	122,963	-22%
Delta smelt	0	0	0	4,982	1,960	610	0	8,058	39,864	1,254	68	0	56,796	-10%
														Reduced
Model Final														from Baseline
Chinook	0	0	163	2,754	1,132	608	1,072	2,479	566	14	178	0	8,965	44%
Steelhead	0	0	19	2,268	9,312	3,186	228	222	0	0	0	0	15,236	40%
Striped Bass	180	72,711	43,267	497,514	64,065	4,068	42	293,038	7,891,488	4,568,160	832,205	34,326	14,301,063	58%
Splittail	0	0	19	43,553	5,376	1,078	142	11,149	9,869	2,012	776	121	74,094	40%
Delta smelt	0	0	0	4,607	919	519	0	7,768	9,809	1,150	66	0	24,837	56%
Pumping (cfs)														
Historic	1,709	2,327	3,960	11,570	9,231	5,945	5,604	3,197	4,011	8,503	10,582	10,748	4,669 (TAF)	
Model Base	4,553	3,653	6,189	13,702	11,974	8,853	7,753	1,500	13,502	5,979	12,494	9,225	5,972 (TAF)	
Model Final	4,787	4,328	4,911	13,179	6,715	8,090	1,500	1,500	6,952	5,979	12,494	9,225	4,806 (TAF)	
Model change	234	675	(1,278)	(523)	(5,259)	(763)	(6,253)	0	(6,550)	0	0	0	(1,166)(TAF)	

D-016073

D-016074

Delta Inflows and San Luis Storage for 1994 USFWS/NMFS

Freeport (cfs)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
DWRSIM-His	1530	778	-3148	2584	6938	1972	1859	552	6868	1307	4614	-4426	
Historic	13,819	12,093	20,342	14,190	20,196	13,461	8,435	8,848	8,091	11,864	12,145	14,168	9,504
DWRSIM	15349	12871	17194	16774	27134	15433	10294	9400	14959	13171	16759	9742	10,804
Model Base	15,349	12,871	17,194	16,774	27,134	15,433	10,294	9,400	14,959	13,171	16,759	9,987	10,756
Model Final	15,349	12,871	17,194	16,774	27,134	15,433	10,294	9,400	14,959	13,171	16,759	9,987	10,756
Model Change	0	0	0	0	0	0	0	0	0	0	0	0.000	0
Model Excess	0	0	0	0	3,500	0	0	0	0	0	0	0	211
Vernalis (cfs)													
DWRSIM-His	1138	82	-136	-387	55	-705	740	511	410	54	223	545	
Historic	3,041	1,759	1,628	1,773	1,987	2,206	1,863	1,973	1,109	1,135	867	869	1,220
DWRSIM	4179	1841	1492	1386	2042	1501	2603	2484	1519	1189	1090	1414	1,372
Model Base	4,179	1,841	1,492	1,386	2,345	2,280	3,277	4,714	1,519	1,189	1,090	1,414	1,612
Model Final	4,179	1,841	1,492	1,386	2,345	2,280	4,880	4,880	3,355	1,189	1,090	1,414	1,830
Model Change	0	0	0	0	0	0	1,603	166	1,836	0	0	0	218
Model HOR	209	1,522	1,398	1,337	1,710	1,811	244	244	2,088	1,206	1,402	1,337	875
San Luis (TAF)													
Historic	1,592	1,693	1,986	2,031	2,031	1,997	1,792	1,570	1,017	488	298	491	
DWRSIM	152	214	706	1445	1877	2037	1944	1639	1539	895	847	921	
Model Base	1,385	1,735	2,041	2,047	2,052	2,046	1,746	1,232	665	18	(118)	(260)	
Model Final	1,385	1,497	1,623	1,668	1,524	1,571	1,089	558	(106)	(818)	(954)	(1,096)	
Model Change	0	(238)	(418)	(379)	(528)	(474)	(657)	(674)	(771)	(836)	(836)	(836)	
EWA Credits	0	0	14	88	62	30	0	0	18	0	0	0	211
EWA Uses	0	238	193	49	211	84	93	0	115	65	0	0	1,048
EWA Balance	0	(238)	(418)	(379)	(528)	(582)	(674)	(674)	(772)	(837)	(837)	(837)	0
Model Deman	302	213	231	284	453	332	579	609	914	949	741	454	6,096
DWR Demand	413	365	339	342	304	227	450	570	732	773	713	475	5,703

D—016074

Summary for Delta EWA Operations for 1994 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
Pumping (cfs)													
Historic	10,739	6,835	10,432	5,772	5,782	4,172	1,816	1,760	1,689	4,186	5,880	7,172	4,004
DWRSIM	12989	10055	12622	9229	6156	5180	2873	2114	5903	5903	11824	6280	5,498
Model Base	12,594	9,448	8,833	4,841	7,641	5,575	6,130	2,040	5,690	5,279	10,135	5,172	4,795
Model Final	12,594	5,441	5,896	5,474	4,954	8,167	1,564	1,500	4,049	4,218	10,135	5,172	4,173
Model Change	0	(4,007)	(2,937)	633	(2,687)	2,592	(4,566)	(540)	(1,641)	(1,061)	0	0	(622)
Model Limits	12,594	5,441	5,896	5,474	4,954	4,409	1,500	1,500	4,049	4,218	10,135	5,172	3,942
Monthly E/I	62%	35%	30%	29%	16%	44%	10%	10%	21%	29%	56%	44%	
SL Limits	0	0	0	0	0	0	0	0	0	0	0	0	0
Fish Limits	0	0	0	0	0	0	0	0	0	0	0	0	0
DW Pass Thro	0	0	0	0	0	0	0	0	0	0	0	0	
Outflow (cfs)													
Historic	5,145	7,381	12,361	10,788	20,557	10,612	8,232	8,011	3,919	4,541	3,417	5,570	6,010
DWRSIM	5577	4502	5854	9984	25902	10829	8551	8032	6199	4000	2992	3007	5,758
Model Req'd	4,500	4,500	4,500	4,500	7,100	7,100	7,100	4,000	4,000	4,000	3,750	3,750	3,548
Model Deficit	0	0	0	0	0	0	0	0	0	0	0	0	0
Model Base	6,256	5,997	8,901	12,421	26,405	11,914	10,570	11,925	7,395	4,926	4,098	3,750	6,912
Model Final	6,256	10,004	13,958	13,557	24,808	12,834	13,767	12,091	10,872	5,987	4,098	3,750	7,963
Model Change	0	4,007	5,057	1,136	(1,598)	920	3,197	166	3,477	1,061	(0)	0	1,051
Extra DW Pu	0	0	0	0	2000	0	0	0	0	0	0	0	
Historic X2	87.5	82.5	77.0	75.6	69.8	75.9	78.0	80.9	86.4	86.6	88.6	84.6	
Model Base X	83.3	82.9	81.4	74.8	67.4	75.1	75.0	75.2	79.2	84.5	86.2	87.7	
Model X2	83.3	77.6	74.1	72.8	67.2	73.6	72.8	74.8	77.4	81.9	85.7	87.7	
Change X2	0.0	-5.3	-7.4	-2.0	-0.2	-1.5	-2.2	-0.4	-1.8	-2.6	-0.5	-0.1	
Historic Cl	194	107	32	22	17	18	27	27	77	123	185	176	100
Model Base C	167	112	47	30	17	17	22	18	26	56	120	165	80
Model Cl	167	58	20	18	17	17	17	17	19	38	92	148	70
Change Cl	-0	-54	-27	-13	-0	-0	-5	-1	-7	-18	-28	-16	-10
DWRSIM X2	85.7	87.7	84.1	66.1	61.3	62.8	61.9	63.5	67.4	75.4	83.3	87.2	

D-016075

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General Fish Evaluation Parameters for 1994 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Vernalis Flow Ratio (>1 is good)												
Base/Historic	1.4	1.0	0.9	0.8	1.2	1.0	1.8	2.4	1.4	1.0	1.3	1.6
Final/Historic	1.4	1.0	0.9	0.8	1.2	1.0	2.6	2.5	3.0	1.0	1.3	1.6
Vernalis/Export Ratio (Higher is better)												
Base/Historic	1.17	0.76	1.08	0.93	0.89	0.77	0.52	2.06	0.41	0.83	0.73	2.26
Final/Historic	1.17	1.31	1.62	0.82	1.38	0.53	3.04	2.90	1.26	1.04	0.73	2.26

Sacramento Salmon Survival for 1992 Game 2

Out-Migration	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Fall	0	0	0	0	0	0	0.17	0.65	0.18	0	0	0	1
Late-fall		0.25	0.5	0.25									1
Winter			0.10	0.25	0.35	0.25	0.05						1.0
Spring			0.01	0.06	0.17	0.28	0.25	0.16	0.07				1.0
Spring Yearlings	0.05	0.35	0.40	0.13	0.05	0.02							1.0

Historic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		Historic Relative Survival
DCC fraction	0.51	0.59	0.52	0.49	0.17	0.17	0.22	0.49	0.46	0.54	0.53	0.04	Fall	0.756
Central Survival	0.33	0.40	0.40	0.29	0.30	0.15	0.40	0.45	0.44	0.46	0.42	0.35	Late-fall	0.668
Total Survival	0.65	0.64	0.69	0.65	0.88	0.85	0.87	0.73	0.74	0.70	0.69	0.97	Winter	0.798
													Spring	0.821
													Yearling	0.679

Model Base	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep			Change from Historic
DCC fraction	0.55	0.47	0.31	0.23	0.16	0.18	0.24	0.28	0.28	0.65	0.69	0.59	Fall	0.846	11.9%
Central Survival	0.37	0.38	0.37	0.27	0.15	0.21	0.38	0.45	0.44	0.44	0.45	0.40	Late-fall	0.787	17.9%
Survival	0.65	0.71	0.81	0.83	0.87	0.85	0.85	0.84	0.84	0.64	0.62	0.64	Winter	0.848	6.3%
													Spring	0.852	3.7%
													Yearling	0.771	0.134

Model Adjusted	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep			Change from Base
DCC fraction	0.56	0.53	0.31	0.23	0.16	0.18	0.24	0.28	0.28	0.65	0.68	0.60	Fall	0.846	0.0%
Central Survival	0.34	0.34	0.37	0.27	0.22	0.22	0.38	0.45	0.44	0.44	0.45	0.38	Late-fall	0.773	-1.8%
Survival	0.63	0.65	0.81	0.83	0.88	0.86	0.85	0.84	0.84	0.64	0.63	0.63	Winter	0.852	0.5%
													Spring	0.854	0.003
													Yearling	0.75	-0.027

Sacramento relative survival = 1
Central Delta relative survival = 0.5 - 0.0000336* Exports (cfs)
Monthly relative survival = sacramento fraction + DCC fraction * Central Delta relative survival
Population survival = monthly relative survival * migration portion

D-016076
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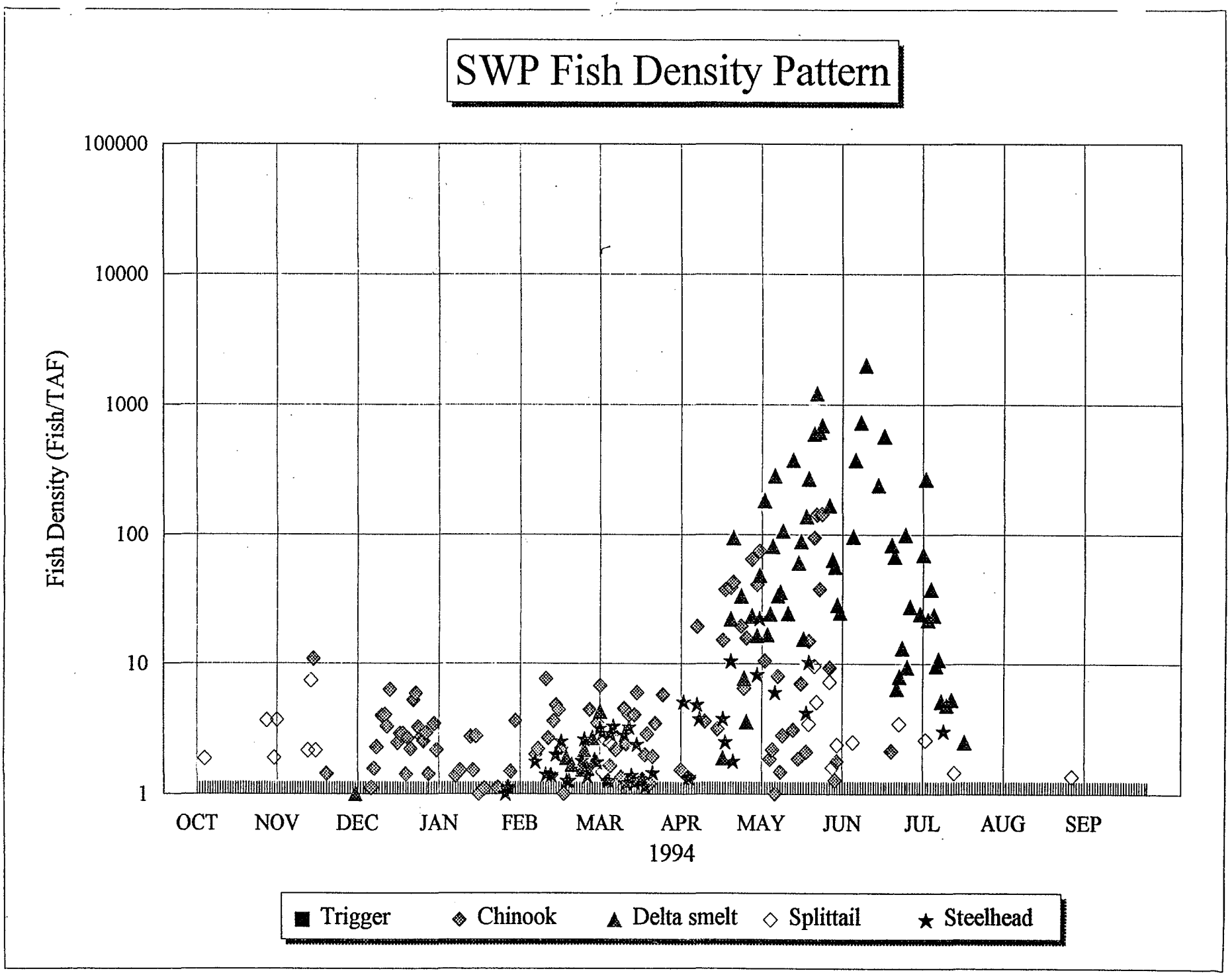
San Joaquin Salmon Survival for 1994 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Out-Migration %	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.48	0.07	0.00	0.00	0.00	1.0
Historic													
Flow survival	0.06	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.02	0.02	0.02	0.02	
Export Survival	0.28	0.54	0.30	0.62	0.61	0.72	0.88	0.88	0.89	0.72	0.61	0.52	
Survival	0.02	0.02	0.01	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.033
Model Base													
Flow survival	0.08	0.04	0.03	0.03	0.05	0.05	0.07	0.09	0.03	0.02	0.02	0.03	
Export Survival	0.16	0.37	0.41	0.68	0.49	0.63	0.59	0.86	0.62	0.65	0.32	0.66	
Survival	0.01	0.01	0.01	0.02	0.02	0.03	0.04	0.08	0.02	0.02	0.01	0.02	0.058
											Change from Histori		76.2%
Model Adjusted													
Flow survival	0.08	0.04	0.03	0.03	0.05	0.05	0.10	0.10	0.07	0.02	0.02	0.03	
Export Survival	0.16	0.64	0.61	0.64	0.67	0.46	0.90	0.90	0.73	0.72	0.32	0.66	
Survival	0.01	0.02	0.02	0.02	0.03	0.02	0.09	0.09	0.05	0.02	0.01	0.02	0.085
											Change from Base		46.8%

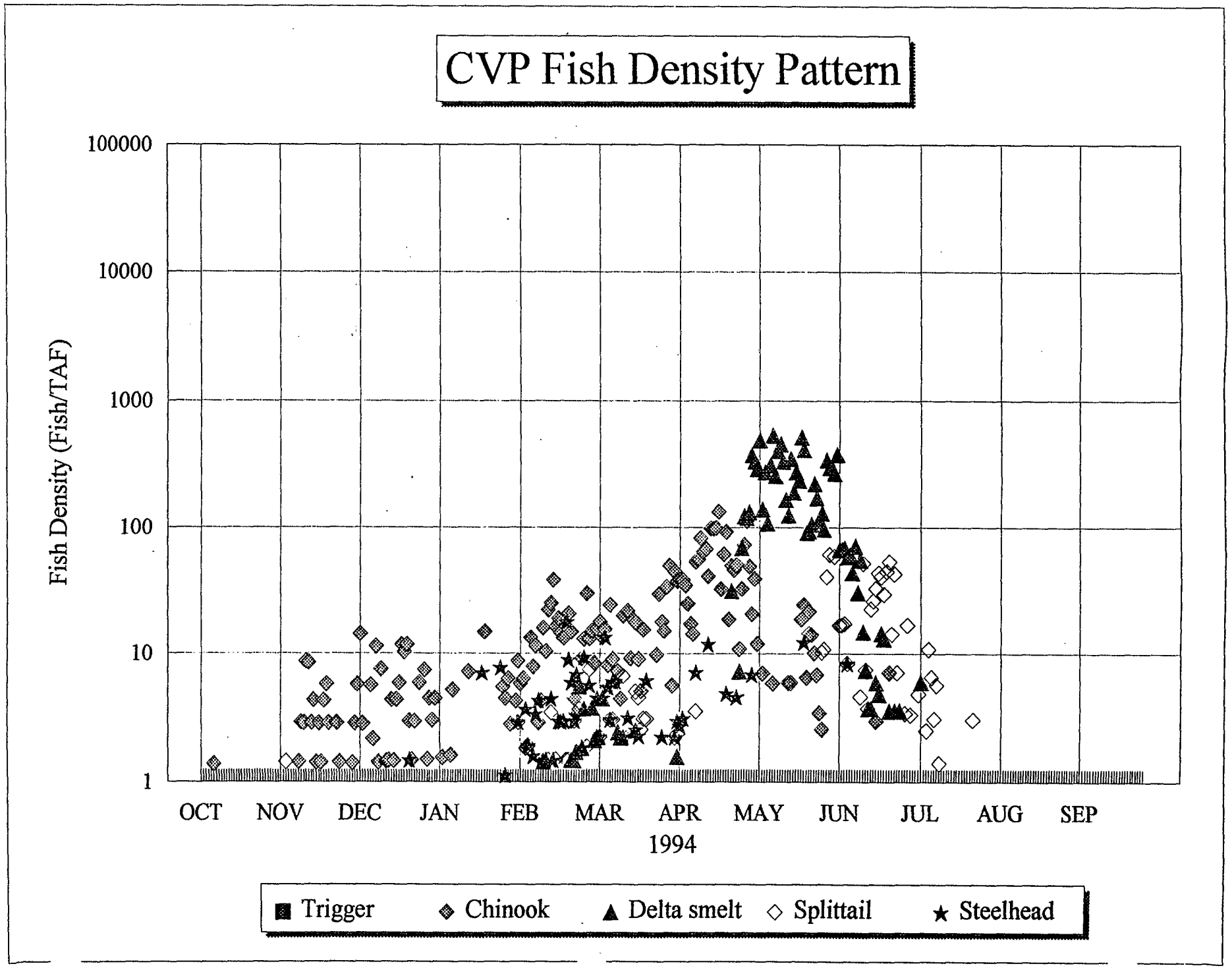
Maximum survival = 0.00002 * Vernalis Flow; 0.2 @ 10,000 cfs
Export survival factor = (15,000 - Export) / 15,000; 0.9 @ 1,500 pumping or may be a constant survival reduction
Monthly relative survival = Maximum survival * Export survival factor
Population survival = monthly relative survival * migration portion
HOR Closure may increase survival by 0.1 or some other factor

D-016077
D-016077



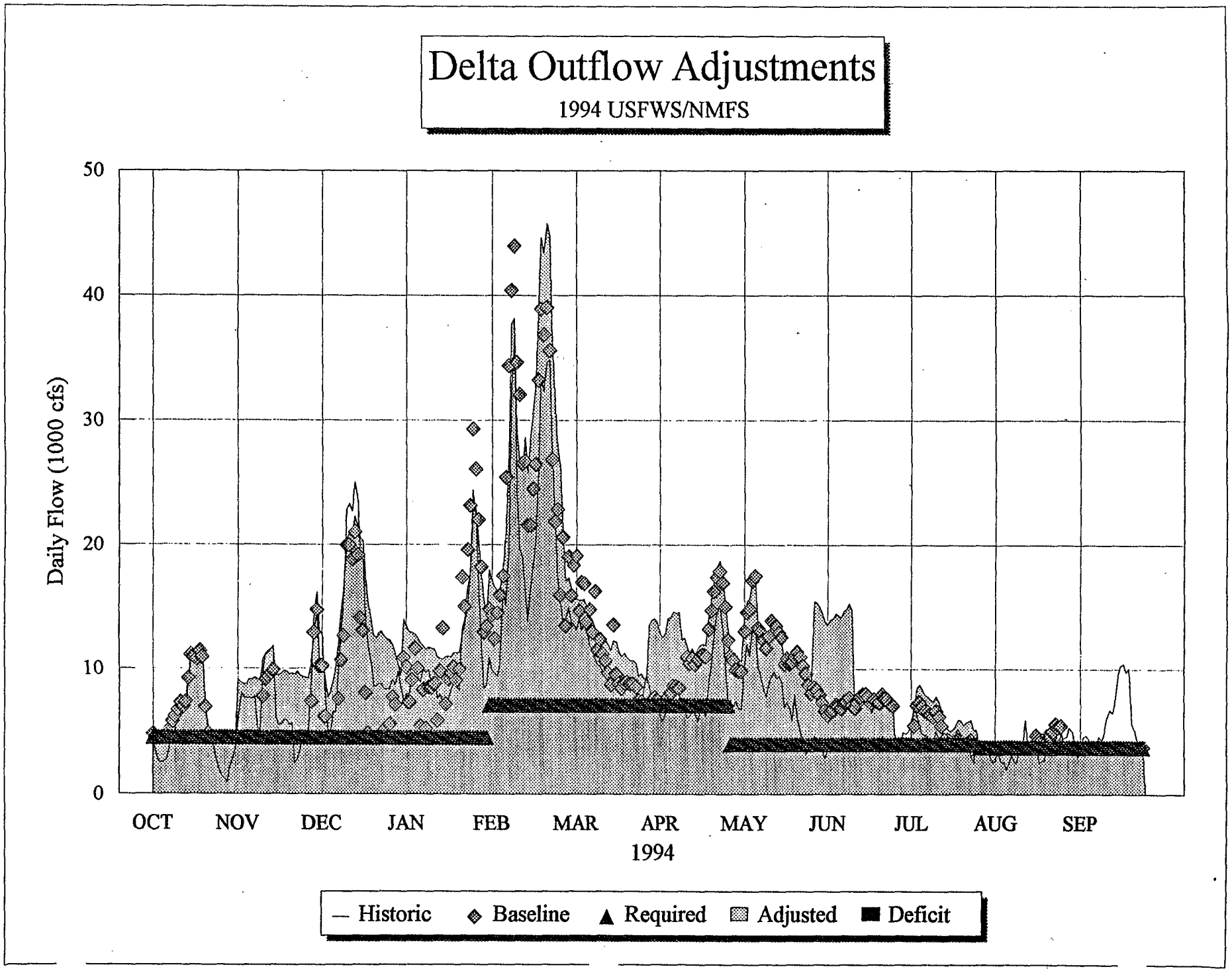
D-016078

D-016078



D-016079

D-016079



D-016080

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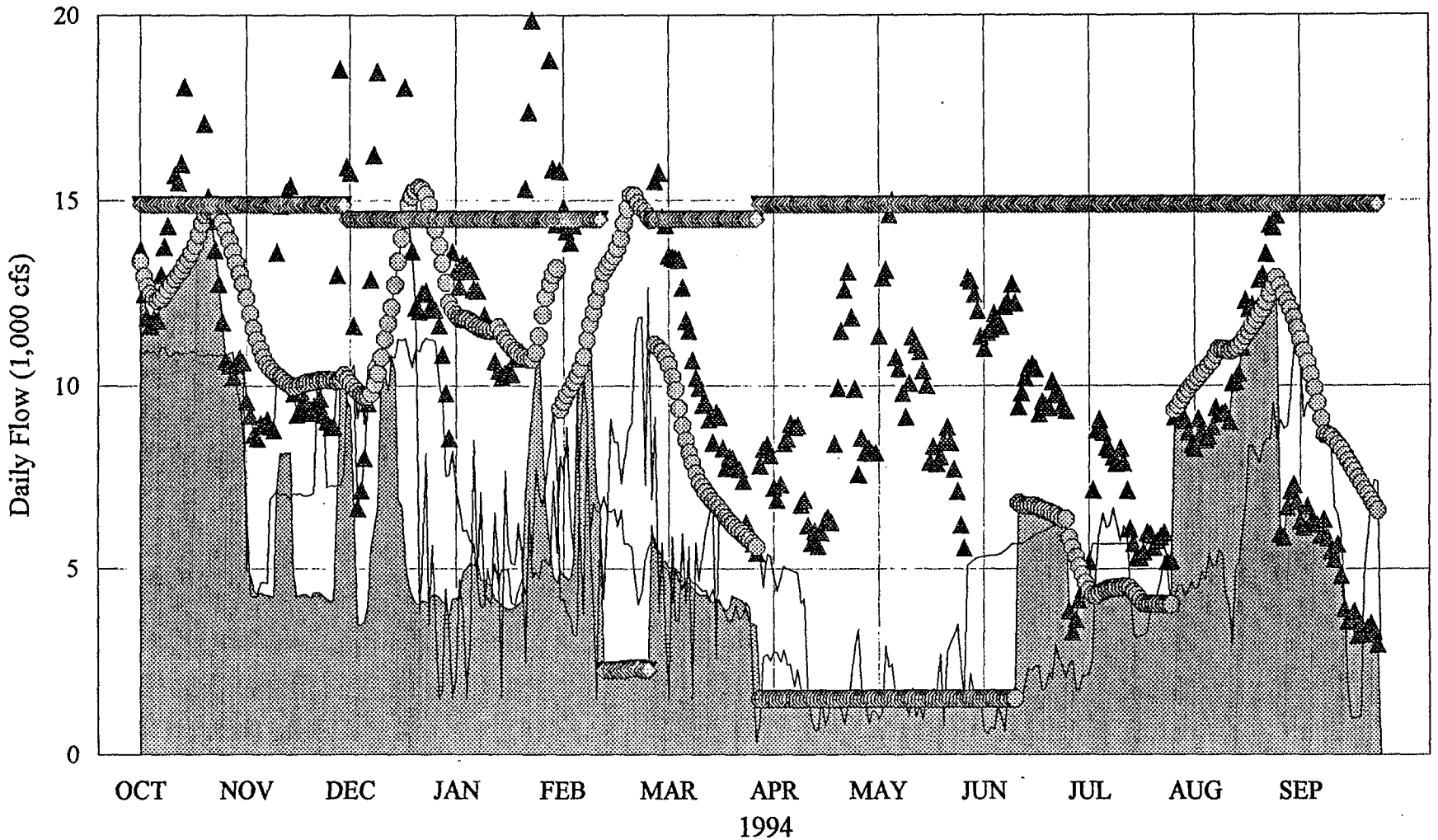
Delta Export Limits

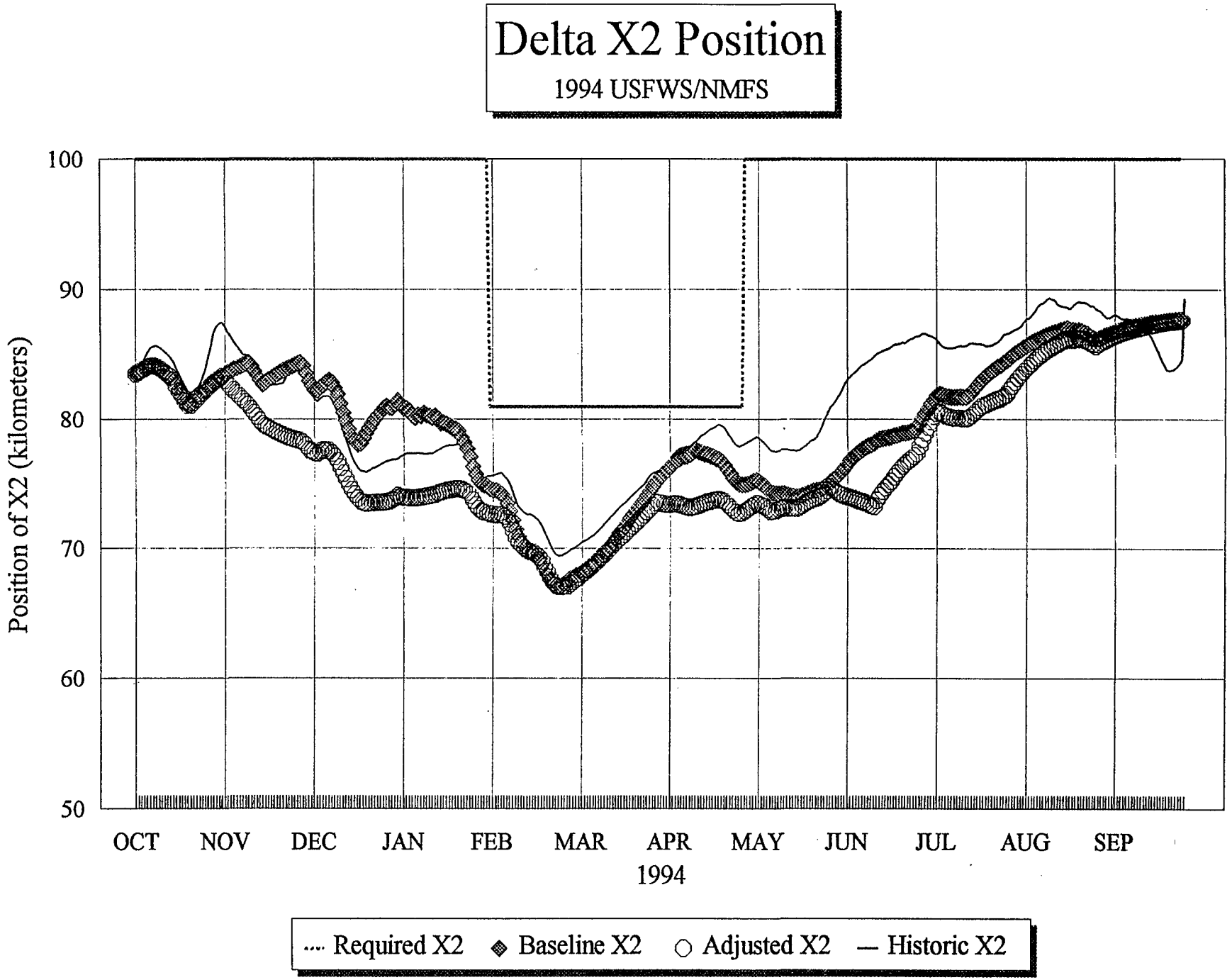
1994 USFWS/NMFS



— Baseline 4795 TAF
Allowed Export 3942 TAF
▲ Outflow Limits
E/I Limits
▼ San Luis Limits
◇ Capacity & Fish Limits
— Historic

D-016081

D-016081

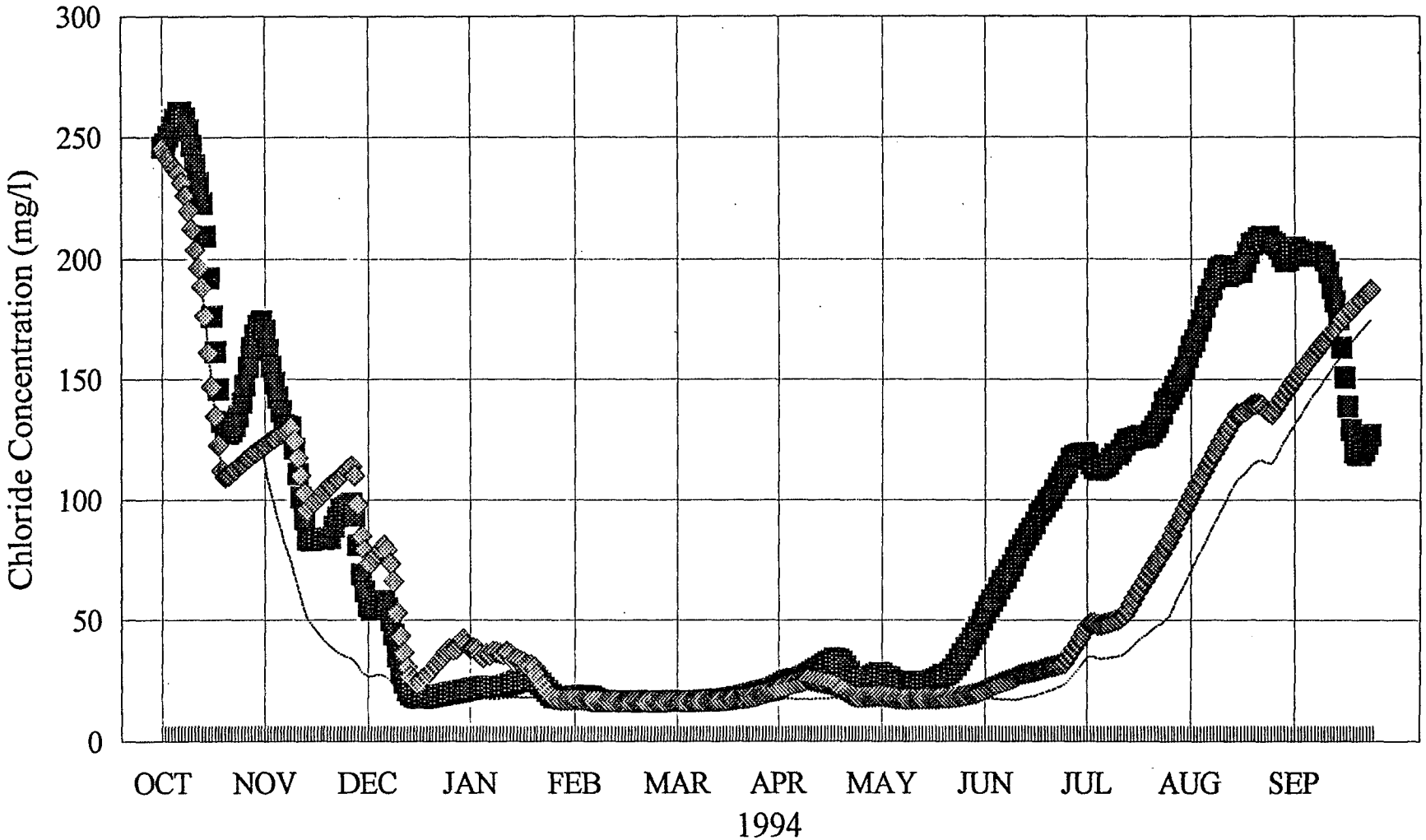

Delta X2 Position
1994 USFWS/NMFS
Position of X2 (kilometers)
100
90
80
70
60
50
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1994
Required X2
Baseline X2
Adjusted X2
Historic X2

D-016082

D-016083

Export Chloride

1994 USFWS/NMFS



Historic Cl Baseline Cl Adjusted Cl

D—016083

Delta Channel Flows for 1994 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
DCC & Georgiana													
Historic	5,879	5,078	8,050	3,553	3,515	2,619	1,951	2,365	4,153	4,931	5,649	6,313	3,268
DWRSIM													
Model Base	7,258	6,535	3,417	3,362	4,679	3,198	2,593	2,493	3,138	6,608	7,654	5,378	3,397
Model Final	7,258	2,891	3,417	3,362	4,679	3,198	2,593	2,493	3,138	6,608	7,654	5,378	3,178
Model Change	0	-3645	-0.00	0	0	0	0	0	0	0	0	0.000	-220
Rio Vista													
Historic	7,960	7,040	12,317	10,662	16,906	10,860	6,520	6,515	3,972	6,968	6,523	8,127	6,266
DWRSIM													
Model Base	7,773	6,356	13,913	13,522	23,563	11,954	7,568	6,574	10,896	5,493	8,166	3,961	7,224
Model Final	7,773	10,000	13,913	13,522	23,563	11,954	7,568	6,574	10,896	5,493	8,166	3,961	7,444
Model Change	0	3645	0.000	0	0	0	0	0	0	0	0	0.000	219.9
Model Req'd	4,000	4,500	4,500	0	0	0	0	0	0	0	0	3,000	
QWEST (cfs)													
Historic	(2,359)	328	(124)	(8)	2,401	155	1,929	1,986	1,259	(903)	(1,780)	(1,635)	59
DWRSIM	-961	-2140	-4674	6633	1822	-133	2806	5041	-3813	684	-5713		
Model Base	(1,381)	(357)	(5,057)	(1,135)	2,489	80	3,070	5,497	(3,118)	(125)	(3,682)	59	(221)
Model Final	(1,381)	6	0	0	891	1,000	6,267	5,663	359	936	(3,682)	59	611
Model Change	0	363	5,057	1,136	(1,598)	920	3,197	166	3,477	1,061	(0)	(0)	831
Model Req'd	(15,000)	0	0	0	1,000	1,000	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)	

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Salvage Fish Density and Triggers for 1994 USFWS/NMFS

Trigger	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	
Days	0	0	0	0	0	0	0	0	0	0	0	0	0	
Density Triggers														
Trigger (1=yes)	0	0	0	0	0	0	0	0	0	0	0	0		
Chinook	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000		
Steelhead	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000		
Striped Bass	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000		
Splittail	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000		
Delta smelt	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000		
Export Frac	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Historic														
Chinook	40	191	1,480	317	512	624	692	3,288	45	0	0	0	7,189	
Steelhead	0	0	0	40	268	329	120	162	0	47	0	0	966	
Striped Bass	9,496	178,534	9,380	2,101	2,830	934	29	251,960	635,745	292,508	17,469	29,412	1,430,398	
Splittail	211	226	25	25	76	122	0	106	63	45	9	24	932	
Delta smelt	0	0	145	34	146	142	510	25,618	16,898	3,423	0	0	46,914	
														Reduced
Model Baseline														from Historic
Chinook	47	260	1,211	259	465	727	1,378	2,426	154	0	0	0	6,926	4%
Steelhead	0	0	0	29	324	361	316	225	0	43	0	0	1,300	-35%
Striped Bass	10,446	244,584	8,071	1,733	3,335	1,015	91	125,220	1,917,611	389,580	34,628	19,693	2,756,006	-93%
Splittail	228	321	11	22	99	138	0	57	199	65	13	16	1,169	-25%
Delta smelt	0	0	126	26	158	94	678	10,082	26,282	3,691	0	0	41,136	12%
														Reduced
Model Final														from Baseline
Chinook	47	133	843	265	377	895	620	1,979	65	0	0	0	5,224	25%
Steelhead	0	0	0	39	158	485	103	156	0	34	0	0	975	25%
Striped Bass	10,446	161,369	5,699	1,890	2,036	1,448	26	125,212	1,058,847	317,236	34,628	19,693	1,738,528	37%
Splittail	228	223	10	18	39	185	0	57	89	51	13	16	930	20%
Delta smelt	0	0	64	17	61	171	275	8,913	8,513	2,496	0	0	20,510	50%
Pumping (cfs)														
Historic	10,739	6,835	10,432	5,772	5,782	4,172	1,816	1,760	1,689	4,186	5,880	7,172	3,996 (TAF)	
Model Base	12,594	9,448	8,822	4,841	7,641	5,286	3,061	1,500	5,690	5,279	10,135	5,172	4,795 (TAF)	
Model Final	12,594	5,441	5,896	5,474	4,954	8,167	1,564	1,500	4,049	4,218	10,135	5,172	4,173 (TAF)	
Model change	0	(4,007)	(2,925)	633	(2,687)	2,881	(1,497)	0	(1,641)	(1,061)	0	0	(622)(TAF)	

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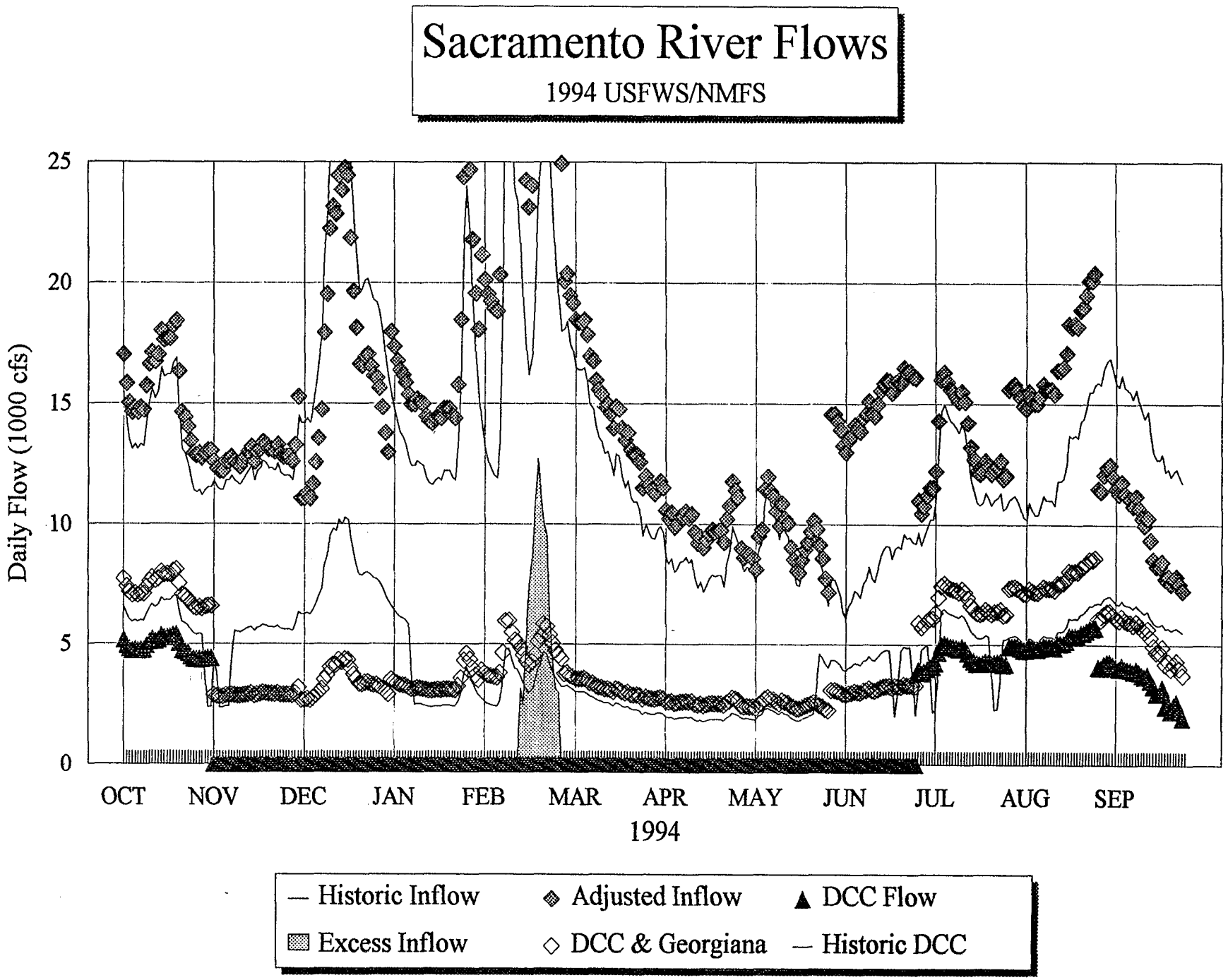

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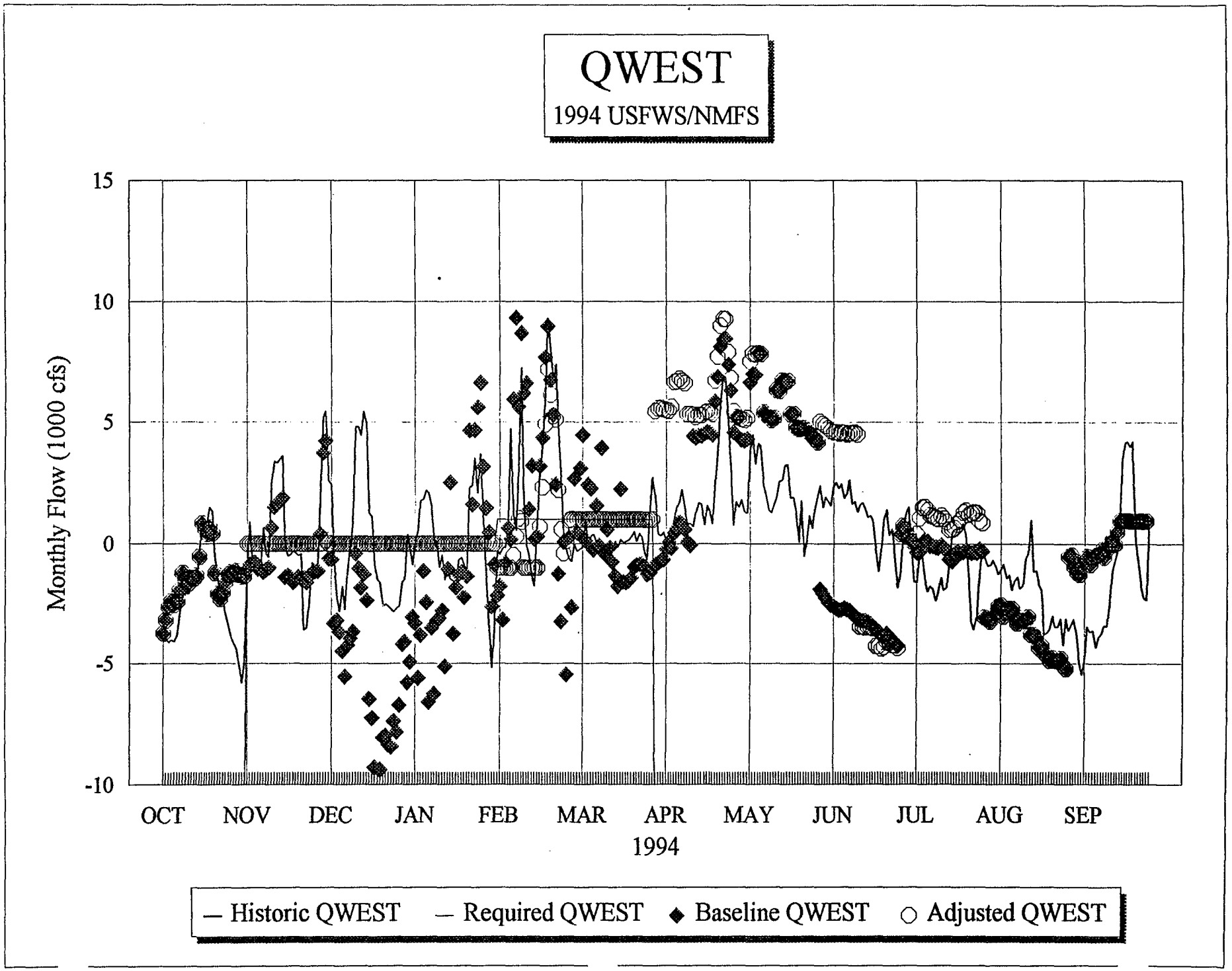

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Delta Inflows and San Luis Storage for 1995 USFWS/NMFS

Freeport (cfs)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
DWRSIM-Hist													
Historic	8,255	9,489	16,371	62,210	58,182	71,923	61,437	63,181	38,957	29,232	18,716	23,270	27,750
DWRSIM													
Model Base	8,255	9,489	16,371	62,210	58,182	71,923	61,437	63,181	38,957	29,232	18,716	23,270	27,690
Model Final	8,255	9,489	16,371	62,210	58,182	71,923	61,437	63,181	38,957	29,232	18,716	23,270	27,690
Model Change	0	0	0	0	0	0	0	0	0	0	0	0	0
Model Excess	0	0	0	11,848	10,053	28,605	0	0	9,142	542	1,854	6,547	4,138
Vernalis (cfs)													
DWRSIM-Hist													
Historic	1,370	1,288	1,295	4,599	6,559	14,612	19,933	22,187	14,101	9,881	3,925	4,734	6,306
DWRSIM													
Model Base	1,618	1,288	1,295	4,599	6,559	14,652	19,933	22,187	14,101	9,881	3,925	4,734	6,321
Model Final	1,618	1,288	1,295	4,599	6,559	14,652	19,933	22,187	14,101	9,881	3,925	4,734	6,321
Model Change	0	0	0	0	0	0	0	0	0	0	0	0	0
Model HOR	81	1,327	1,271	2,959	3,612	7,137	8,935	9,711	6,660	5,197	2,753	3,087	3,181
San Luis (TAF)													
Historic	618	845	1,197	1,774	2,022	2,035	2,027	2,009	1,877	1,764	1,499	1,524	
DWRSIM													
Model Base	282	440	853	1,395	1,771	2,038	1,830	1,341	1,322	1,265	1,420	1,856	
Model Final	282	440	496	1,008	1,106	1,653	1,283	755	338	281	435	870	
Model Change	0	0	(357)	(387)	(665)	(385)	(547)	(586)	(984)	(984)	(985)	(985)	
EWA Credits	0	0	0	0	0	284	0	0	0	0	0	0	284
EWA Uses	0	0	357	29	278	7	201	0	398	0	0	0	1,272
EWA Balance	0	0	(357)	(387)	(665)	(389)	(590)	(590)	(988)	(988)	(988)	(988)	0
Model Deman	302	213	231	284	453	332	579	609	914	949	741	454	6,096

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Summary for Delta EWA Operations for 1995 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
Pumping (cfs)													
Historic	5,226	6,074	7,434	11,648	8,790	2,905	3,438	4,199	7,430	10,364	9,132	7,209	5,056
DWRSIM													
Model Base	4,824	6,220	10,573	13,566	14,340	9,879	7,391	2,859	14,900	14,900	14,900	14,900	7,798
Model Final	4,824	6,220	4,749	13,088	9,318	14,500	5,301	1,613	8,200	14,900	14,855	14,900	6,785
Model Change	0	0	(5,824)	(478)	(5,022)	4,621	(2,091)	(1,246)	(6,700)	0	(45)	0	(1,013)
Model Limits	4,824	6,220	4,749	13,088	9,318	14,387	1,500	1,500	8,200	14,900	14,855	14,900	6,551
Monthly E/I	47%	55%	26%	11%	11%	7%	5%	1%	13%	34%	59%	48%	
SL Limits	0	0	0	0	0	0	0	0	0	0	0	0	0
Fish Limits	0	0	0	0	0	0	0	0	0	0	0	0	0
DW Pass Thro	0	0	0	0	0	0	0	0	0	0	0	0	
Outflow (cfs)													
Historic	3,250	5,357	9,633	107,488	72,836	200,645	90,871	98,112	46,819	26,865	10,952	19,694	41,827
DWRSIM													
Model Req'd	3,750	3,750	3,750	6,000	28,564	7,100	7,100	7,100	7,100	8,000	4,000	3,750	5,428
Model Deficit	0	0	0	0	0	0	0	0	0	0	0	0	0
Model Base	4,081	5,474	6,922	104,942	69,126	200,358	94,345	106,189	39,667	24,566	6,240	13,195	40,731
Model Final	4,081	5,474	12,746	105,474	74,092	195,736	97,769	106,189	47,309	24,344	5,653	13,195	41,754
Model Change	0	0	5,824	532	4,967	(4,621)	3,425	0	7,642	(222)	(587)	0	1,023
Extra DW Pu	0	0	0	0	3000	0	0	0	0	0	2000	0	
Historic X2	90.4	86.8	83.7	55.7	56.5	44.9	50.5	51.9	58.2	65.5	73.9	69.2	
Model Base X	87.2	85.3	85.1	56.2	57.5	45.2	50.0	50.9	59.3	67.1	79.8	74.0	
Model X2	87.2	85.3	76.8	54.5	56.8	45.3	49.8	50.8	59.2	67.2	80.2	74.1	
Change X2	0.0	0.0	-8.4	-1.7	-0.7	0.2	-0.2	-0.0	-0.1	0.1	0.3	0.1	
Historic Cl	198	181	55	23	17	17	17	17	17	17	18	17	43
Model Base C	172	151	78	30	17	17	17	17	17	17	25	24	36
Model Cl	172	151	42	17	17	17	17	17	17	17	26	24	34
Change Cl	0	0	-35	-13	-0	-0	0	0	0	0	1	0	-2

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Delta Channel Flows for 1995 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TAF
DCC & Georgiana													
Historic	4,509	4,535	5,668	9,489	8,567	10,395	9,000	9,232	6,010	5,267	7,574	8,908	5,375
DWRSIM													
Model Base	4,491	5,098	3,323	9,824	9,116	11,214	9,576	9,870	6,279	6,259	8,179	8,973	5,563
Model Final	4,491	5,098	3,323	9,824	9,116	11,214	9,576	9,870	6,279	6,259	8,179	8,973	5,563
Model Change	0	0	0	0	0	0	0	0	0	0	0	0	0
Rio Vista													
Historic	3,771	4,978	10,728	94,159	64,766	163,480	61,417	67,082	32,958	24,090	11,162	14,382	33,392
DWRSIM													
Model Base	3,493	4,538	12,839	95,523	64,124	164,370	60,621	66,033	31,850	22,010	9,611	13,659	33,103
Model Final	3,493	4,538	12,839	95,523	64,124	164,370	60,621	66,033	31,850	22,010	9,611	13,659	33,103
Model Change	0	0	0	0	0	0	0	0	0	0	0	0	0
Model Req'd	3,000	3,500	3,500	0	0	0	0	0	0	0	0	3,000	
QWEST (cfs)													
Historic	(107)	208	(769)	10,951	8,202	34,773	29,762	31,606	15,035	4,298	1,115	6,234	8,539
DWRSIM													
Model Base	706	888	(5,824)	8,740	5,039	35,304	33,811	40,321	8,152	2,992	(2,992)	(201)	7,658
Model Final	706	888	0	9,272	10,005	30,683	37,236	40,321	15,794	2,770	(3,579)	(201)	8,682
Model Change	0	0	5,824	532	4,967	(4,621)	3,425	0	7,642	(222)	(587)	0	1,023
Model Req'd	(15,000)	(15,000)	0	0	0	0	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)	

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Salvage Fish Density and Triggers for 1995 USFWS/NMFS

Trigger	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	
Days	0	0	0	0	0	0	0	0	8	0	0	0	8	
Density Triggers														
Trigger (1=yes)	0	0	0	0	0	0	0	0	0	0	0	0		
Chinook	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000		
Steelhead	1000	1000	1000	1000	10	1000	1000	1000	1000	1000	1000	1000		
Striped Bass	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000		
Splittail	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000		
Delta smelt	10000	10000	10000	10	10000	10000	10000	10000	10000	10000	10000	10000		
Export Frac	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Historic														
Chinook	0	18	1,253	7,763	2,269	50	145	8,655	19,013	321	20	0	39,508	
Steelhead	4	0	7	553	748	181	4	280	231	51	0	0	2,059	
Striped Bass	491	149,247	35,542	158,353	110,205	2,107	9	368	179,529	1,392,161	282,299	18,042	2,328,354	
Splittail	0	0	0	3,621	802	13	73	72,603	4,263,980	181,781	9,245	613	4,532,731	
Delta smelt	0	0	73	2,986	847	18	0	0	0	0	0	0	3,925	
														Reduced
Model Baseline														from Historic
Chinook	0	20	1,546	9,224	2,956	110	136	3,566	36,305	453	27	0	54,344	-38%
Steelhead	4	0	7	657	1,308	405	9	181	395	69	0	0	3,035	-47%
Striped Bass	399	165,031	47,264	186,842	167,161	4,742	18	297	321,541	2,006,648	470,668	34,483	3,405,094	-46%
Splittail	0	0	0	4,362	1,123	30	68	24,625	7,808,445	273,086	14,548	1,222	8,127,509	-79%
Delta smelt	0	0	116	3,895	1,378	54	0	0	0	0	0	0	5,444	-39%
														Reduced
Model Final														from Baseline
Chinook	0	20	619	9,175	1,178	108	106	2,728	8,108	453	27	0	22,523	59%
Steelhead	4	0	3	655	1,090	402	2	101	40	69	0	0	2,366	22%
Striped Bass	399	165,031	20,608	182,957	93,022	4,633	4	148	317,294	2,006,648	470,492	34,483	3,295,719	3%
Splittail	0	0	0	4,348	479	30	53	20,607	1,421,916	273,086	14,538	1,222	1,736,279	79%
Delta smelt	0	0	23	2,629	557	52	0	0	0	0	0	0	3,260	40%
Pumping (cfs)														
Historic	5,226	6,074	7,434	11,648	8,790	2,905	3,438	4,199	7,430	10,364	9,132	7,209	5,059	(TAF)
Model Base	4,824	6,220	10,572	13,566	14,340	9,879	4,889	1,500	14,900	14,900	14,855	14,900	7,541	(TAF)
Model Final	4,824	6,220	4,749	13,088	9,318	14,500	5,301	1,613	8,200	14,900	14,855	14,900	6,785	(TAF)
Model change	0	0	(5,823)	(478)	(5,022)	4,621	412	113	(6,700)	0	0	0	(756)	(TAF)

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General Fish Evaluation Parameters for 1995 USFWS/NMFS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Vernalis Flow Ratio (>1 is good)												
Base/Historic	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Final/Historic	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Vernalis/Export Ratio (Higher is better)												
Base/Historic	1.28	0.98	0.70	0.86	0.61	0.29	0.47	1.47	0.50	0.70	0.61	0.48
Final/Historic	1.28	0.98	1.57	0.89	0.94	0.20	0.65	2.60	0.91	0.70	0.61	0.48

Sacramento Salmon Survival for 1995 USFWS/NMFS

Out-Migration	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Fall	0	0	0	0	0	0	0.17	0.65	0.18	0	0	0	1
Late-fall		0.25	0.5	0.25									1
Winter			0.10	0.25	0.35	0.25	0.05						1.0
Spring			0.01	0.06	0.17	0.28	0.25	0.16	0.07				1.0
Spring Yearlings	0.05	0.35	0.40	0.13	0.05	0.02							1.0

Historic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
DCC fraction	0.51	0.59	0.52	0.49	0.17	0.17	0.22	0.49	0.46	0.54	0.53	0.04
Central Survival	0.33	0.40	0.40	0.29	0.30	0.15	0.40	0.45	0.44	0.46	0.42	0.35
Total Survival	0.65	0.64	0.69	0.65	0.88	0.85	0.87	0.73	0.74	0.70	0.69	0.97

	Historic Relative Survival
Fall	0.756
Late-fall	0.668
Winter	0.798
Spring	0.821
Yearling	0.679

Model Base	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
DCC fraction	0.55	0.47	0.31	0.23	0.16	0.18	0.24	0.28	0.28	0.65	0.69	0.59
Central Survival	0.37	0.38	0.37	0.27	0.15	0.21	0.38	0.45	0.44	0.44	0.45	0.40
Survival	0.65	0.71	0.81	0.83	0.87	0.85	0.85	0.84	0.84	0.64	0.62	0.64

		Change from Historic
Fall	0.846	11.9%
Late-fall	0.787	17.9%
Winter	0.848	6.3%
Spring	0.852	3.7%
Yearling	0.771	0.134

Model Adjusted	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
DCC fraction	0.56	0.53	0.31	0.23	0.16	0.18	0.24	0.28	0.28	0.65	0.68	0.60
Central Survival	0.34	0.34	0.37	0.27	0.22	0.22	0.38	0.45	0.44	0.44	0.45	0.38
Survival	0.63	0.65	0.81	0.83	0.88	0.86	0.85	0.84	0.84	0.64	0.63	0.63

		Change from Base
Fall	0.846	0.0%
Late-fall	0.773	-1.8%
Winter	0.852	0.5%
Spring	0.854	0.003
Yearling	0.75	-0.027

Sacramento relative survival = 1
Central Delta relative survival = 0.5 - 0.0000336* Exports (cfs)
Monthly relative survival = sacramento fraction + DCC fraction * Central Delta relative survival
Population survival = monthly relative survival * migration portion

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San Joaquin Salmon Survival for 1995 USFWS/NMFS

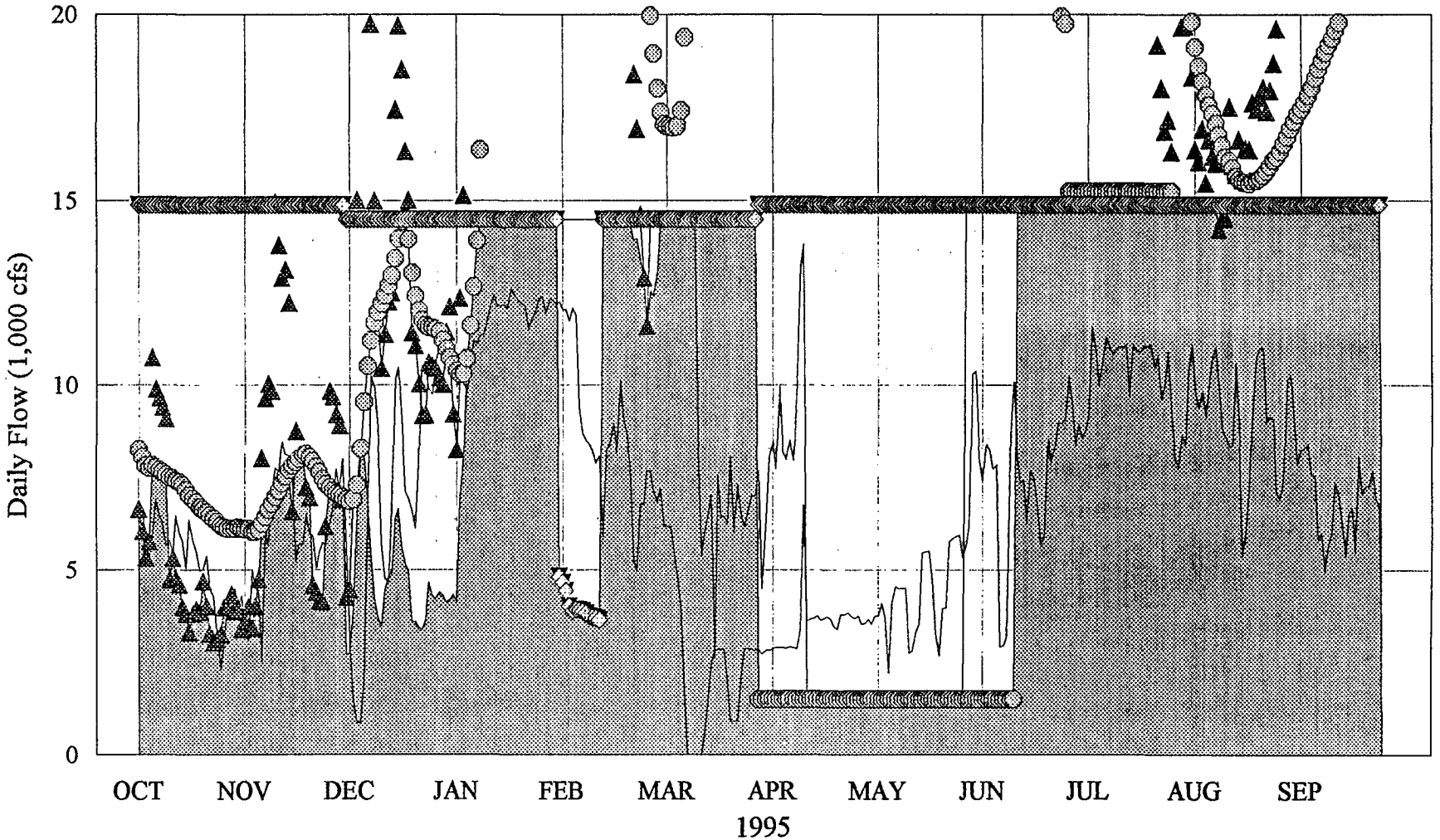
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Out-Migration %	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.48	0.07	0.00	0.00	0.00	1.0
Historic													
Flow survival	0.03	0.03	0.03	0.09	0.13	0.29	0.40	0.44	0.28	0.20	0.08	0.09	
Export Survival	0.65	0.60	0.50	0.22	0.41	0.81	0.77	0.72	0.50	0.31	0.39	0.52	
Survival	0.02	0.02	0.01	0.02	0.05	0.24	0.31	0.32	0.14	0.06	0.03	0.05	0.302
Model Base													
Flow survival	0.03	0.03	0.03	0.09	0.13	0.29	0.40	0.44	0.28	0.20	0.08	0.09	
Export Survival	0.68	0.59	0.30	0.10	0.04	0.34	0.51	0.81	0.01	0.01	0.01	0.01	
Survival	0.02	0.02	0.01	0.01	0.01	0.10	0.20	0.36	0.00	0.00	0.00	0.00	0.264
											Change from Histori		-12.6%
Model Adjusted													
Flow survival	0.03	0.03	0.03	0.09	0.13	0.29	0.40	0.44	0.28	0.20	0.08	0.09	
Export Survival	0.68	0.59	0.68	0.13	0.38	0.03	0.65	0.89	0.45	0.01	0.01	0.01	
Survival	0.02	0.02	0.02	0.01	0.05	0.01	0.26	0.40	0.13	0.00	0.00	0.00	0.315
											Change from Base		19.5%

Maximum survival = 0.00002 * Vernalis Flow; 0.2 @ 10,000 cfs
Export survival factor = (15,000 - Export) / 15,000; 0.9 @ 1,500 pumping or may be a constant survival reduction
Monthly relative survival = Maximum survival * Export survival factor
Population survival = monthly relative survival * migration portion
HOR Closure may increase survival by 0.1 or some other factor

D-016093
D-016093

Delta Export Limits

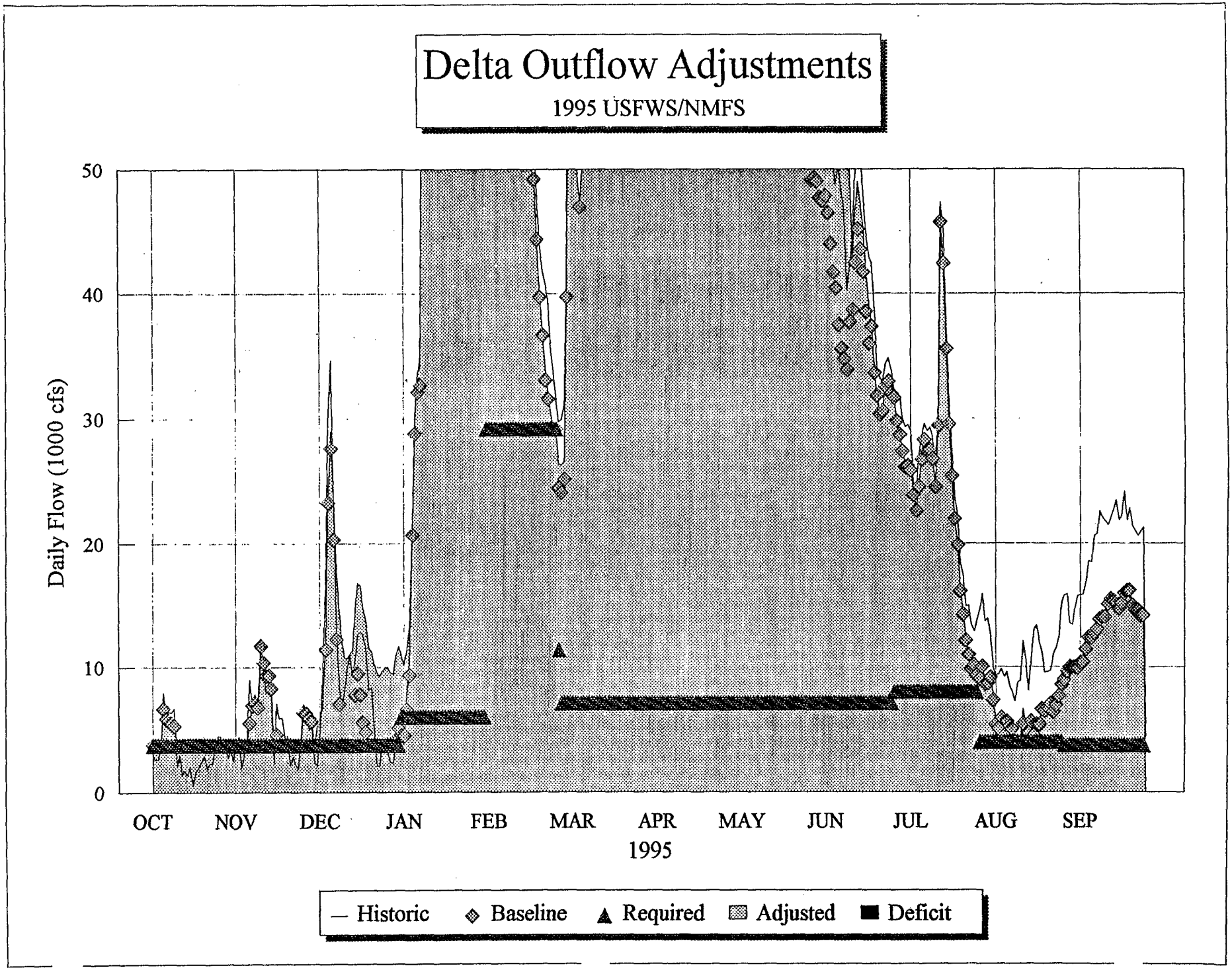
1995 USFWS/NMFS



— Baseline 7541 TAF
Allowed Export 6551 TAF
▲ Outflow Limits
E/I Limits
▼ San Luis Limits
Capacity & Fish Limits
— Historic

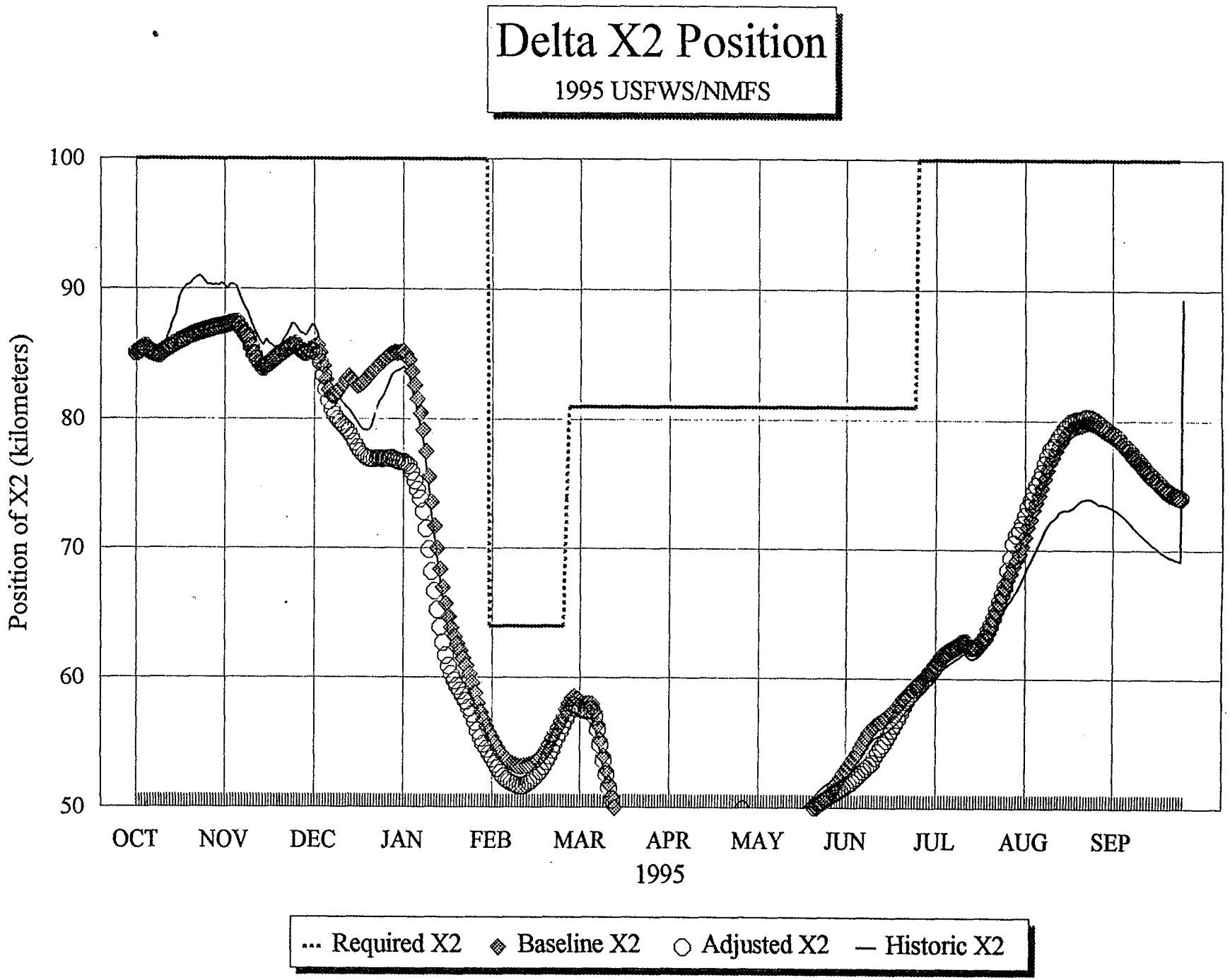
D-016094

D-016094



D-016095

D-016095



D-016096

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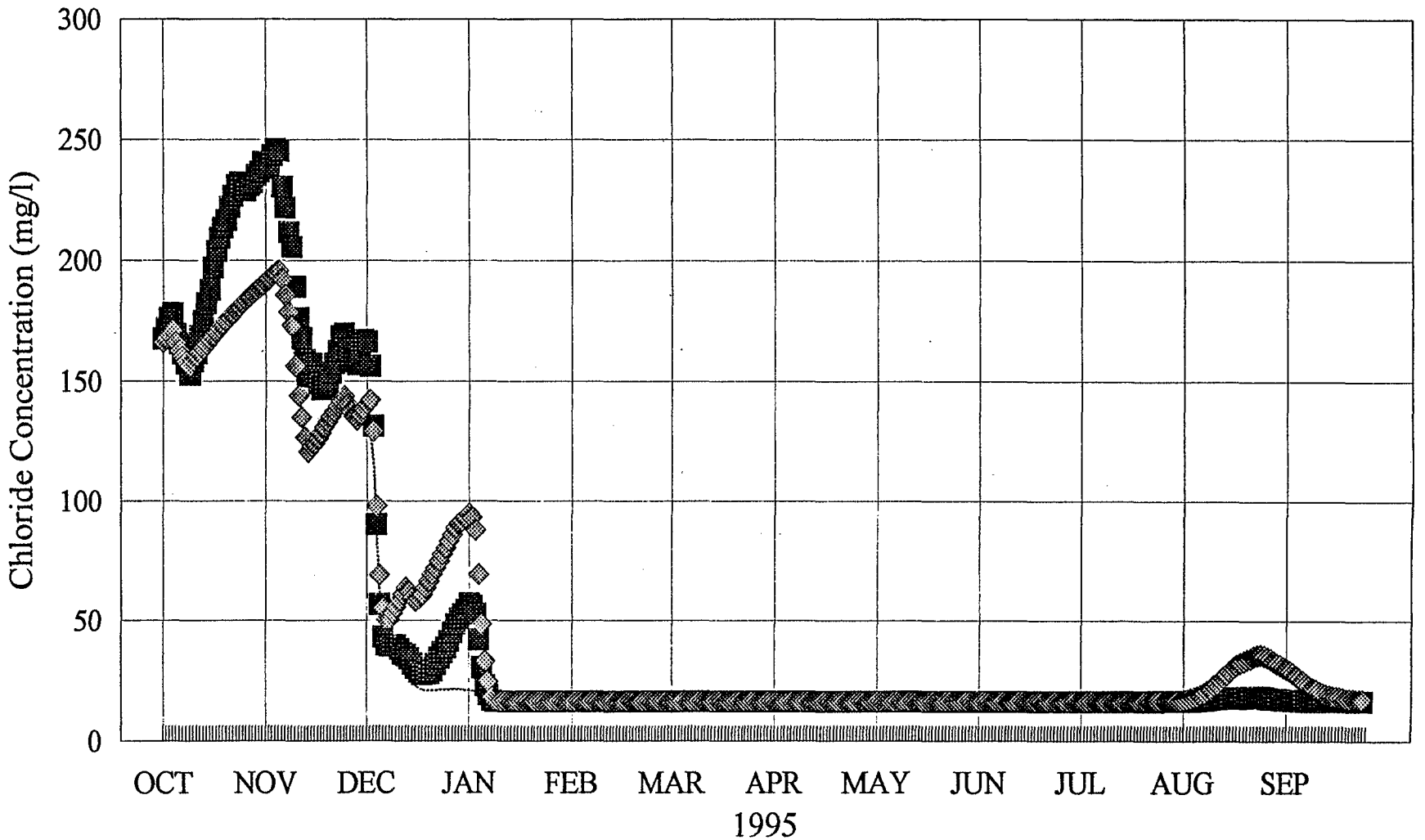
D-016097

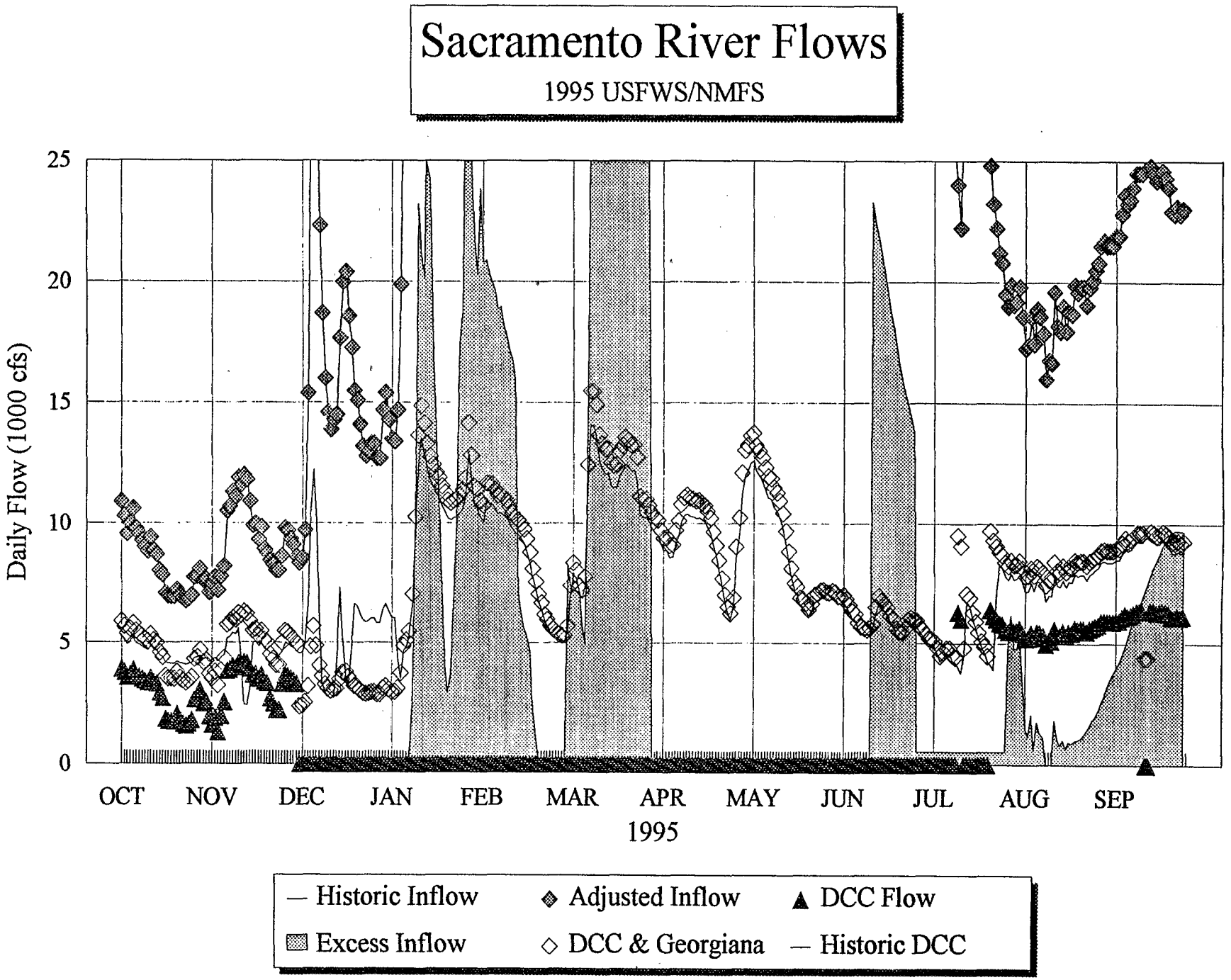
Export Chloride

1995 USFWS/NMFS



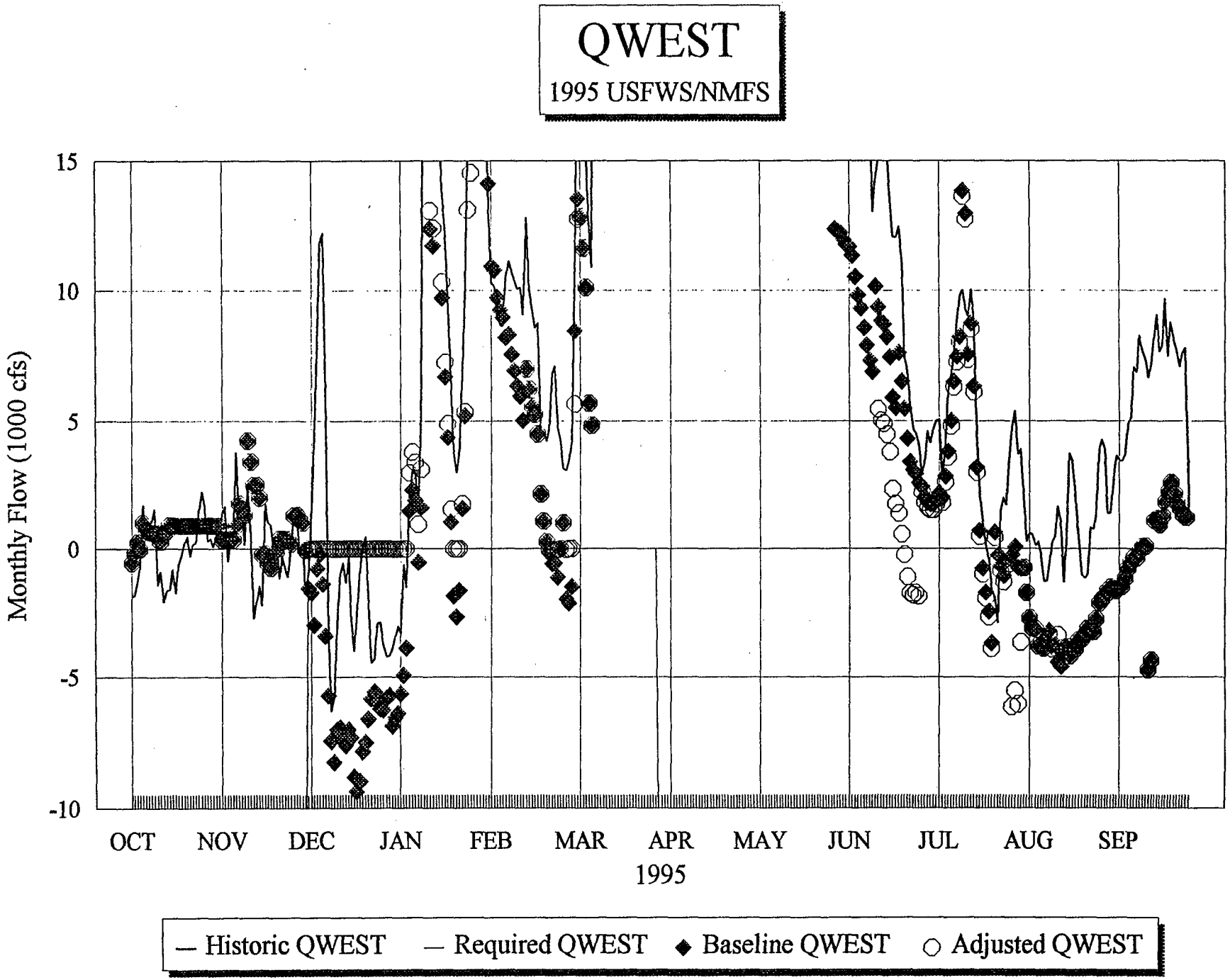
■ Historic Cl ◇ Baseline Cl ---- Adjusted Cl

D—016097



D-016098

D-016098



D-016099

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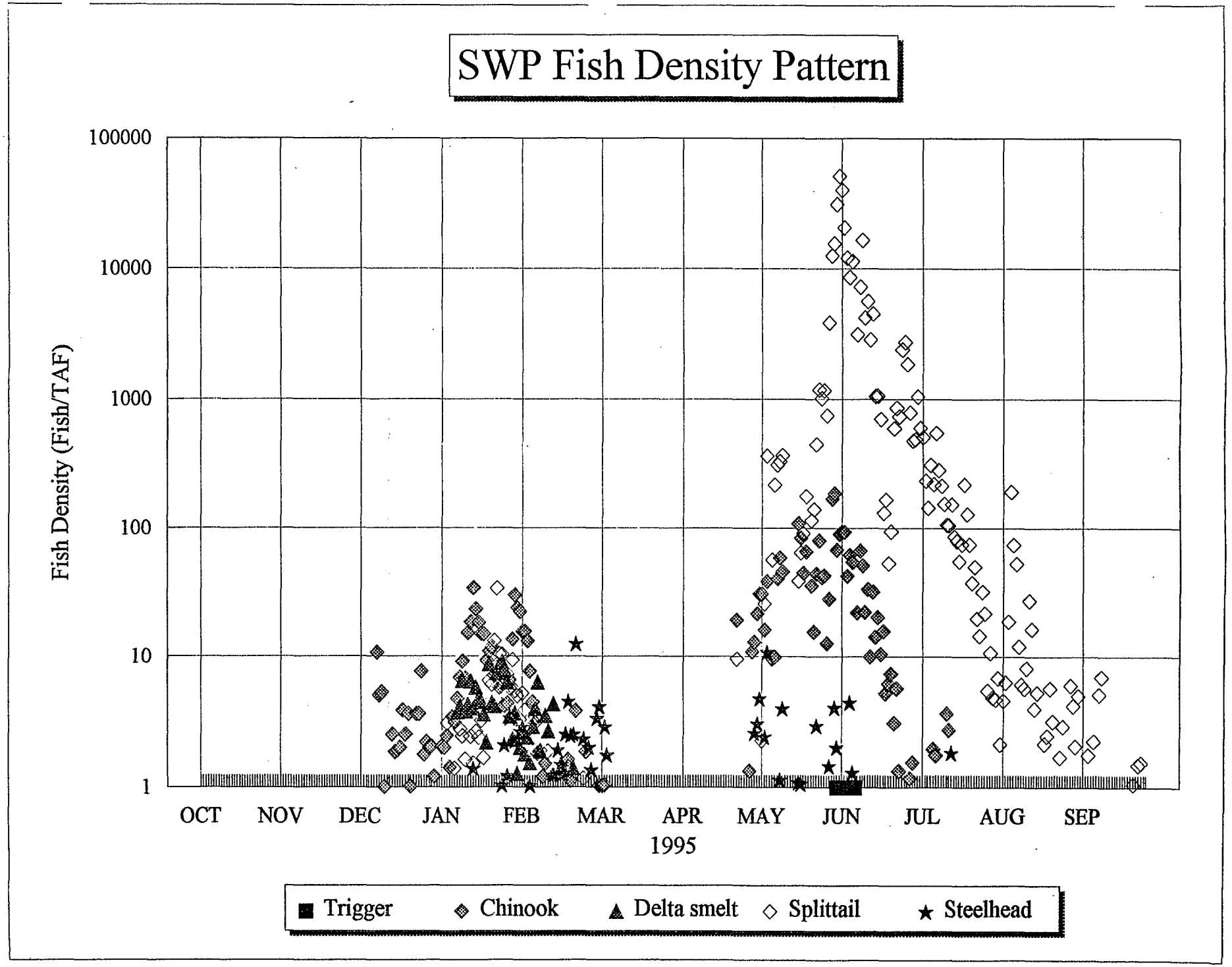
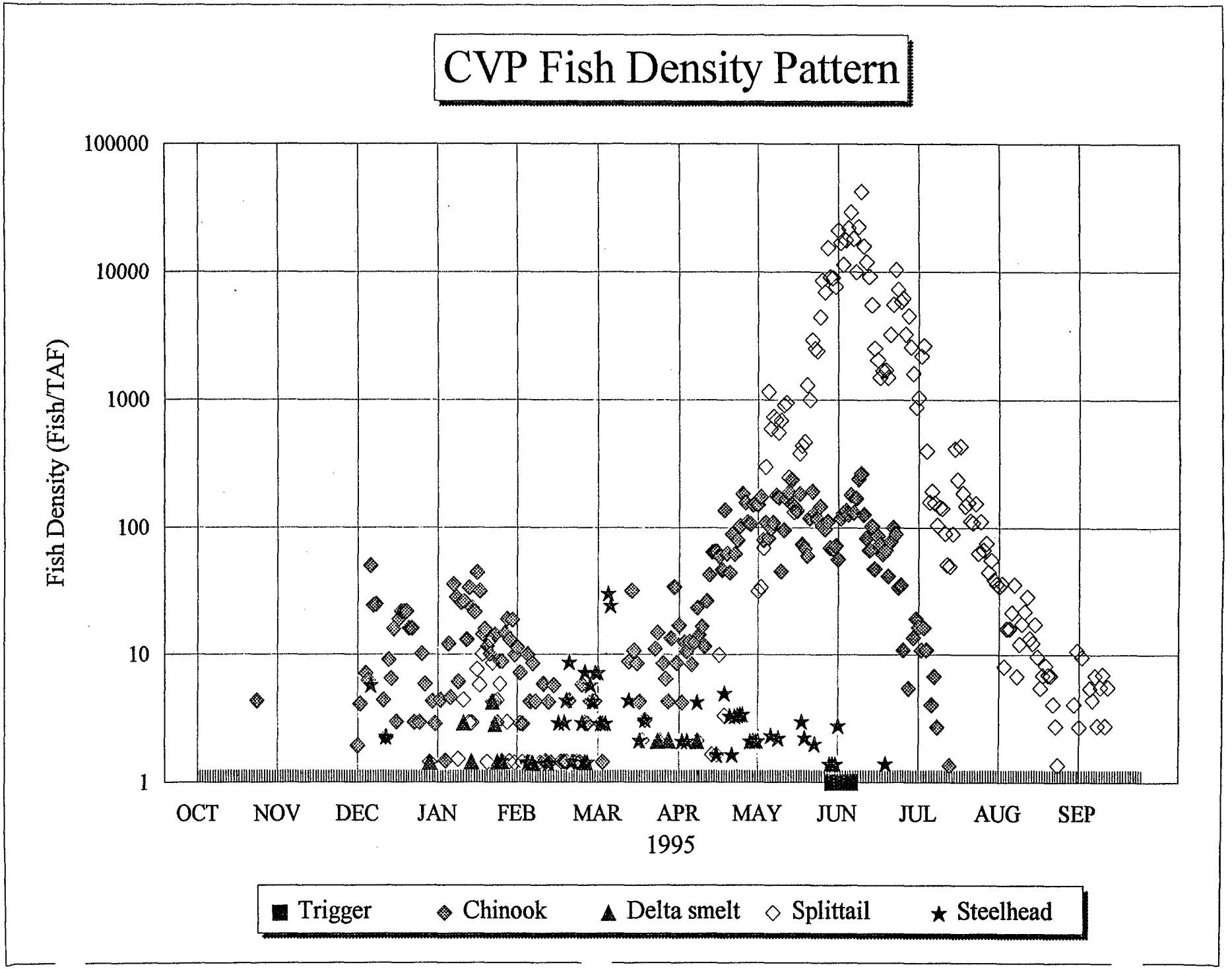


D-016100

D-016100



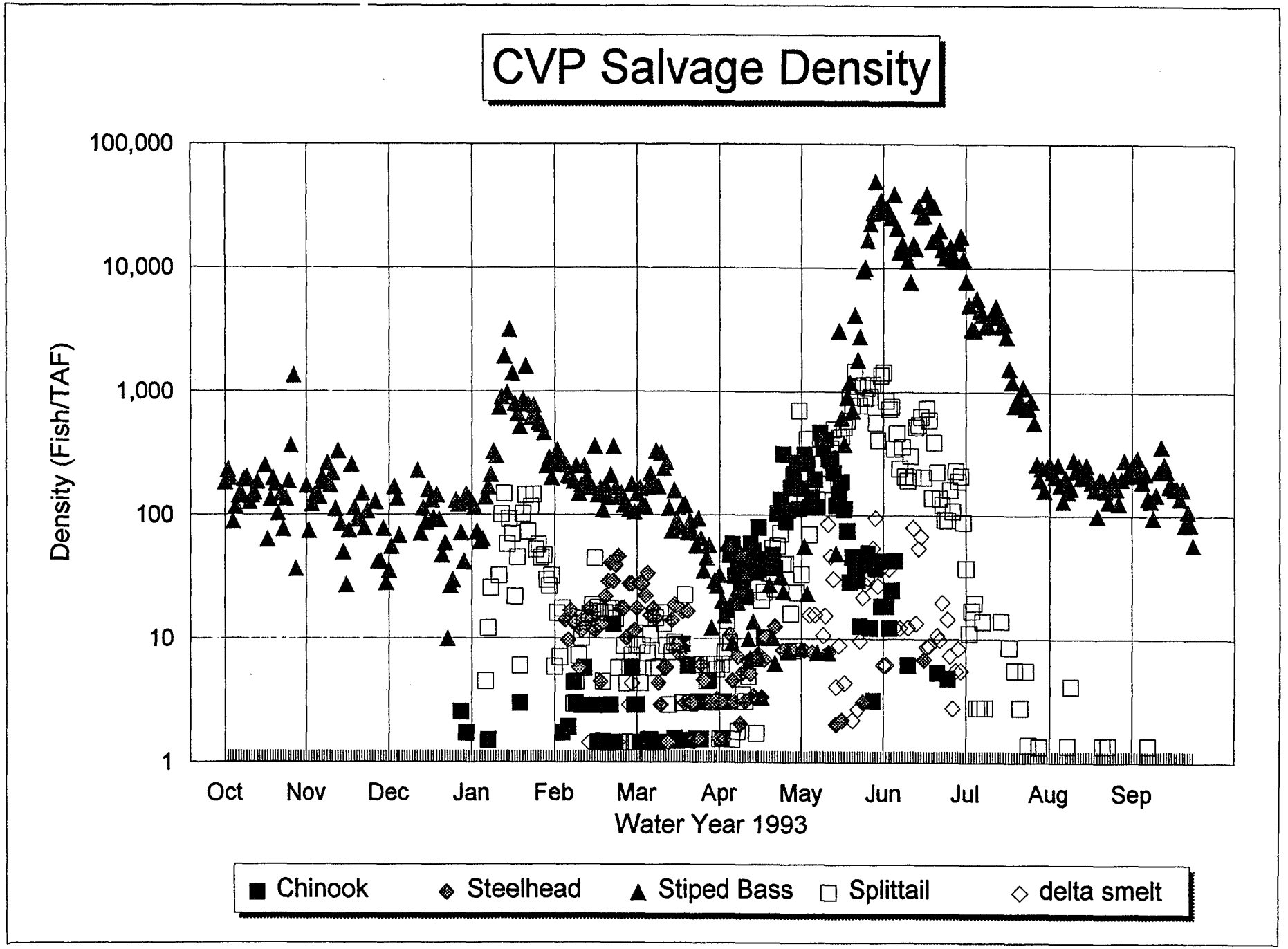
D-016101

D-016101

DEFT 10/1/98
Russ Brown

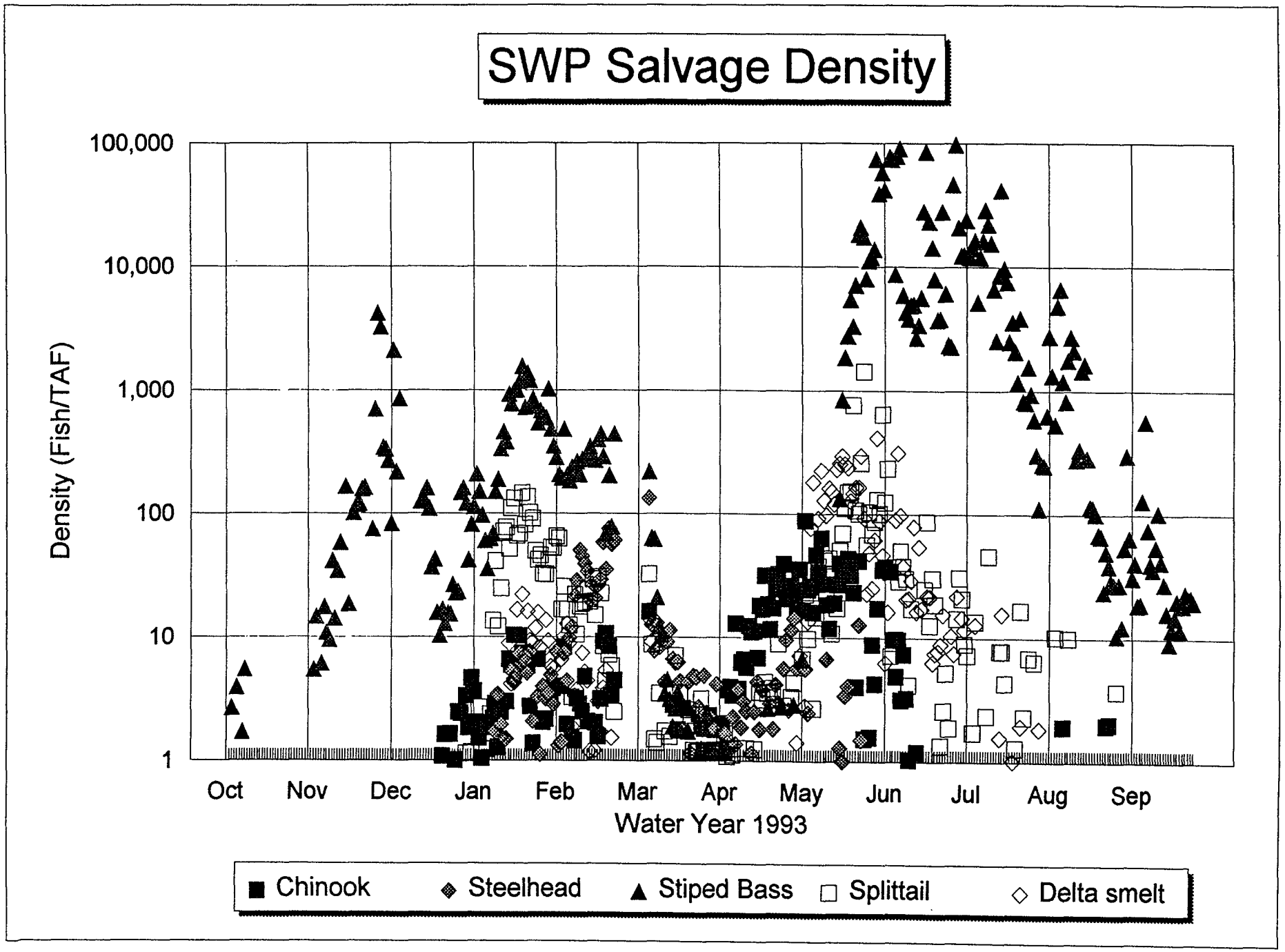
Analysis of Daily Salvage Records for Delta Smelt, Striped Bass, Splittail, Salmon, and Steelhead at the CVP and SWP Pumping Facilities

- Eliminate days with less than 100 cfs pumping
- Calculate density = Salvage / Pumping (Fish/TAF)
- Select density trigger for reduced pumping
- Calculate fish saved with a 3-day moving average trigger with 1 day delay
- Report monthly statistics (density, percent occurrence, days of missing density, days of fish occurrence, days with reduced pumping, density of fish saved)



D-016103

D-016103



D-016104

D-016104

Average Delta Smelt Density (Fish/TAF) at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
1980	95	2	NA	NA	24	39	18	3	7	9	1	8	17
1981	58	14	29	39	64	45	10	532	254	201	200	16	123
1982	10	33	0	22	31	16	1	4	16	0	2	7	12
1983	5	2	0	8	2	0	0	0	10	4	0	0	3
1984	0	0	6	0	0	6	0	113	33	0	3	0	14
1985	1	1	10	1	1	0	1	31	10	14	8	2	7
1986	0	0	0	2	2	0	0	0	1	1	5	0	1
1987	1	0	0	0	0	3	72	69	0	0	0	1	12
1988	0	0	6	7	1	0	0	20	11	0	0	0	4
1989	1	0	0	0	0	0	16	18	1	3	1	1	3
1990	0	0	0	0	0	0	21	33	6	1	0	0	5
1991	0	0	1	2	0	1	3	8	0	0	0	5	2
1992	0	0	0	0	0	2	2	1	0	0	0	0	0
1993	0	0	0	0	0	0	0	11	22	1	0	0	3
1994	0	0	0	0	1	1	8	254	73	0	0	0	28
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	4	2	1	0	213	4	0	0	0	19
Avg	10	3	3	5	8	7	9	77	26	14	13	2	15

Average Percent Occurrence of Delta Smelt by Month at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sum
1980	47	1	NA	NA	11	19	8	2	3	4	1	4	100
1981	4	1	2	3	4	3	1	37	17	14	14	1	100
1982	7	24	0	16	21	12	0	3	11	0	1	5	100
1983	17	6	0	24	6	0	1	1	30	13	0	1	100
1984	0	0	4	0	0	4	0	70	20	0	2	0	100
1985	1	1	13	1	1	0	1	40	12	18	10	2	100
1986	3	0	0	17	17	0	0	0	6	10	47	0	100
1987	1	0	0	0	0	2	48	48	0	0	0	1	100
1988	0	0	13	17	2	0	0	44	24	0	0	0	100
1989	1	0	1	0	0	0	38	44	3	7	4	2	100
1990	1	0	0	0	0	0	33	55	10	2	0	0	100
1991	0	0	5	8	0	5	16	41	0	0	0	25	100
1992	0	0	0	0	7	31	34	29	0	0	0	0	100
1993	0	0	0	0	0	1	0	32	64	3	0	0	100
1994	0	0	0	0	0	0	2	76	21	0	0	0	100
1995	0	0	6	57	11	10	17	0	0	0	0	0	100
1996	0	0	0	2	1	0	0	95	2	0	0	0	100
Avg	5	2	3	9	5	5	12	36	13	4	5	2	

Number of Days with Missing Data for CVP Fish Screens (i.e., Number of Days with Pumping < 100 cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	20	31	31	1	0	0	0	0	0	0	0	83
1981	0	0	0	0	0	0	0	0	1	0	0	0	1
1982	0	1	18	0	0	0	0	0	0	0	0	0	19
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	4	1	0	0	0	0	0	0	0	0	0	5
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	2	0	0	0	0	0	0	0	0	2
1992	0	0	0	0	3	0	0	0	0	0	0	0	3
1993	5	2	6	0	0	0	0	0	0	0	0	0	13
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	5	0	0	0	0	0	0	5
1996	0	0	0	0	0	12	0	0	0	0	0	0	12
Avg	0	2	3	2	0	1	0	0	0	0	0	0	8

Number of Days with Delta Smelt Density Greater than 0 at CVP Fish Screens

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	5	1	NA	NA	10	19	9	2	1	8	2	9	66
1981	23	10	15	22	26	17	10	26	12	13	22	7	203
1982	2	4	0	4	15	10	1	1	2	0	1	3	43
1983	6	2	0	8	1	0	1	1	3	1	0	1	24
1984	0	0	1	0	0	1	1	10	10	0	4	0	27
1985	1	1	1	2	2	1	1	20	7	6	5	2	49
1986	1	0	0	8	11	1	0	0	1	1	6	0	29
1987	1	0	0	0	0	2	22	14	0	0	0	2	41
1988	0	1	6	6	2	0	0	10	6	0	0	0	31
1989	1	0	1	0	0	0	9	12	1	1	3	2	30
1990	1	0	0	0	0	0	12	17	3	1	0	0	34
1991	0	0	1	2	0	2	6	6	0	0	0	1	18
1992	0	0	0	0	1	8	1	2	0	0	0	0	12
1993	0	0	0	0	3	2	0	17	23	5	0	0	50
1994	0	0	0	0	7	7	5	31	25	1	0	0	76
1995	0	0	1	6	2	1	2	0	0	0	0	0	12
1996	0	0	0	17	20	2	7	27	22	5	0	0	100
Avg	2	1	2	5	6	4	5	12	7	2	3	2	50

Number of Days with Reduced CVP Pumping for the Purpose of Saving Delta Smelt
Using a Threshold of 140 Fish/TAF for the Average Density of the Previous 3 Days

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	3	0	NA	NA	0	0	0	0	0	0	0	0	3
1981	0	0	0	2	2	0	0	17	10	8	17	0	56
1982	0	3	2	1	0	0	0	0	0	0	0	0	6
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	10	3	0	0	0	13
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	6	6	0	0	0	0	12
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	26	7	0	0	0	33
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	6	0	0	0	0	6
Avg	0	0	0	0	0	0	0	4	1	0	1	0	8

Average Density of Delta Smelt Saved (Fish/TAF) at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Percent Saved
1980	0	0	NA	NA	0	0	0	0	0	0	0	0	0
1981	0	0	0	4	5	0	0	447	210	145	169	0	67
1982	0	11	0	0	0	0	0	0	0	0	0	0	8
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	63	0	0	0	0	39
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	11	43	0	0	0	0	37
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	201	44	0	0	0	73
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	142	0	0	0	0	64
Avg	0	1	0	0	0	0	1	53	15	9	10	0	50

Average Striped Bass Density (Fish/TAF) at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
1980	304	448	NA	NA	70	16	40	11	961	2325	457	302	413
1981	319	611	299	103	150	88	106	7577	28406	2734	384	255	3403
1982	350	454	379	479	323	82	125	50	1254	3532	1332	287	726
1983	164	265	168	121	97	29	25	15	94	82	284	74	118
1984	9	49	51	37	13	6	30	1142	9616	6520	519	157	1510
1985	913	465	354	121	92	41	51	706	3692	2001	372	88	743
1986	55	88	148	215	757	68	14	124	14498	5027	923	372	1846
1987	191	306	124	150	104	73	50	6697	4392	283	81	69	1049
1988	23	21	86	110	175	81	32	82	2294	641	171	66	313
1989	32	19	107	110	150	60	33	902	5109	909	103	62	630
1990	48	16	18	33	67	92	16	853	2811	1759	425	128	523
1991	31	18	113	116	142	120	114	397	13862	9956	749	156	2149
1992	56	31	42	76	814	202	24	23781	9785	1270	109	96	3042
1993	206	132	92	655	207	136	21	1690	23806	5230	214	185	2699
1994	93	82	55	67	75	70	39	378	12070	3322	187	64	1367
1995	47	35	41	433	135	64	12	12	72	223	122	107	109
1996	63	33	38	24	32	1	9	9	214	138	51	32	54
Avg	171	181	132	178	200	72	44	2613	7820	2703	381	147	1217

Average Percent Occurrence of Striped Bass by Month at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sum
1980	6	9	NA	NA	1	0	1	0	19	48	9	6	100
1981	1	1	1	0	0	0	0	19	69	7	1	1	100
1982	4	5	4	6	3	1	1	1	14	41	16	3	100
1983	12	18	12	9	6	2	2	1	7	6	20	5	100
1984	0	0	0	0	0	0	0	6	52	37	3	1	100
1985	10	5	4	1	1	0	1	8	41	23	4	1	100
1986	0	0	1	1	3	0	0	1	65	23	4	2	100
1987	2	2	1	1	1	1	0	54	34	2	1	1	100
1988	1	1	2	3	4	2	1	2	60	17	5	2	100
1989	0	0	1	1	2	1	0	12	67	12	1	1	100
1990	1	0	0	1	1	1	0	14	44	29	7	2	100
1991	0	0	0	0	1	0	0	2	53	39	3	1	100
1992	0	0	0	0	2	1	0	66	26	4	0	0	100
1993	1	0	0	2	1	0	0	5	73	16	1	1	100
1994	1	0	0	0	0	0	0	2	73	21	1	0	100
1995	4	3	3	34	10	5	1	1	5	17	10	8	100
1996	10	5	6	4	5	0	1	1	33	22	8	5	100
Avg	3	3	2	4	2	1	1	12	43	21	6	2	

Number of Days with Missing Data for CVP Fish Screens (i.e., Number of Days with Pumping < 100 cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	20	31	31	1	0	0	0	0	0	0	0	83
1981	0	0	0	0	0	0	0	0	1	0	0	0	1
1982	0	1	18	0	0	0	0	0	0	0	0	0	19
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	4	1	0	0	0	0	0	0	0	0	0	5
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	2	0	0	0	0	0	0	0	0	2
1992	0	0	0	0	3	0	0	0	0	0	0	0	3
1993	5	2	6	0	0	0	0	0	0	0	0	0	13
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	5	0	0	0	0	0	0	5
1996	0	0	0	0	0	12	0	0	0	0	0	0	12
Avg	0	2	3	2	0	1	0	0	0	0	0	0	8

Number of Days with Striped Bass Density Greater than 0 at CVP Fish Screens

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	31	10	NA	NA	24	12	16	5	26	31	31	29	215
1981	31	30	31	30	28	29	30	29	29	31	31	30	359
1982	31	20	12	31	28	28	27	19	27	31	31	29	314
1983	31	30	30	27	26	28	17	7	10	7	29	25	267
1984	13	17	23	19	18	11	17	24	30	31	31	30	264
1985	31	30	31	31	28	29	27	30	30	31	31	30	359
1986	30	30	31	31	28	27	18	22	30	31	31	30	339
1987	31	30	31	31	26	26	27	31	30	31	31	29	354
1988	24	25	27	28	29	31	27	26	30	31	31	28	337
1989	28	17	31	31	28	29	25	31	30	31	31	30	342
1990	30	22	22	29	28	30	26	25	30	31	31	30	334
1991	16	23	25	26	27	31	27	23	30	31	30	29	318
1992	22	19	24	29	26	31	15	25	30	31	27	27	306
1993	26	28	25	31	28	31	26	19	30	31	31	30	336
1994	31	30	31	31	28	29	27	18	30	31	31	30	347
1995	27	26	31	31	28	26	25	20	19	31	31	30	325
1996	31	30	31	31	27	6	19	14	30	31	31	30	311
Avg	27	25	27	29	27	26	23	22	28	30	31	29	319

Number of Days with Reduced CVP Pumping for the Purpose of Saving Striped Bass
Using a Threshold of 12,500 Fish/TAF for the Average Density of the Previous 3 Days

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	NA	NA	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	5	30	3	0	0	38
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	10	10	0	0	20
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	14	4	0	0	18
1987	0	0	0	0	0	0	0	4	0	0	0	0	4
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	15	16	0	0	31
1992	0	0	0	0	0	0	0	15	11	0	0	0	26
1993	0	0	0	0	0	0	0	0	27	8	0	0	35
1994	0	0	0	0	0	0	0	0	15	0	0	0	15
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg	0	0	0	0	0	0	0	1	7	2	0	0	11

Average Density of Striped Bass Saved (Fish/TAF) at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Percent Saved
1980	0	0	NA	NA	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	4624	25566	952	0	0	75
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	4901	4592	0	0	52
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	8450	1434	0	0	44
1987	0	0	0	0	0	0	0	1543	0	0	0	0	12
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	8241	7608	0	0	62
1992	0	0	0	0	0	0	0	19123	6081	0	0	0	70
1993	0	0	0	0	0	0	0	0	19829	2845	0	0	69
1994	0	0	0	0	0	0	0	0	8285	0	0	0	50
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg	0	0	0	0	0	0	0	1488	4785	1025	0	0	50

Average Splittail Density (Fish/TAF) at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
1980	0	0	NA	NA	1	3	10	850	314	114	9	1	109
1981	1	0	1	1	7	3	28	455	162	9	4	0	56
1982	0	0	0	0	42	24	11	33	364	647	105	14	104
1983	1	0	8	7	54	40	17	271	1020	219	103	18	146
1984	5	0	1	1	16	29	11	52	214	54	9	0	32
1985	0	0	0	0	7	13	7	17	46	36	13	2	12
1986	0	6	0	0	6	23	188	5017	1162	64	10	10	547
1987	3	2	0	3	11	13	9	18	4	1	1	1	5
1988	0	0	1	10	3	6	13	13	14	4	0	0	5
1989	0	0	0	1	3	13	16	26	12	0	0	0	6
1990	0	0	0	0	0	11	6	5	132	13	0	0	14
1991	0	0	0	5	1	15	12	13	71	2	0	0	10
1992	0	0	0	2	10	8	1	7	56	0	1	0	7
1993	0	0	0	47	12	7	17	459	498	36	0	0	90
1994	0	0	0	0	1	2	0	1	21	2	0	0	2
1995	0	0	0	3	0	0	1	1030	11504	930	22	2	1114
1996	3	1	1	1	4	0	10	215	70	13	4	1	27
Avg	1	1	1	5	11	12	21	499	921	126	16	3	135

Average Percent Occurrence of Splittail by Month at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sum
1980	0	0	NA	NA	0	0	1	66	24	9	1	0	100
1981	0	0	0	0	1	0	4	69	24	1	1	0	100
1982	0	0	0	0	3	2	1	3	29	53	9	1	100
1983	0	0	0	0	3	2	1	16	57	13	6	1	100
1984	1	0	0	0	4	8	3	13	54	14	2	0	100
1985	0	0	0	0	5	9	5	13	32	26	9	1	100
1986	0	0	0	0	0	0	3	78	17	1	0	0	100
1987	5	3	1	5	15	21	13	28	6	1	1	1	100
1988	0	0	1	16	4	10	19	21	22	7	0	0	100
1989	0	0	0	1	4	18	22	38	16	0	0	0	100
1990	0	0	0	0	0	7	4	3	79	8	0	0	100
1991	0	0	0	4	1	13	10	11	59	2	0	0	100
1992	0	0	0	2	11	10	1	9	66	0	1	0	100
1993	0	0	0	4	1	1	2	43	45	3	0	0	100
1994	0	0	0	0	3	6	1	5	77	7	0	0	100
1995	0	0	0	0	0	0	0	8	85	7	0	0	100
1996	1	0	0	0	1	0	3	67	21	4	1	0	100
Avg	0	0	0	2	3	6	5	29	42	9	2	0	

Number of Days with Missing Data for CVP Fish Screens (i.e., Number of Days with Pumping < 100 cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	20	31	31	1	0	0	0	0	0	0	0	83
1981	0	0	0	0	0	0	0	0	1	0	0	0	1
1982	0	1	18	0	0	0	0	0	0	0	0	0	19
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	4	1	0	0	0	0	0	0	0	0	0	5
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	2	0	0	0	0	0	0	0	0	2
1992	0	0	0	0	3	0	0	0	0	0	0	0	3
1993	5	2	6	0	0	0	0	0	0	0	0	0	13
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	5	0	0	0	0	0	0	5
1996	0	0	0	0	0	12	0	0	0	0	0	0	12
Avg	0	2	3	2	0	1	0	0	0	0	0	0	8

Number of Days with Splittail Density Greater than 0 at CVP Fish Screens

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	NA	NA	1	3	10	25	27	29	8	1	104
1981	1	0	1	3	11	3	18	17	20	7	5	0	86
1982	0	0	0	0	17	16	7	6	9	31	28	4	118
1983	1	0	4	6	25	27	14	22	30	27	22	12	190
1984	5	1	1	1	17	26	10	17	19	17	8	0	122
1985	0	0	0	1	8	22	8	14	19	9	8	2	91
1986	1	3	0	3	16	19	21	31	30	27	14	10	175
1987	2	2	1	6	9	8	15	20	5	2	2	2	74
1988	0	0	1	10	5	7	16	12	14	3	0	0	68
1989	0	0	0	3	5	16	19	20	5	1	0	0	69
1990	0	0	0	0	0	15	11	4	26	8	0	0	64
1991	0	0	0	2	1	17	15	5	18	3	0	0	61
1992	0	0	1	1	8	7	7	5	2	0	1	0	32
1993	0	0	0	23	25	30	26	31	30	20	5	1	191
1994	0	1	0	0	11	12	3	5	22	11	0	0	65
1995	0	0	0	16	8	1	5	26	30	31	30	12	159
1996	18	14	11	14	19	0	23	31	30	31	26	15	232
Avg	2	1	1	6	11	13	13	17	20	15	9	3	112

Number of Days with Reduced CVP Pumping for the Purpose of Saving Splittail
Using a Threshold of 3,300 Fish/TAF for the Average Density of the Previous 3 Days

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	NA	NA	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	1	0	0	0	1
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	17	3	0	0	0	20
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	25	5	0	0	30
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg	0	0	0	0	0	0	0	1	2	0	0	0	3

Average Density of Splittail Saved (Fish/TAF) at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Percent Saved
1980	0	0	NA	NA	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	67	0	0	0	4
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	3121	266	0	0	0	52
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	9941	531	0	0	77
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg	0	0	0	0	0	0	0	184	604	31	0	0	50

Average Salmon Density (Fish/TAF) at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
1980	0	11	NA	NA	1	2	408	281	46	4	0	0	62
1981	1	6	1	0	0	23	108	149	25	0	0	0	26
1982	23	3	129	24	25	52	31	544	379	6	1	0	102
1983	0	74	69	25	19	26	224	659	176	4	0	0	107
1984	14	4	1	2	0	34	363	414	10	4	0	0	71
1985	44	30	21	0	32	19	207	328	9	0	0	0	58
1986	33	19	21	8	1847	185	351	996	242	37	0	0	301
1987	3	0	4	1	2	20	178	203	0	0	0	0	35
1988	0	0	10	15	9	6	100	118	1	0	0	0	22
1989	0	0	1	0	0	24	57	163	13	0	0	0	22
1990	0	0	0	0	0	0	8	19	4	0	0	0	3
1991	0	0	0	0	1	10	133	96	6	0	0	0	21
1992	0	22	2	3	18	71	296	36	0	0	0	0	37
1993	0	0	0	0	2	1	46	165	8	0	0	0	19
1994	0	2	4	2	13	12	52	12	0	0	0	0	8
1995	0	0	10	15	3	5	45	131	103	4	0	0	26
1996	1	0	1	3	5	2	142	175	12	0	0	0	28
Avg	7	10	17	6	116	29	162	264	61	3	0	0	56

Average Percent Occurrence of Salmon by Month at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sum
1980	0	1	NA	NA	0	0	54	38	6	1	0	0	100
1981	0	2	0	0	0	7	34	48	8	0	0	0	100
1982	2	0	11	2	2	4	3	45	31	0	0	0	100
1983	0	6	5	2	1	2	17	52	14	0	0	0	100
1984	2	0	0	0	0	4	42	50	1	0	0	0	100
1985	7	4	3	0	4	3	30	48	1	0	0	0	100
1986	1	1	1	0	47	5	10	28	7	1	0	0	100
1987	1	0	1	0	1	5	42	50	0	0	0	0	100
1988	0	0	4	6	3	2	38	46	0	0	0	0	100
1989	0	0	0	0	0	9	22	63	5	0	0	0	100
1990	0	0	0	1	1	1	25	60	12	0	0	0	100
1991	0	0	0	0	0	4	53	40	2	0	0	0	100
1992	0	5	0	1	4	16	66	8	0	0	0	0	100
1993	0	0	0	0	1	1	20	75	4	0	0	0	100
1994	0	2	5	2	12	13	54	12	0	0	0	0	100
1995	0	0	3	5	1	2	14	42	32	1	0	0	100
1996	0	0	0	1	1	1	41	52	3	0	0	0	100
Avg	1	1	2	1	5	5	33	45	7	0	0	0	

Number of Days with Missing Data for CVP Fish Screens (i.e., Number of Days with Pumping < 100 cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	20	31	31	1	0	0	0	0	0	0	0	83
1981	0	0	0	0	0	0	0	0	1	0	0	0	1
1982	0	1	18	0	0	0	0	0	0	0	0	0	19
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	4	1	0	0	0	0	0	0	0	0	0	5
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	2	0	0	0	0	0	0	0	0	2
1992	0	0	0	0	3	0	0	0	0	0	0	0	3
1993	5	2	6	0	0	0	0	0	0	0	0	0	13
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	5	0	0	0	0	0	0	5
1996	0	0	0	0	0	12	0	0	0	0	0	0	12
Avg	0	2	3	2	0	1	0	0	0	0	0	0	8

Number of Days with Salmon Density Greater than 0 at CVP Fish Screens

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	2	NA	NA	1	2	30	30	18	3	0	0	86
1981	1	7	2	1	0	13	25	25	6	0	0	0	80
1982	5	2	10	12	10	25	19	31	21	2	1	0	138
1983	0	17	26	13	14	24	30	31	25	5	0	0	185
1984	8	3	1	2	0	22	30	31	4	1	0	0	102
1985	10	16	13	0	14	26	29	30	6	1	0	0	145
1986	13	11	20	21	26	27	29	31	23	1	0	0	202
1987	1	1	6	3	4	14	25	23	0	0	0	0	77
1988	0	0	10	10	13	10	24	25	3	1	0	0	96
1989	0	0	2	1	0	19	26	21	9	0	0	0	78
1990	0	0	0	1	1	1	13	23	6	0	0	0	45
1991	0	0	0	0	1	13	28	26	3	0	0	0	71
1992	0	10	3	7	12	25	30	15	0	0	0	0	102
1993	0	0	2	2	14	16	26	31	13	0	0	0	104
1994	1	17	26	10	28	27	30	17	2	0	0	0	158
1995	1	0	25	29	21	16	30	31	30	12	0	0	195
1996	7	0	8	18	24	6	29	31	19	0	0	0	142
Avg	3	5	10	8	11	17	27	27	11	2	0	0	118

Number of Days with Reduced CVP Pumping for the Purpose of Saving Salmon
Using a Threshold of 350 Fish/TAF for the Average Density of the Previous 3 Days

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	NA	NA	0	0	20	12	0	0	0	0	32
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	13	8	0	0	0	21
1983	0	0	0	0	0	0	5	30	8	0	0	0	43
1984	0	0	0	0	0	0	14	21	0	0	0	0	35
1985	0	0	0	0	0	0	0	15	0	0	0	0	15
1986	0	0	0	0	13	5	8	29	7	3	0	0	65
1987	0	0	0	0	0	0	2	10	0	0	0	0	12
1988	0	0	0	0	0	0	1	5	0	0	0	0	6
1989	0	0	0	0	0	0	0	5	0	0	0	0	5
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	2	0	0	0	0	0	2
1992	0	0	0	0	0	0	9	0	0	0	0	0	9
1993	0	0	0	0	0	0	0	1	0	0	0	0	1
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	3	0	0	0	0	3
Avg	0	0	0	0	1	0	4	8	1	0	0	0	15

Average Density of Salmon Saved (Fish/TAF) at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Percent Saved
1980	0	0	NA	NA	0	0	299	158	0	0	0	0	61
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	337	262	0	0	0	53
1983	0	0	0	0	0	0	70	579	91	0	0	0	58
1984	0	0	0	0	0	0	177	288	0	0	0	0	55
1985	0	0	0	0	0	0	0	200	0	0	0	0	29
1986	0	0	0	0	1492	72	236	830	188	0	0	0	75
1987	0	0	0	0	0	0	34	165	0	0	0	0	49
1988	0	0	0	0	0	0	15	27	0	0	0	0	17
1989	0	0	0	0	0	0	0	54	0	0	0	0	21
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	7	0	0	0	0	0	3
1992	0	0	0	0	0	0	120	0	0	0	0	0	27
1993	0	0	0	0	0	0	0	8	0	0	0	0	4
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	30	0	0	0	0	9
Avg	0	0	0	0	88	4	56	157	32	0	0	0	50

Average Steelhead Density (Fish/TAF) at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
1980	0	0	NA	NA	0	0	3	1	0	0	0	0	0
1981	0	0	1	1	6	6	1	1	0	0	0	0	1
1982	0	0	0	0	0	0	0	1	0	0	0	0	0
1983	0	0	10	0	0	0	0	0	0	0	0	0	1
1984	0	0	0	0	0	1	1	0	0	0	0	0	0
1985	0	0	0	0	0	1	1	1	0	0	0	0	0
1986	0	0	0	0	2	1	3	1	0	0	0	0	1
1987	0	0	0	1	0	6	3	1	0	0	0	0	1
1988	0	0	0	1	0	2	4	9	0	0	0	0	1
1989	0	0	1	0	1	20	13	8	0	0	0	0	4
1990	0	0	0	0	5	8	3	0	0	0	0	0	1
1991	0	0	0	1	1	18	6	1	0	0	0	0	2
1992	0	0	0	19	8	11	2	0	0	0	0	0	3
1993	0	0	0	0	15	12	4	1	0	0	0	0	3
1994	0	0	0	1	3	2	1	1	0	0	0	0	1
1995	0	0	0	0	1	4	1	1	0	0	0	0	1
1996	0	0	0	4	4	0	2	1	0	0	0	0	1
Avg	0	0	1	2	3	5	3	2	0	0	0	0	1

Average Percent Occurrence of Steelhead by Month at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sum
1980	0	0	NA	NA	0	11	72	17	0	0	0	0	100
1981	0	0	7	6	32	41	5	9	0	0	0	0	100
1982	0	0	0	0	0	0	0	100	0	0	0	0	100
1983	0	0	100	0	0	0	0	0	0	0	0	0	100
1984	0	9	0	0	0	28	38	25	0	0	0	0	100
1985	0	0	0	0	16	25	30	29	0	0	0	0	100
1986	0	0	0	2	30	8	38	17	3	2	0	0	100
1987	0	0	0	5	4	52	26	12	0	0	0	0	100
1988	0	0	0	6	0	12	26	56	0	0	0	0	100
1989	0	0	1	0	2	47	30	19	0	0	0	0	100
1990	0	0	0	0	27	54	19	0	0	0	0	0	100
1991	0	0	0	3	3	68	23	3	0	0	0	0	100
1992	0	0	0	47	20	27	5	0	0	0	0	0	100
1993	0	0	0	0	44	39	13	4	1	0	0	0	100
1994	0	0	1	7	37	29	16	8	3	0	0	0	100
1995	0	0	4	1	15	53	15	9	4	0	0	0	100
1996	0	0	0	38	34	4	19	5	0	0	0	0	100
Avg	0	1	7	7	16	29	22	18	1	0	0	0	

Number of Days with Missing Data for CVP Fish Screens (i.e., Number of Days with Pumping < 100 cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	20	31	31	1	0	0	0	0	0	0	0	83
1981	0	0	0	0	0	0	0	0	1	0	0	0	1
1982	0	1	18	0	0	0	0	0	0	0	0	0	19
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	4	1	0	0	0	0	0	0	0	0	0	5
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	2	0	0	0	0	0	0	0	0	2
1992	0	0	0	0	3	0	0	0	0	0	0	0	3
1993	5	2	6	0	0	0	0	0	0	0	0	0	13
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	5	0	0	0	0	0	0	5
1996	0	0	0	0	0	12	0	0	0	0	0	0	12
Avg	0	2	3	2	0	1	0	0	0	0	0	0	8

Number of Days with Steelhead Density Greater than 0 at CVP Fish Screens

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	NA	NA	0	1	3	1	0	0	0	0	5
1981	0	0	3	2	9	7	1	1	0	0	0	0	23
1982	0	0	0	0	0	0	0	1	0	0	0	0	1
1983	0	0	6	0	0	0	0	0	0	0	0	0	6
1984	0	1	0	0	0	1	2	1	0	0	0	0	5
1985	0	0	0	0	1	1	1	4	0	0	0	0	7
1986	0	0	0	2	10	5	18	7	2	1	0	0	45
1987	0	0	0	2	1	4	6	5	0	0	0	0	18
1988	0	0	0	1	0	3	9	11	0	0	0	0	24
1989	0	0	1	0	1	16	13	9	0	0	0	0	40
1990	0	0	0	0	11	15	10	0	0	0	0	0	36
1991	0	0	0	2	2	20	10	2	0	0	0	0	36
1992	0	0	0	2	10	20	9	0	0	0	0	0	41
1993	0	0	0	0	23	30	23	7	1	0	0	0	84
1994	0	0	1	3	20	15	8	2	1	0	0	0	50
1995	0	0	2	1	9	13	11	9	5	0	0	0	50
1996	0	0	0	16	16	2	15	5	1	0	0	0	55
Avg	0	0	1	2	7	9	8	4	1	0	0	0	31

Number of Days with Reduced CVP Pumping for the Purpose of Saving Steelhead
Using a Threshold of 6 Fish/TAF for the Average Density of the Previous 3 Days

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	NA	NA	0	0	6	6	0	0	0	0	12
1981	0	0	1	0	11	15	3	3	0	0	0	0	33
1982	0	0	0	0	0	0	0	3	0	0	0	0	3
1983	0	0	12	0	0	0	0	0	0	0	0	0	12
1984	0	0	0	0	0	0	2	0	0	0	0	0	2
1985	0	0	0	0	0	0	0	3	0	0	0	0	3
1986	0	0	0	0	3	0	2	0	0	0	0	0	5
1987	0	0	0	0	0	8	6	3	0	0	0	0	17
1988	0	0	0	3	0	6	6	18	0	0	0	0	33
1989	0	0	0	0	3	22	20	13	0	0	0	0	58
1990	0	0	0	0	9	14	7	0	0	0	0	0	30
1991	0	0	0	1	1	21	17	3	0	0	0	0	43
1992	0	0	0	4	11	15	3	0	0	0	0	0	33
1993	0	0	0	0	21	24	2	0	0	0	0	0	47
1994	0	0	0	0	3	3	0	0	0	0	0	0	6
1995	0	0	0	0	0	5	0	0	0	0	0	0	5
1996	0	0	0	2	9	0	3	0	0	0	0	0	14
Avg	0	0	1	1	4	8	5	3	0	0	0	0	21

Average Density of Steelhead Saved (Fish/TAF) at CVP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Percent Saved
1980	0	0	NA	NA	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	2	4	0	0	0	0	0	0	39
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	5	0	0	0	0	0	0	0	0	0	48
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	4
1987	0	0	0	0	0	3	0	0	0	0	0	0	28
1988	0	0	0	0	0	0	1	8	0	0	0	0	55
1989	0	0	0	0	0	14	10	6	0	0	0	0	70
1990	0	0	0	0	3	5	1	0	0	0	0	0	55
1991	0	0	0	0	0	13	3	0	0	0	0	0	63
1992	0	0	0	9	6	6	0	0	0	0	0	0	51
1993	0	0	0	0	13	10	0	0	0	0	0	0	70
1994	0	0	0	0	1	0	0	0	0	0	0	0	12
1995	0	0	0	0	0	1	0	0	0	0	0	0	12
1996	0	0	0	1	2	0	0	0	0	0	0	0	34
Avg	0	0	0	1	2	3	1	1	0	0	0	0	50

Average Delta Smelt Density (Fish/TAF) at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
1980	1	5	0	13	0	3	3	4	76	109	27	1	20
1981	2	2	12	43	49	20	15	81	174	170	0	0	47
1982	0	2	3	17	11	5	1	0	1	12	5	0	5
1983	0	2	2	7	2	6	0	0	28	16	0	5	6
1984	0	0	0	0	0	0	0	3	13	10	0	0	2
1985	0	0	1	0	2	2	6	8	42	0	0	2	5
1986	0	0	1	3	7	9	3	1	0	1	0	0	2
1987	0	0	2	0	4	1	5	1	113	8	9	0	12
1988	0	0	18	12	1	1	0	47	361	20	0	0	38
1989	1	0	2	3	0	1	0	7	20	21	2	0	5
1990	0	1	0	1	2	1	1	23	229	180	0	0	37
1991	0	0	0	3	5	3	4	5	175	110	26	0	28
1992	2	0	0	1	2	1	0	41	38	0	0	0	7
1993	0	0	0	6	4	1	0	117	51	3	0	0	15
1994	0	0	0	0	1	0	10	226	233	18	0	0	41
1995	0	0	0	4	2	0	0	0	0	0	0	0	0
1996	0	0	0	8	5	1	0	81	38	0	0	0	11
Avg	0	1	2	7	6	3	3	38	94	40	4	1	17

Average Percent Occurrence of Delta Smelt by Month at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sum
1980	0	2	0	5	0	1	1	2	31	46	11	0	100
1981	0	0	2	8	8	4	3	14	30	30	0	0	100
1982	1	4	6	30	17	9	1	1	1	23	8	0	100
1983	0	3	3	10	3	9	0	0	40	24	0	7	100
1984	0	0	0	0	1	0	1	12	48	38	0	0	100
1985	0	0	2	1	3	3	9	14	66	0	0	3	100
1986	0	0	5	12	26	37	13	2	1	3	0	0	100
1987	0	0	1	0	2	1	3	1	79	6	6	0	100
1988	0	0	4	3	0	0	0	11	78	4	0	0	100
1989	1	0	3	5	1	1	1	13	34	37	4	1	100
1990	0	0	0	0	0	0	0	5	51	42	0	0	100
1991	0	0	0	1	2	1	1	2	52	34	8	0	100
1992	2	0	0	1	3	1	0	49	44	0	0	0	100
1993	0	0	0	3	2	1	0	65	27	2	0	0	100
1994	0	0	0	0	0	0	2	47	47	4	0	0	100
1995	0	0	3	69	25	4	0	0	0	0	0	0	100
1996	0	0	0	6	3	1	0	61	28	0	0	0	100
Avg	0	1	2	9	6	4	2	18	39	17	2	1	

Number of Days with Missing Data for SWP Fish Screens
(i.e., Number of Days with Pumping < 100 cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	0	0	9	11	0	0	0	0	0	2	22
1981	0	0	0	0	0	0	0	9	8	0	0	0	17
1982	0	0	0	0	0	0	0	0	15	11	0	0	26
1983	0	0	1	0	0	21	27	21	4	6	0	8	88
1984	18	11	17	20	0	0	0	3	0	0	0	0	69
1985	6	0	0	0	0	0	0	0	0	0	0	0	6
1986	0	0	0	0	4	20	5	1	0	0	0	0	30
1987	0	0	1	0	0	0	0	0	0	0	0	0	1
1988	2	3	3	0	0	0	0	0	0	0	0	0	8
1989	1	2	0	0	1	0	0	7	1	0	0	0	12
1990	0	0	0	0	0	0	0	8	8	0	0	0	16
1991	0	0	1	2	2	0	0	2	4	7	1	1	20
1992	0	6	6	0	6	0	1	8	2	11	1	0	41
1993	10	1	7	0	4	8	0	0	0	0	0	0	30
1994	0	3	0	0	5	1	13	9	10	2	0	5	48
1995	0	0	5	0	0	23	26	6	0	0	0	0	60
1996	0	19	29	0	1	1	0	0	1	0	0	0	51
Avg	2	3	4	1	2	5	4	4	3	2	0	1	32

Number of Days with Delta Smelt Density Greater than 0 at SWP Fish Screens

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	3	6	0	12	2	12	17	5	18	19	13	3	110
1981	3	3	10	20	24	24	17	7	2	6	0	1	117
1982	2	3	4	12	14	6	2	2	1	1	1	0	48
1983	1	1	4	18	6	5	0	0	6	5	0	4	50
1984	0	0	0	0	4	1	3	9	3	4	0	1	25
1985	0	0	2	1	8	9	10	11	9	1	0	2	53
1986	0	0	4	11	9	2	4	1	2	1	0	0	34
1987	0	1	4	2	6	4	5	1	7	7	10	2	49
1988	2	0	8	23	7	7	0	21	23	7	0	0	98
1989	1	0	3	14	8	11	2	6	5	9	3	1	63
1990	0	2	0	4	12	17	12	7	13	19	1	0	87
1991	0	0	1	9	15	23	13	12	7	12	3	0	95
1992	1	0	0	5	11	19	0	9	11	1	0	0	57
1993	0	0	0	24	24	6	0	28	26	10	1	0	119
1994	0	0	12	3	12	11	6	22	17	14	0	0	97
1995	0	0	7	28	24	3	0	0	0	0	0	0	62
1996	0	0	0	26	27	20	2	21	22	4	0	0	122
Avg	1	1	3	12	13	11	5	10	10	7	2	1	76

Number of Days with Reduced SWP Pumping for the Purpose of Saving Delta Smelt Using a Threshold of 140 Fish/TAF for the Average Density of the Previous 3 Days

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	0	0	0	0	0	0	3	7	3	0	13
1981	0	0	0	1	0	0	0	4	4	11	0	0	20
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	3	0	0	0	3
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	3	0	0	0	3
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	7	0	0	0	7
1988	0	0	0	0	0	0	0	3	24	0	0	0	27
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	15	13	0	0	28
1991	0	0	0	0	0	0	0	0	6	8	3	0	17
1992	0	0	0	0	0	0	0	5	3	0	0	0	8
1993	0	0	0	0	0	0	0	14	5	0	0	0	19
1994	0	0	0	0	0	0	0	10	12	0	0	0	22
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	9	3	0	0	0	12
Avg	0	0	0	0	0	0	0	3	5	2	0	0	11

Average Density of Delta Smelt Saved (Fish/TAF) at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Percent Saved
1980	0	0	0	0	0	0	0	0	5	14	1	0	8
1981	0	0	0	3	0	0	0	21	0	116	0	0	27
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	8	0	0	0	11
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	1	0	0	0	1
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	67	0	0	0	47
1988	0	0	0	0	0	0	0	7	316	0	0	0	70
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	108	100	0	0	47
1991	0	0	0	0	0	0	0	0	0	31	1	0	9
1992	0	0	0	0	0	0	0	17	2	0	0	0	20
1993	0	0	0	0	0	0	0	74	6	0	0	0	44
1994	0	0	0	0	0	0	0	135	145	0	0	0	55
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	43	2	0	0	0	34
Avg	0	0	0	0	0	0	0	17	39	15	0	0	36

Average Striped Bass Density (Fish/TAF) at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
1980	244	404	440	84	41	7	3	3	2857	10216	1762	343	1379
1981	54	474	670	244	103	23	5	2125	18106	7671	553	27	2501
1982	19	218	246	299	103	37	18	8	593	3715	1498	189	586
1983	118	344	532	36	21	11	0	228	127	200	222	53	159
1984	9	91	647	29	15	4	5	95	14624	12583	362	110	2380
1985	651	579	473	130	50	9	8	2085	13222	3132	331	52	1722
1986	23	486	256	116	89	19	6	408	45623	23838	1218	343	6023
1987	210	437	321	100	99	11	4	55227	48724	5488	95	65	9273
1988	2	238	631	60	140	15	1	3000	53820	23723	1432	24	6889
1989	30	428	956	64	45	21	4	8154	40197	7463	554	37	4810
1990	13	100	30	142	102	38	2	5625	10209	5344	1112	60	1905
1991	22	332	102	61	44	14	54	154	23412	6929	1316	108	2698
1992	28	99	960	122	218	81	3	11584	16530	3117	258	7	2749
1993	1	344	199	572	271	18	0	3151	32091	14631	1022	62	4356
1994	14	463	15	6	9	3	1	1897	8323	1253	61	63	1004
1995	1	381	80	218	207	20	0	2	360	2172	510	39	335
1996	12	49	7	16	6	3	0	21	1262	821	17	26	186
Avg	85	322	386	135	92	20	7	5516	19416	7782	725	95	2880

Average Percent Occurrence of Striped Bass by Month at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sum
1980	1	2	3	1	0	0	0	0	17	63	11	2	100
1981	0	2	2	1	0	0	0	7	60	26	2	0	100
1982	0	3	4	4	1	1	0	0	8	54	22	3	100
1983	6	18	28	2	1	1	0	12	7	11	12	3	100
1984	0	0	2	0	0	0	0	0	50	45	1	0	100
1985	3	3	2	1	0	0	0	10	63	15	2	0	100
1986	0	1	0	0	0	0	0	1	62	34	2	0	100
1987	0	0	0	0	0	0	0	51	43	5	0	0	100
1988	0	0	1	0	0	0	0	4	64	29	2	0	100
1989	0	1	2	0	0	0	0	14	69	13	1	0	100
1990	0	0	0	1	0	0	0	25	44	24	5	0	100
1991	0	1	0	0	0	0	0	0	71	22	4	0	100
1992	0	0	3	0	1	0	0	36	49	10	1	0	100
1993	0	1	0	1	0	0	0	6	61	29	2	0	100
1994	0	4	0	0	0	0	0	16	68	11	1	1	100
1995	0	9	2	6	5	1	0	0	9	55	13	1	100
1996	1	2	0	1	0	0	0	1	56	37	1	1	100
Avg	1	3	3	1	1	0	0	11	47	28	5	1	

Number of Days with Missing Data for SWP Fish Screens
(i.e., Number of Days with Pumping < 100 cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	0	0	9	11	0	0	0	0	0	2	22
1981	0	0	0	0	0	0	0	9	8	0	0	0	17
1982	0	0	0	0	0	0	0	0	15	11	0	0	26
1983	0	0	1	0	0	21	27	21	4	6	0	8	88
1984	18	11	17	20	0	0	0	3	0	0	0	0	69
1985	6	0	0	0	0	0	0	0	0	0	0	0	6
1986	0	0	0	0	4	20	5	1	0	0	0	0	30
1987	0	0	1	0	0	0	0	0	0	0	0	0	1
1988	2	3	3	0	0	0	0	0	0	0	0	0	8
1989	1	2	0	0	1	0	0	7	1	0	0	0	12
1990	0	0	0	0	0	0	0	8	8	0	0	0	16
1991	0	0	1	2	2	0	0	2	4	7	1	1	20
1992	0	6	6	0	6	0	1	8	2	11	1	0	41
1993	10	1	7	0	4	8	0	0	0	0	0	0	30
1994	0	3	0	0	5	1	13	9	10	2	0	5	48
1995	0	0	5	0	0	23	26	6	0	0	0	0	60
1996	0	19	29	0	1	1	0	0	1	0	0	0	51
Avg	2	3	4	1	2	5	4	4	3	2	0	1	32

Number of Days with Striped Bass Density Greater than 0 at SWP Fish Screens

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	26	30	31	31	17	13	15	10	30	31	31	28	293
1981	29	29	31	31	28	25	8	15	18	24	29	27	294
1982	27	30	31	29	28	17	13	1	6	20	31	26	259
1983	29	27	30	28	23	6	0	8	11	17	26	15	220
1984	12	18	14	9	22	16	8	15	30	31	31	30	236
1985	24	30	31	31	28	18	9	28	30	31	31	30	321
1986	28	29	31	31	23	6	5	7	30	31	31	29	281
1987	30	30	30	31	27	21	9	29	30	31	31	28	327
1988	13	23	28	31	29	22	9	18	30	31	31	27	292
1989	28	28	31	31	27	30	16	24	29	31	31	27	333
1990	27	27	28	31	28	31	20	18	18	30	29	29	316
1991	28	29	30	29	24	31	25	12	25	21	27	17	298
1992	24	20	23	30	21	31	13	17	23	17	26	27	272
1993	6	24	24	31	24	19	13	14	30	31	31	30	277
1994	30	25	31	31	23	23	3	13	17	29	31	21	277
1995	17	30	26	31	28	7	1	4	18	31	30	30	253
1996	30	11	2	31	26	24	6	21	29	31	31	29	271
Avg	24	26	27	29	25	20	10	15	24	28	30	26	284

Number of Days with Reduced SWP Pumping for the Purpose of Saving Striped Bass Using a Threshold of 12,500 Fish/TAF for the Average Density of the Previous 3 Days

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	0	0	0	0	0	0	0	11	0	0	11
1981	0	0	0	0	0	0	0	0	11	6	0	0	17
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	9	14	0	0	23
1985	0	0	0	0	0	0	0	0	13	0	0	0	13
1986	0	0	0	0	0	0	0	0	26	20	0	0	46
1987	0	0	0	0	0	0	0	16	30	4	0	0	50
1988	0	0	0	0	0	0	0	1	28	17	0	0	46
1989	0	0	0	0	0	0	0	6	29	11	0	0	46
1990	0	0	0	0	0	0	0	7	12	4	0	0	23
1991	0	0	0	0	0	0	0	0	13	5	0	0	18
1992	0	0	0	0	0	0	0	5	14	2	0	0	21
1993	0	0	0	0	0	0	0	3	17	16	0	0	36
1994	0	0	0	0	0	0	0	1	8	0	0	0	9
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg	0	0	0	0	0	0	0	2	12	6	0	0	21

Average Density of Striped Bass Saved (Fish/TAF) at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Percent Saved
1980	0	0	0	0	0	0	0	0	0	6318	0	0	39
1981	0	0	0	0	0	0	0	0	11080	3845	0	0	47
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	7367	8926	0	0	58
1985	0	0	0	0	0	0	0	0	6771	0	0	0	33
1986	0	0	0	0	0	0	0	0	39226	20136	0	0	82
1987	0	0	0	0	0	0	0	47643	43852	2536	0	0	85
1988	0	0	0	0	0	0	0	384	47319	19256	0	0	81
1989	0	0	0	0	0	0	0	2474	33673	4251	0	0	70
1990	0	0	0	0	0	0	0	2435	5303	932	0	0	35
1991	0	0	0	0	0	0	0	0	18501	1500	0	0	59
1992	0	0	0	0	0	0	0	7624	8810	0	0	0	49
1993	0	0	0	0	0	0	0	1071	20677	8180	0	0	57
1994	0	0	0	0	0	0	0	304	3041	0	0	0	25
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg	0	0	0	0	0	0	0	3643	14448	4463	0	0	66

Average Splittail Density (Fish/TAF) at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
1980	0	0	3	108	313	7	19	586	557	115	18	3	143
1981	0	0	1	3	23	15	11	11	0	0	0	0	5
1982	0	1	4	62	73	22	10	112	524	182	224	1	101
1983	0	0	2	1	9	24	0	59	575	162	69	3	75
1984	0	0	0	0	6	8	19	17	72	113	25	3	22
1985	0	1	5	1	30	10	21	19	88	11	1	1	15
1986	1	1	0	0	2	15	216	3274	2832	174	28	12	548
1987	1	0	6	2	7	11	5	22	1031	23	2	1	91
1988	0	0	9	48	42	14	13	22	63	30	1	2	20
1989	0	1	1	1	3	17	28	56	23	11	25	4	14
1990	0	0	0	3	17	9	4	37	0	1	0	0	6
1991	0	0	0	0	1	8	29	8	187	33	0	0	22
1992	1	0	0	1	7	6	2	1	2	0	0	0	2
1993	0	0	0	49	21	4	2	120	59	6	1	0	22
1994	0	1	0	0	0	0	0	1	1	0	0	0	0
1995	0	0	0	5	1	0	2	275	8734	296	16	1	769
1996	0	0	0	1	1	2	0	107	37	3	1	0	13
Avg	0	0	2	17	33	10	22	278	870	68	24	2	110

Average Percent Occurrence of Splittail by Month at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sum
1980	0	0	0	6	17	0	1	35	32	7	1	0	100
1981	0	0	2	4	34	25	17	17	0	0	0	0	100
1982	0	0	0	5	6	2	1	9	43	15	19	0	100
1983	0	0	0	0	1	3	0	7	63	18	8	0	100
1984	0	0	0	0	2	3	7	7	27	44	10	1	100
1985	0	1	3	0	15	6	11	11	47	6	1	0	100
1986	0	0	0	0	0	0	3	51	42	3	0	0	100
1987	0	0	1	0	1	1	0	2	93	2	0	0	100
1988	0	0	4	20	16	6	5	9	26	13	0	1	100
1989	0	1	0	1	1	10	16	33	13	7	15	3	100
1990	0	1	1	4	22	13	5	53	0	2	0	0	100
1991	0	0	0	0	0	3	11	3	70	13	0	0	100
1992	7	0	0	4	36	31	9	4	8	0	0	0	100
1993	0	0	0	19	7	1	1	46	22	2	0	0	100
1994	9	16	1	2	6	12	0	23	24	6	0	1	100
1995	0	0	0	0	0	0	0	3	93	3	0	0	100
1996	0	0	0	1	1	1	0	71	23	2	1	0	100
Avg	1	1	1	4	10	7	5	23	37	8	3	0	

Number of Days with Missing Data for SWP Fish Screens
(i.e., Number of Days with Pumping < 100 cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	0	0	9	11	0	0	0	0	0	2	22
1981	0	0	0	0	0	0	0	9	8	0	0	0	17
1982	0	0	0	0	0	0	0	0	15	11	0	0	26
1983	0	0	1	0	0	21	27	21	4	6	0	8	88
1984	18	11	17	20	0	0	0	3	0	0	0	0	69
1985	6	0	0	0	0	0	0	0	0	0	0	0	6
1986	0	0	0	0	4	20	5	1	0	0	0	0	30
1987	0	0	1	0	0	0	0	0	0	0	0	0	1
1988	2	3	3	0	0	0	0	0	0	0	0	0	8
1989	1	2	0	0	1	0	0	7	1	0	0	0	12
1990	0	0	0	0	0	0	0	8	8	0	0	0	16
1991	0	0	1	2	2	0	0	2	4	7	1	1	20
1992	0	6	6	0	6	0	1	8	2	11	1	0	41
1993	10	1	7	0	4	8	0	0	0	0	0	0	30
1994	0	3	0	0	5	1	13	9	10	2	0	5	48
1995	0	0	5	0	0	23	26	6	0	0	0	0	60
1996	0	19	29	0	1	1	0	0	1	0	0	0	51
Avg	2	3	4	1	2	5	4	4	3	2	0	1	32

Number of Days with Splittail Density Greater than 0 at SWP Fish Screens

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	4	2	2	31	18	15	29	30	28	16	12	4	191
1981	3	0	1	4	14	22	19	4	0	0	2	0	69
1982	0	1	2	15	23	20	15	14	8	11	22	4	135
1983	1	0	2	8	11	10	0	6	25	15	21	2	101
1984	1	0	0	0	14	29	27	13	8	26	17	5	140
1985	0	2	7	3	12	25	24	16	17	7	2	1	116
1986	3	2	0	3	5	4	21	29	30	26	31	16	170
1987	1	0	3	5	20	24	16	9	7	7	12	4	108
1988	2	2	6	29	29	27	26	21	14	9	7	4	176
1989	0	4	1	5	21	31	30	19	6	9	5	7	138
1990	1	1	1	9	26	31	22	5	0	3	0	0	99
1991	0	0	0	3	8	30	27	15	13	7	0	0	103
1992	1	0	0	4	15	30	11	5	2	0	1	1	70
1993	0	0	2	28	24	23	22	28	25	18	9	4	183
1994	7	7	2	2	8	14	0	4	6	6	1	1	58
1995	0	0	0	28	22	1	1	19	29	31	27	16	174
1996	7	1	0	18	21	25	9	31	27	29	22	6	196
Avg	2	1	2	11	17	21	18	16	14	13	11	4	131

Number of Days with Reduced SWP Pumping for the Purpose of Saving Splittail Using a Threshold of 3,300 Fish/TAF for the Average Density of the Previous 3 Days

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	18	7	0	0	0	25
1987	0	0	0	0	0	0	0	0	3	0	0	0	3
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	17	0	0	0	17
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg	0	0	0	0	0	0	0	1	2	0	0	0	3

Average Density of Splittail Saved (Fish/TAF) at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Percent Saved
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	1726	828	0	0	0	39
1987	0	0	0	0	0	0	0	0	19	0	0	0	2
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	7077	0	0	0	76
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg	0	0	0	0	0	0	0	102	466	0	0	0	44

Average Salmon Density (Fish/TAF) at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
1980	6	23	16	16	2	1	229	296	138	7	0	5	61
1981	7	6	9	7	16	33	219	111	3	0	0	0	34
1982	2	12	54	41	78	59	78	632	350	0	0	0	109
1983	0	34	148	33	37	85	0	5	362	5	0	0	59
1984	0	3	0	0	1	9	125	211	282	0	2	0	52
1985	63	39	34	1	4	9	159	525	55	1	0	0	75
1986	5	5	5	5	264	427	1103	948	495	0	0	0	270
1987	0	1	2	1	3	23	326	619	85	2	0	0	89
1988	0	0	78	8	12	15	152	354	130	10	1	0	63
1989	1	3	4	8	1	22	133	210	5	0	0	0	32
1990	0	2	3	6	3	12	60	397	38	0	0	0	44
1991	0	0	0	0	0	12	93	164	16	0	0	0	24
1992	0	33	0	5	30	24	38	34	0	0	0	0	14
1993	0	0	1	3	3	2	12	27	6	0	0	0	4
1994	0	0	2	1	2	2	12	30	1	0	0	0	4
1995	0	0	3	10	4	0	5	36	41	0	0	0	8
1996	0	0	0	8	1	2	19	28	5	0	0	0	5
Avg	5	10	21	9	27	43	162	272	118	2	0	0	56

Average Percent Occurrence of Salmon by Month at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sum
1980	1	3	2	2	0	0	31	41	18	1	0	1	100
1981	2	2	2	2	4	8	53	28	1	0	0	0	100
1982	0	1	4	3	5	5	6	49	26	0	0	0	100
1983	0	5	21	5	5	12	0	1	51	1	0	0	100
1984	0	0	0	0	0	1	20	34	44	0	0	0	100
1985	7	4	4	0	0	1	17	60	6	0	0	0	100
1986	0	0	0	0	8	13	34	30	15	0	0	0	100
1987	0	0	0	0	0	2	30	59	8	0	0	0	100
1988	0	0	10	1	2	2	20	47	17	1	0	0	100
1989	0	1	1	2	0	6	34	55	1	0	0	0	100
1990	0	0	1	1	1	2	11	77	7	0	0	0	100
1991	0	0	0	0	0	4	32	58	6	0	0	0	100
1992	0	20	0	3	17	15	23	21	0	0	0	0	100
1993	0	0	1	6	6	3	22	50	11	0	0	0	100
1994	0	1	4	2	3	5	24	60	1	0	0	0	100
1995	0	0	3	11	3	0	5	37	40	1	0	0	100
1996	0	0	0	13	2	3	30	45	8	0	0	0	100
Avg	1	2	3	3	3	5	23	44	15	0	0	0	

Number of Days with Missing Data for SWP Fish Screens
(i.e., Number of Days with Pumping < 100 cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	0	0	9	11	0	0	0	0	0	2	22
1981	0	0	0	0	0	0	0	9	8	0	0	0	17
1982	0	0	0	0	0	0	0	0	15	11	0	0	26
1983	0	0	1	0	0	21	27	21	4	6	0	8	88
1984	18	11	17	20	0	0	0	3	0	0	0	0	69
1985	6	0	0	0	0	0	0	0	0	0	0	0	6
1986	0	0	0	0	4	20	5	1	0	0	0	0	30
1987	0	0	1	0	0	0	0	0	0	0	0	0	1
1988	2	3	3	0	0	0	0	0	0	0	0	0	8
1989	1	2	0	0	1	0	0	7	1	0	0	0	12
1990	0	0	0	0	0	0	0	8	8	0	0	0	16
1991	0	0	1	2	2	0	0	2	4	7	1	1	20
1992	0	6	6	0	6	0	1	8	2	11	1	0	41
1993	10	1	7	0	4	8	0	0	0	0	0	0	30
1994	0	3	0	0	5	1	13	9	10	2	0	5	48
1995	0	0	5	0	0	23	26	6	0	0	0	0	60
1996	0	19	29	0	1	1	0	0	1	0	0	0	51
Avg	2	3	4	1	2	5	4	4	3	2	0	1	32

Number of Days with Salmon Density Greater than 0 at SWP Fish Screens

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	9	15	19	19	3	5	29	31	22	4	1	2	159
1981	5	11	11	13	20	30	30	15	1	0	1	0	137
1982	7	12	11	15	17	29	22	31	11	0	0	0	155
1983	0	12	28	29	28	10	0	3	23	3	0	0	136
1984	0	1	0	0	6	26	30	28	21	1	1	0	114
1985	5	23	21	2	11	25	30	29	9	1	0	1	157
1986	11	9	9	13	17	10	24	29	17	0	0	0	139
1987	0	2	8	2	14	28	30	22	7	3	3	1	120
1988	1	2	16	20	26	30	30	31	14	3	4	1	178
1989	4	10	6	20	11	29	30	22	2	0	3	0	137
1990	1	5	10	17	15	31	30	21	6	1	0	0	137
1991	1	0	1	4	4	28	30	26	6	0	0	0	100
1992	1	4	1	19	17	31	24	13	0	0	0	1	111
1993	0	0	16	28	21	18	30	29	14	1	5	0	162
1994	4	5	28	21	18	29	13	22	4	0	0	0	144
1995	0	2	23	31	23	5	1	24	28	10	1	0	148
1996	0	0	0	27	22	21	30	31	17	2	0	2	152
Avg	3	7	12	16	16	23	24	24	12	2	1	0	140

Number of Days with Reduced SWP Pumping for the Purpose of Saving Salmon Using a Threshold of 350 Fish/TAF for the Average Density of the Previous 3 Days

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	0	0	0	0	5	10	5	0	0	0	20
1981	0	0	0	0	0	0	2	5	0	0	0	0	7
1982	0	0	0	0	0	0	2	21	8	0	0	0	31
1983	0	0	4	0	0	0	0	0	10	0	0	0	14
1984	0	0	0	0	0	0	1	6	13	0	0	0	20
1985	0	2	0	0	0	0	1	22	0	0	0	0	25
1986	0	0	0	0	3	8	14	28	14	0	0	0	67
1987	0	0	0	0	0	0	11	21	3	0	0	0	35
1988	0	0	3	0	0	0	0	15	5	0	0	0	23
1989	0	0	0	0	0	0	2	3	0	0	0	0	5
1990	0	0	0	0	0	0	0	12	0	0	0	0	12
1991	0	0	0	0	0	0	0	4	0	0	0	0	4
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg	0	0	0	0	0	0	2	9	3	0	0	0	15

Average Density of Salmon Saved (Fish/TAF) at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Percent Saved
1980	0	0	0	0	0	0	123	111	45	0	0	0	38
1981	0	0	0	0	0	0	35	72	0	0	0	0	22
1982	0	0	0	0	0	0	11	444	91	0	0	0	44
1983	0	0	38	0	0	0	0	0	162	0	0	0	29
1984	0	0	0	0	0	0	2	30	115	0	0	0	23
1985	0	4	0	0	0	0	3	399	0	0	0	0	47
1986	0	0	0	0	143	345	840	821	431	0	0	0	78
1987	0	0	0	0	0	0	181	533	27	0	0	0	70
1988	0	0	22	0	0	0	0	163	15	0	0	0	27
1989	0	0	0	0	0	0	14	32	0	0	0	0	11
1990	0	0	0	0	0	0	0	187	0	0	0	0	34
1991	0	0	0	0	0	0	0	19	0	0	0	0	6
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg	0	0	4	0	8	20	71	165	52	0	0	0	47

Average Steelhead Density (Fish/TAF) at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
1980	0	0	0	1	5	0	1	3	0	0	0	0	1
1981	0	0	0	1	7	18	19	0	0	0	0	0	4
1982	0	0	2	3	4	3	30	20	8	0	0	0	6
1983	0	0	0	1	0	0	0	8	0	0	0	0	1
1984	0	0	0	0	0	0	2	0	0	0	0	0	0
1985	0	0	0	0	1	4	5	3	0	0	0	0	1
1986	0	0	0	0	1	1	8	3	0	0	0	0	1
1987	0	0	9	0	0	18	8	2	0	0	0	0	3
1988	0	0	2	0	7	4	9	2	0	0	0	0	2
1989	0	0	0	0	2	13	6	2	0	0	0	0	2
1990	0	0	0	0	4	6	3	1	0	0	0	0	1
1991	0	0	0	0	0	15	8	1	0	0	0	0	2
1992	0	5	0	1	19	10	3	1	0	0	0	0	3
1993	0	0	0	3	28	11	3	2	0	0	0	0	4
1994	0	0	0	0	1	1	2	2	0	0	0	0	1
1995	0	0	0	1	2	2	0	1	0	0	0	0	1
1996	0	0	0	6	3	1	1	1	0	0	0	0	1
Avg	0	0	1	1	5	6	6	3	1	0	0	0	2

Average Percent Occurrence of Steelhead by Month at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sum
1980	0	1	1	9	42	4	13	27	4	0	0	0	100
1981	0	0	0	1	16	40	42	0	0	0	0	0	100
1982	0	0	2	5	6	4	42	29	12	0	0	0	100
1983	1	0	0	8	3	0	0	89	0	0	0	0	100
1984	0	0	0	0	0	15	81	4	0	0	0	0	100
1985	0	0	1	0	9	31	37	23	0	0	0	0	100
1986	0	0	0	0	7	8	62	23	0	0	0	0	100
1987	0	0	25	0	1	48	21	6	0	0	0	0	100
1988	0	0	7	1	28	16	38	10	1	0	0	0	100
1989	0	0	0	1	8	58	25	9	0	0	0	0	100
1990	0	0	0	0	26	43	24	8	0	0	0	0	100
1991	0	0	1	1	1	62	33	3	0	0	0	0	100
1992	1	12	0	2	48	27	8	2	0	0	0	0	100
1993	0	0	0	6	57	26	6	5	0	0	0	0	100
1994	0	0	0	1	12	19	29	36	0	2	0	0	100
1995	0	0	0	12	25	30	1	23	7	1	0	0	100
1996	0	0	0	46	23	11	12	8	0	0	0	0	100
Avg	0	1	2	5	18	26	28	18	1	0	0	0	

Number of Days with Missing Data for SWP Fish Screens
(i.e., Number of Days with Pumping < 100 cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	0	0	9	11	0	0	0	0	0	2	22
1981	0	0	0	0	0	0	0	9	8	0	0	0	17
1982	0	0	0	0	0	0	0	0	15	11	0	0	26
1983	0	0	1	0	0	21	27	21	4	6	0	8	88
1984	18	11	17	20	0	0	0	3	0	0	0	0	69
1985	6	0	0	0	0	0	0	0	0	0	0	0	6
1986	0	0	0	0	4	20	5	1	0	0	0	0	30
1987	0	0	1	0	0	0	0	0	0	0	0	0	1
1988	2	3	3	0	0	0	0	0	0	0	0	0	8
1989	1	2	0	0	1	0	0	7	1	0	0	0	12
1990	0	0	0	0	0	0	0	8	8	0	0	0	16
1991	0	0	1	2	2	0	0	2	4	7	1	1	20
1992	0	6	6	0	6	0	1	8	2	11	1	0	41
1993	10	1	7	0	4	8	0	0	0	0	0	0	30
1994	0	3	0	0	5	1	13	9	10	2	0	5	48
1995	0	0	5	0	0	23	26	6	0	0	0	0	60
1996	0	19	29	0	1	1	0	0	1	0	0	0	51
Avg	2	3	4	1	2	5	4	4	3	2	0	1	32

Number of Days with Steelhead Density Greater than 0 at SWP Fish Screens

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	1	1	2	3	4	13	9	2	0	0	0	35
1981	1	0	1	2	7	26	20	0	0	0	0	0	57
1982	0	0	3	4	5	12	23	12	1	0	0	0	60
1983	1	0	0	3	1	0	0	3	0	0	0	0	8
1984	0	0	0	0	0	7	12	1	0	0	0	0	20
1985	0	0	1	0	5	21	17	8	0	0	0	0	52
1986	0	0	0	0	3	1	10	2	0	0	0	0	16
1987	0	0	1	0	3	22	20	2	0	0	0	0	48
1988	0	0	1	2	17	14	27	13	2	0	0	0	76
1989	0	0	0	1	15	27	18	6	0	0	0	0	67
1990	0	0	0	0	19	30	28	1	0	0	0	0	78
1991	0	0	1	2	7	29	21	10	0	0	0	0	70
1992	1	3	0	3	15	31	14	4	0	0	0	0	71
1993	0	0	3	24	24	23	29	15	0	0	0	0	118
1994	0	0	0	4	16	25	9	6	0	3	0	0	63
1995	1	0	1	21	21	6	1	10	5	2	0	0	68
1996	1	0	0	21	24	26	19	15	2	0	0	0	108
Avg	0	0	1	5	11	18	17	7	1	0	0	0	60

Number of Days with Reduced SWP Pumping for the Purpose of Saving Steelhead Using a Threshold of 6 Fish/TAF for the Average Density of the Previous 3 Days

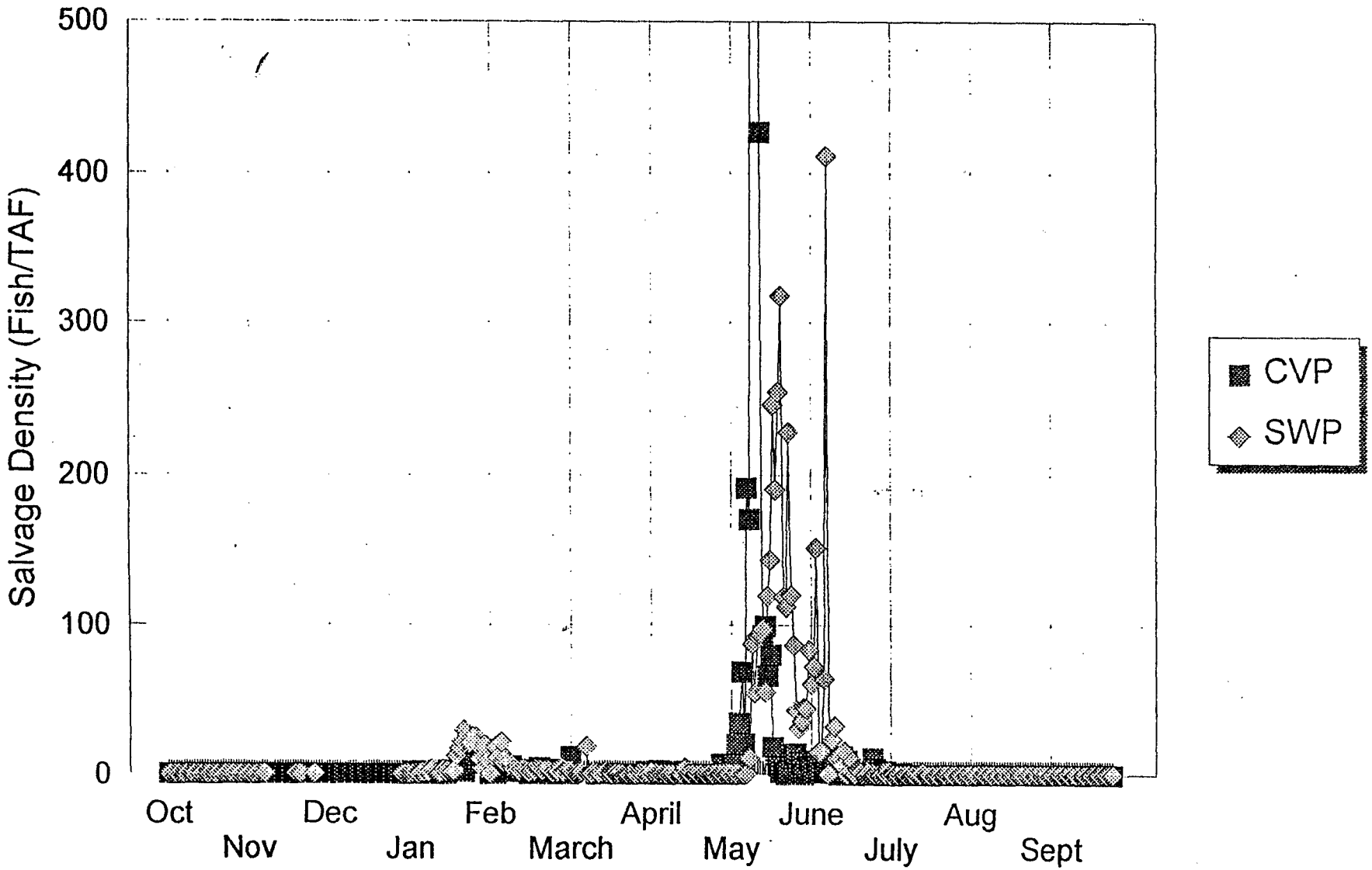
Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1980	0	0	0	3	3	0	0	5	0	0	0	0	11
1981	0	0	0	0	4	22	22	3	0	0	0	0	51
1982	0	0	3	6	6	5	22	15	3	0	0	0	60
1983	0	0	0	0	0	0	0	5	0	0	0	0	5
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	1	10	10	8	0	0	0	0	29
1986	0	0	0	0	0	1	7	8	0	0	0	0	16
1987	0	0	3	0	0	9	13	6	0	0	0	0	31
1988	0	0	3	0	7	3	17	3	0	0	0	0	33
1989	0	0	0	0	1	19	12	3	0	0	0	0	35
1990	0	0	0	0	2	13	2	3	0	0	0	0	20
1991	0	0	0	0	0	21	16	0	0	0	0	0	37
1992	0	4	0	0	11	19	5	0	0	0	0	0	39
1993	0	0	0	3	20	12	0	4	0	0	0	0	39
1994	0	0	0	0	0	0	3	4	0	0	0	0	7
1995	0	0	0	0	0	0	0	1	0	0	0	0	1
1996	0	0	0	8	6	0	0	0	0	0	0	0	14
Avg	0	0	1	1	4	8	8	4	0	0	0	0	25

Average Density of Steelhead Saved (Fish/TAF) at SWP Pumping Facility

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Percent Saved
1980	0	0	0	0	0	0	0	1	0	0	0	0	15
1981	0	0	0	0	0	15	13	0	0	0	0	0	62
1982	0	0	0	0	0	0	24	15	0	0	0	0	61
1983	0	0	0	0	0	0	0	6	0	0	0	0	42
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	2	3	0	0	0	0	0	33
1986	0	0	0	0	0	0	6	0	0	0	0	0	44
1987	0	0	0	0	0	1	4	0	0	0	0	0	13
1988	0	0	0	0	2	1	5	1	0	0	0	0	37
1989	0	0	0	0	0	9	3	0	0	0	0	0	59
1990	0	0	0	0	1	3	0	0	0	0	0	0	29
1991	0	0	0	0	0	12	6	0	0	0	0	0	72
1992	0	0	0	0	16	8	0	0	0	0	0	0	61
1993	0	0	0	0	24	4	0	1	0	0	0	0	59
1994	0	0	0	0	0	0	0	0	0	0	0	0	1
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	3	1	0	0	0	0	0	0	0	32
Avg	0	0	0	0	3	3	4	1	0	0	0	0	48

Salvage Density of Delta Smelt

1996



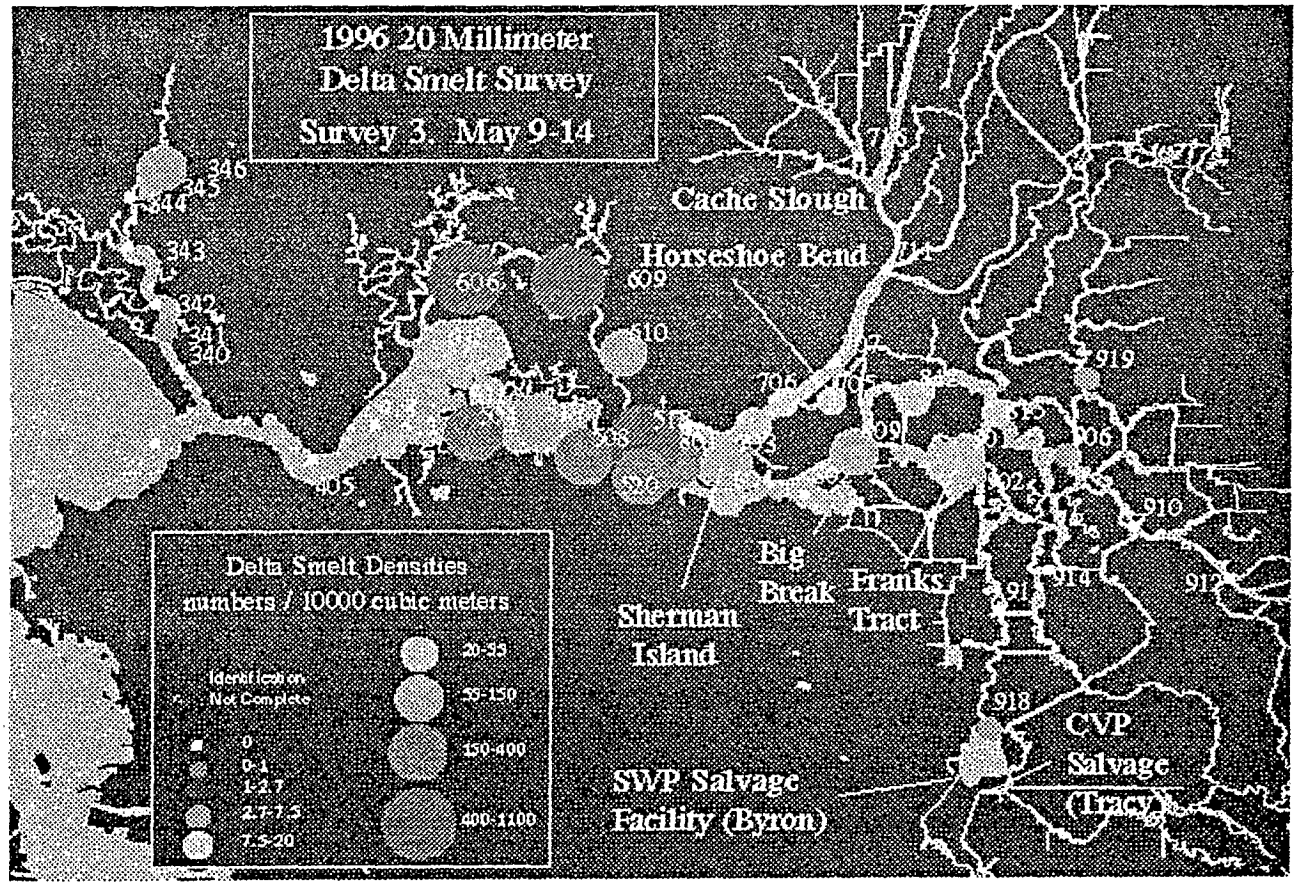
D-016135

D-016135

Survey 3 Results

Spatial and temporal distribution:

A total of 853 larval/juvenile delta smelt were found predominantly from Napa River to the Lower Sacramento River. No delta smelt were found in San Pablo bay. Low densities were sampled in the Napa River (14.3 ds/10,000 m³), Suisun Bay (3.6 ds/10,000 m³), Grizzly Bay (12.8 ds/10,000 m³), Honker Bay (124.3 ds/10,000 m³), Confluence of the Sacramento/San Joaquin Rivers (205.0 ds/10,000 m³), Lower Sacramento River (23.0 ds/10,000 m³), Lower San Joaquin River (34.6 ds/10,000 m³), and the South Delta (1.1 ds/10,000 m³). The highest density was found in Montezuma Slough (517.9 ds/10,000 m³).



Changes from last survey:

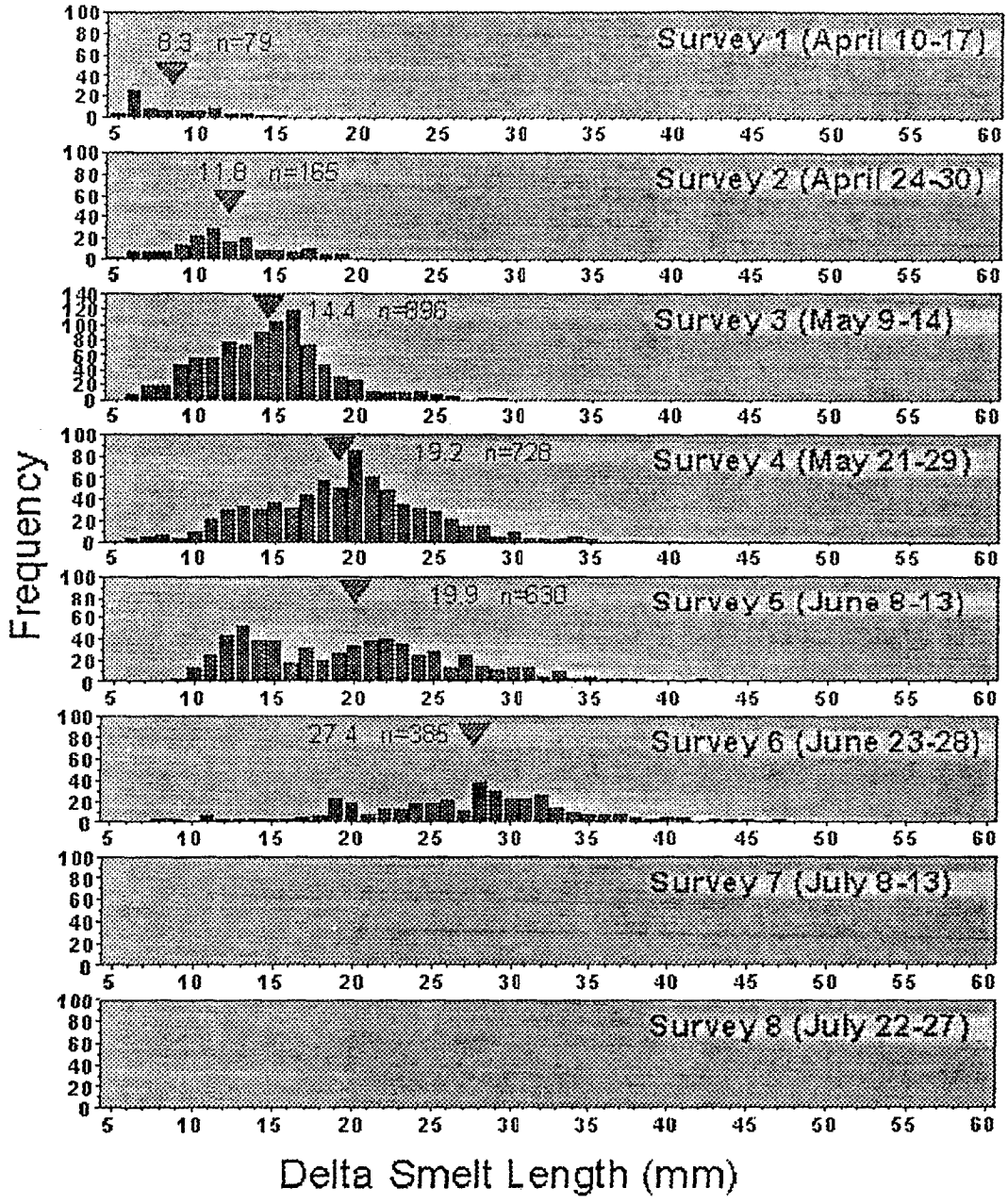
There was a significant increase in total delta smelt sampled between Survey 2 (n=166) and 3 (n=853) due to an influx of larval delta smelt. The delta smelt distribution shifted downstream to Montezuma Slough, Honker Bay, and the Confluence of the Sacramento/San Joaquin Rivers even though outflow decreased. The entrapment zone was located in the vicinity of Roe Island with an outflow (5 day running average) of 23,188 cfs during the week of Survey 3, which constituted a significant decrease in outflow (38,360 cfs) from the week of Survey 2.

Size distribution:

D-016136

D-016136

A total of 853 delta smelt ranging in size from 5 to 28 mm were sampled during Survey 3.



A Kolmogorov-Smirnov Normality test indicated that the distribution was not normally distributed due to recruitment of larger juvenile delta smelt. The mean FL for larval delta smelt during Survey 3 was 14.4 mm, while the mean SL for Survey 2 was 11.8 mm. The dominant size class was 16 mm during Survey 3, while the dominant size class was 11 mm during Survey 2.

D-016137

D-016137

TOTAL CATCH OF ALL SPECIES IN SURVEY 3	
Common Name	Total Catch
Shimofuri Goby	4775
Shimofuri Goby	5218
Longfin Smelt	2850
Striped Bass	2746
Delta Smelt	900
Yellowfin Goby	879
Prickly Sculpin	220
Threadfin Shad	160
Northern Anchovy	115
Cheekspot Goby	88
Pacific Herring	69
Unknown	37
Starry Flounder	26
White Catfish	25
Three Spine Stickleback	19
Longjaw Mudsucker	12
Splittail	7
Sacramento Sucker	5
Gobies (Unid)	5
Wakasagi	4
Cyprinids (Unid)	4
Staghorn Sculpin	3
Centrarchids (Unid)	3
Bigscale Logperch	3
American Shad	2
Tule Perch	2
White Croaker	1
Chinook Salmon	1
White Sturgeon	1
Jacksmelt	1

Delta Smelt Catch Data by Station

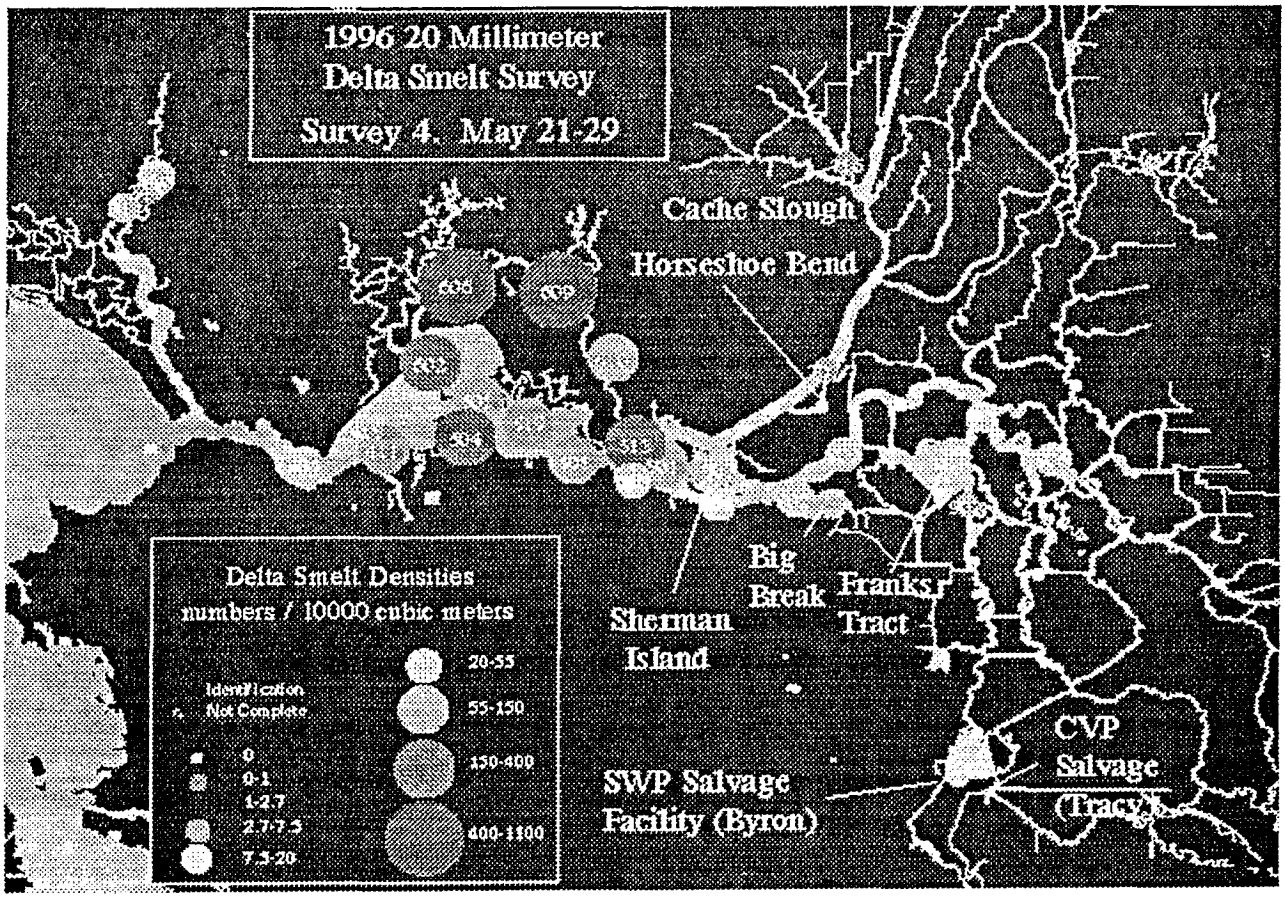
D-016138

D-016138

Survey 4 Results

Spatial and temporal distribution:

A total of 728 larval/juvenile delta smelt were found predominantly from Napa River to the Lower Sacramento River. No delta smelt were found at the one San Pablo Bay station or the Mokelumne River. Low densities were sampled in the Napa River (9.4 ds/10,000 m³), Suisun Bay (48.9 ds/10,000 m³), Grizzly Bay (151.8 ds/10,000 m³), Honker Bay (172.5 ds/10,000 m³), Confluence of the Sacramento/San Joaquin Rivers (82.2 ds/10,000 m³), Lower Sacramento River (4.3 ds/10,000 m³), Lower San Joaquin River (15.7 ds/10,000 m³), and the South Delta (5.1 ds/10,000 m³). The highest density was found in Montezuma Slough (421.3 ds/10,000 m³).

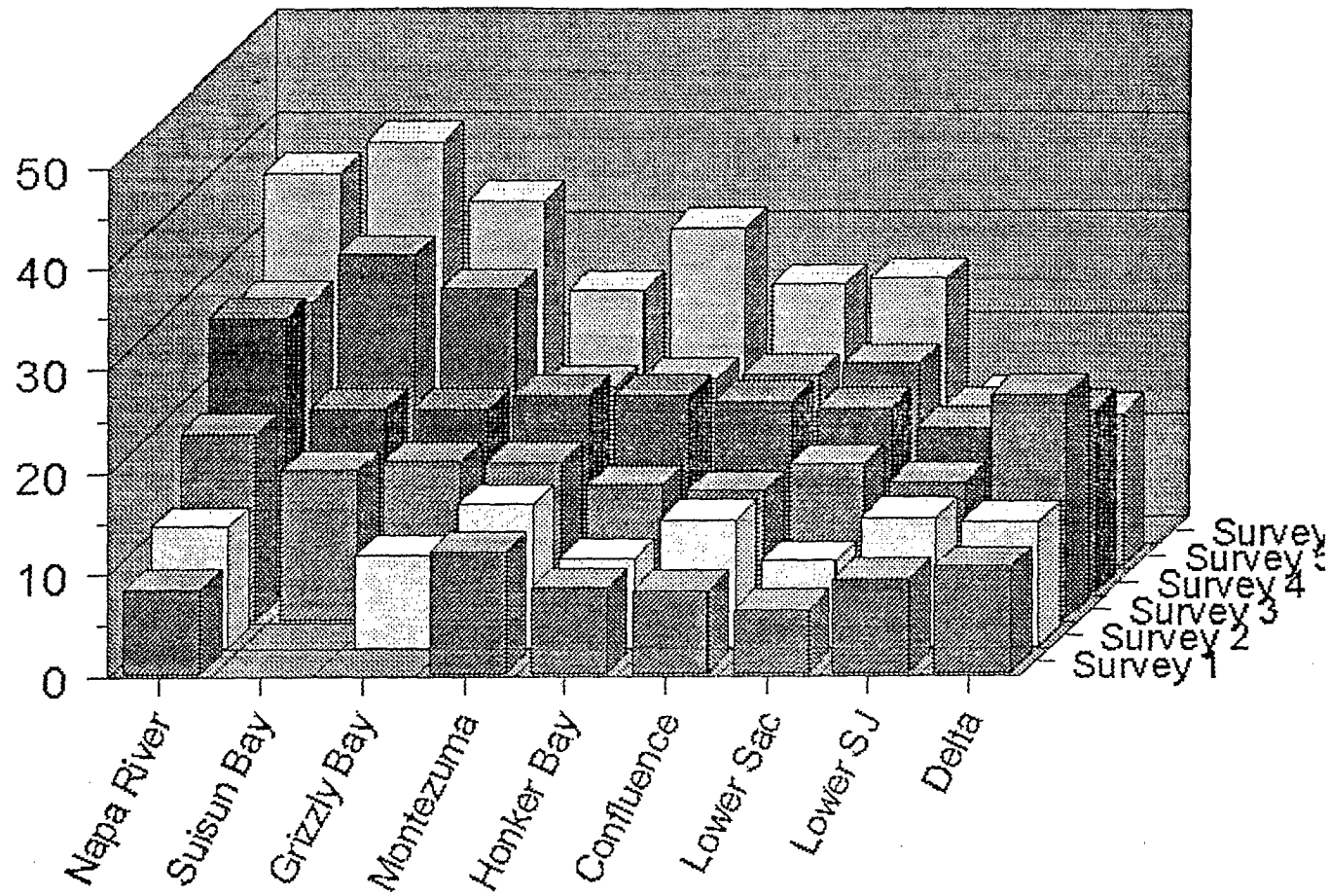


Changes from last survey:

The delta smelt distribution shifted downstream from the Lower Sacramento River, Lower San Joaquin River, and the Confluence of the Sacramento/San Joaquin Rivers to Suisun and Grizzly Bays in response to increased outflows. The entrapment zone was located in the vicinity of Carquinez Strait with an outflow (5 day running average) of 69,158 cfs during the week of Survey 4, which constituted a significant increase in outflow (23,188 cfs) from the week of Survey 3.

Size distribution:

Delta Smelt Mean Length by Area and Survey



TOTAL CATCH OF ALL SPECIES IN SURVEY 4	
Common Name	Total Catch
Shimofuri Goby	4775
Longfin Smelt	1910
Striped Bass	1791
Delta Smelt	728
Yellowfin Goby	575
Threadfin Shad	419
Three Spine Stickleback	167
Northern Anchovy	51
Prickly Sculpin	37
Cheekspot Goby	27
Sacramento Sucker	19
Unknown	15
Centrarchids (Unid)	13
Longjaw Mudsucker	13
Pacific Herring	6
Splittail	4
Largemouth Bass	4
Inland Silverside	4
Cyprinids (Unid)	4
Chinook Salmon	4
White Catfish	3
Jacksmelt	2
Starry Flounder	2
American Shad	2
Plainfin Midshipman	1
Adult Striped Bass	1
Lampreys (Unid)	1
Wakasagi	1
Mosquitofish	1

Delta Smelt Catch Data by Station

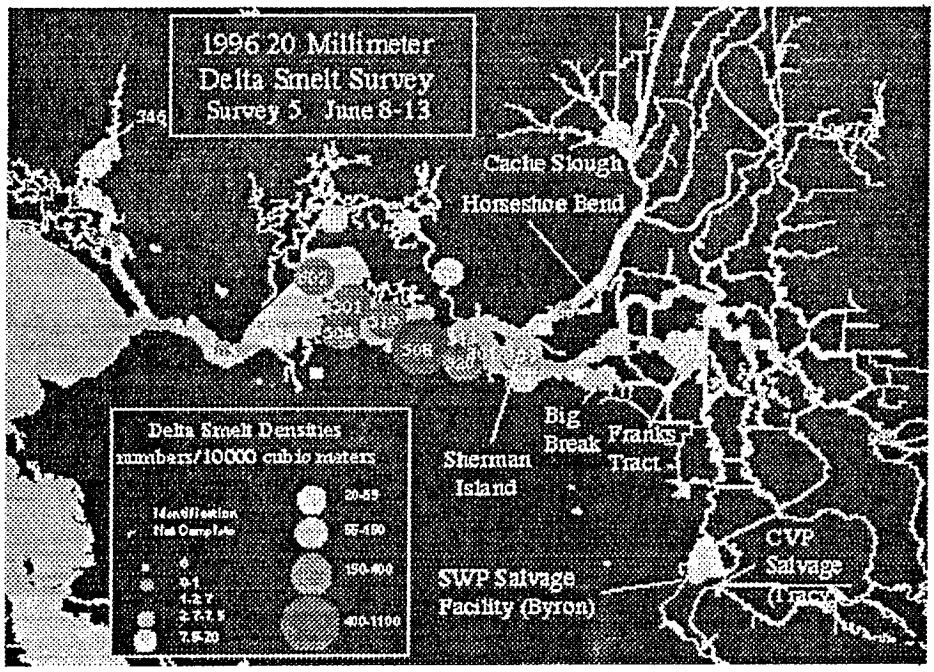
D-016141

D-016141

Survey 5 Results

Spatial and temporal distribution:

A total of 628 larval/juvenile delta smelt were found predominantly from Napa River to the Lower Sacramento River. No delta smelt were found in the Mokelumne River. San Pablo Bay was not sampled due to rough seas. Low densities were sampled in the Napa River (13.7 ds/10,000 m³), Suisun Bay (30.3 ds/10,000 m³), Grizzly Bay (225.6 ds/10,000 m³), Montezuma Slough (26.7 ds/10,000 m³), Confluence of the Sacramento/San Joaquin Rivers (129.2 ds/10,000 m³), Lower Sacramento River (22.9 ds/10,000 m³), Lower San Joaquin River (21.4 ds/10,000 m³), and the South Delta (0.9 ds/10,000 m³). The highest density was found in Honker Bay (297.0 ds/10,000 m³).



Changes from last survey:

The delta smelt distribution shifted from Montezuma Slough to Suisun and Grizzly Bays. The entrapment zone was located in the vicinity of Roe Island with an outflow (5 day running average) of 22,305 cfs during the week of Survey 5, which constituted a significant decrease in outflow (69,158 cfs) from the week of Survey 4.

Size distribution:

A total of 628 delta smelt ranging in size from 8 to 42mm were sampled during Survey 5.

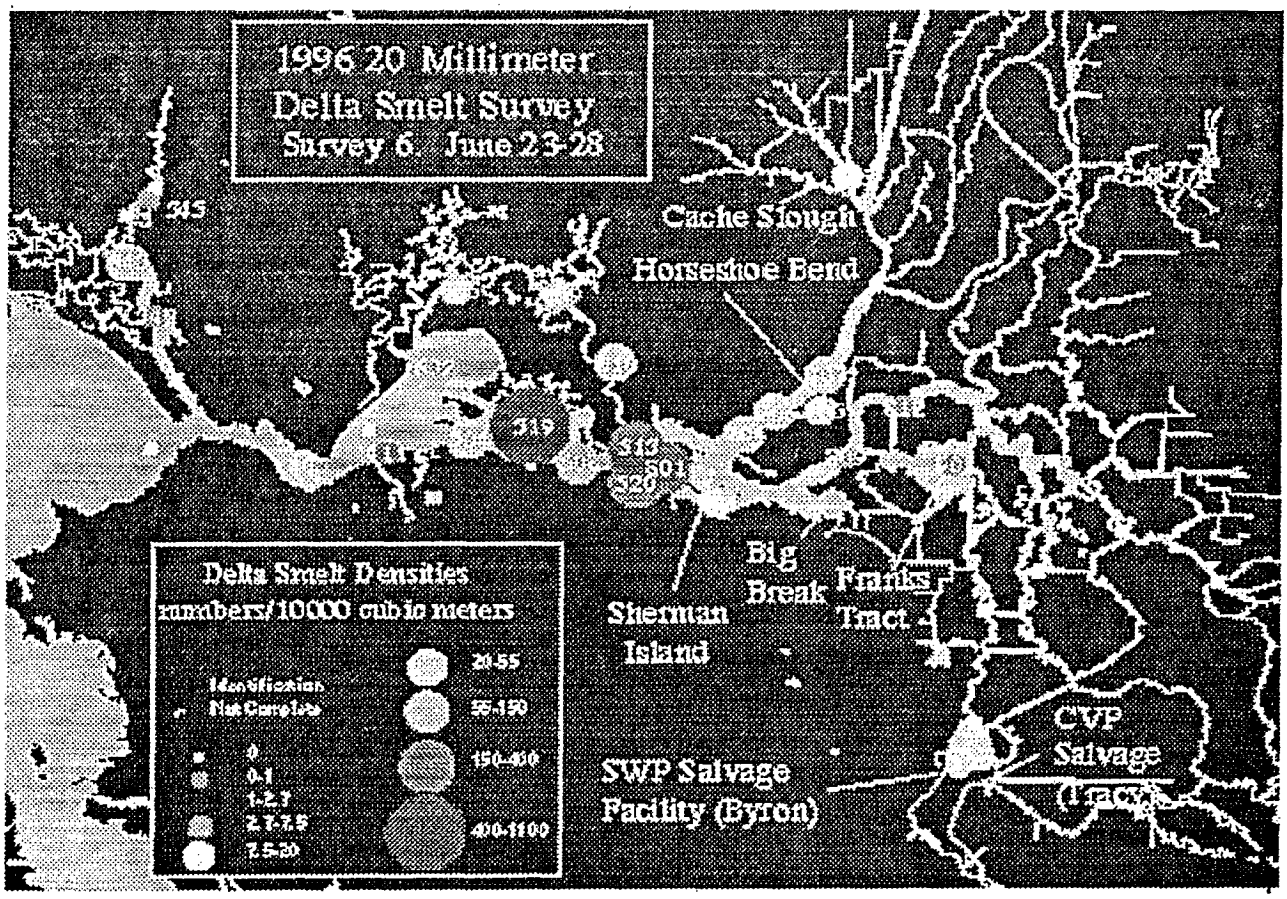
D-016142

D-016142

Survey 6 Results

Spatial and temporal distribution:

A total of 385 larval/juvenile delta smelt were found predominantly from the Napa River to the Lower Sacramento River. No delta smelt were found in the Mokelumne River, Delta, or San Pablo Bay. Low densities were sampled in the Napa River (8.5 ds/10,000 m³), Suisun Bay (7.0 ds/10,000 m³), Grizzly Bay (94.0 ds/10,000 m³), Montezuma Slough (16.2 ds/10,000 m³), Honker Bay (140.5 ds/10,000 m³), Lower Sacramento River (23.8 ds/10,000 m³), Lower San Joaquin River (5.7 ds/10,000 m³), and the South Delta (0.9 ds/10,000 m³). The highest density was found in the Confluence of the Sacramento/San Joaquin Rivers (225.3 ds/10,000 m³).



Changes from last survey:

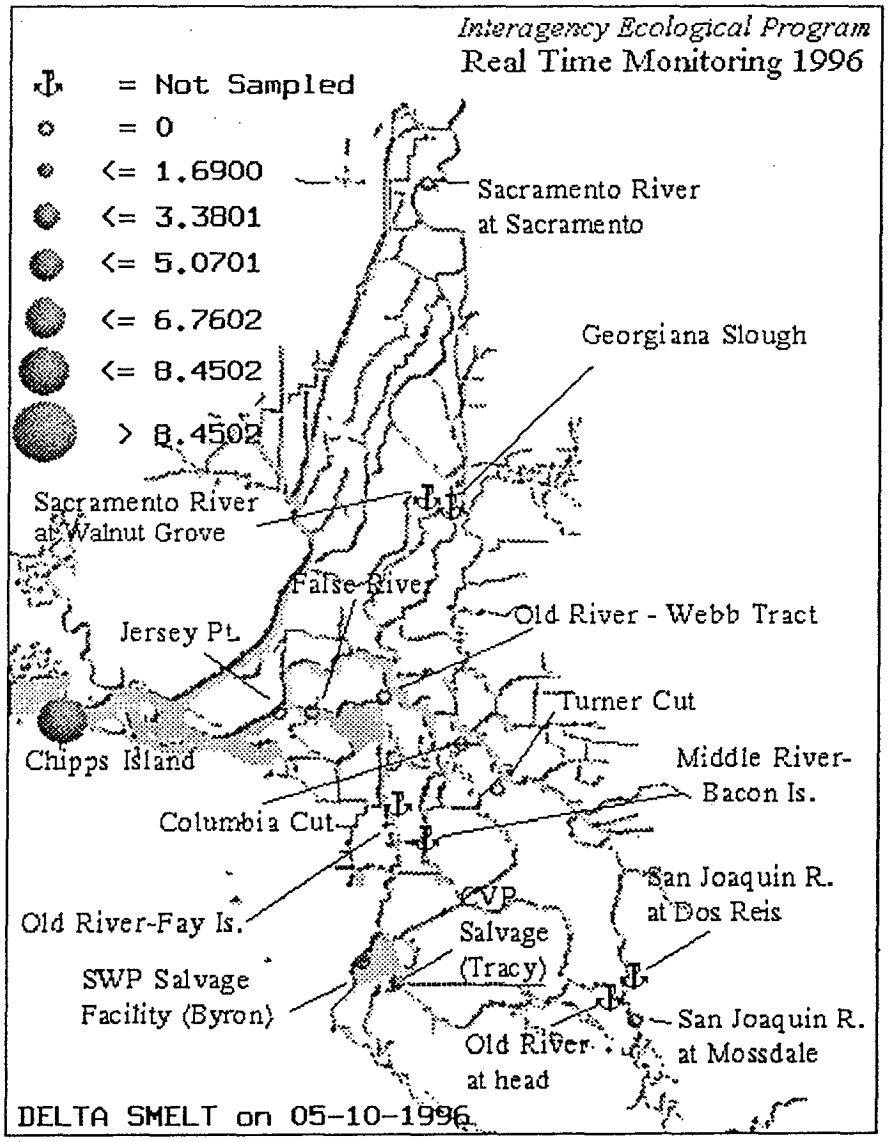
The delta smelt distribution shifted from Honker and Grizzly Bays upstream to the Confluence of the Sacramento/San Joaquin Rivers in response to decreased outflows. The entrapment zone was located in the vicinity of Honker Bay/Chipps Island with an outflow (5 day running average) of 10,729 cfs during the week of Survey 6, which constituted a significant decrease in outflow (22,305 cfs) from the week of Survey 5.

Size distribution:

D-016143

D-016143

INTERAGENCY ECOLOGICAL PROGRAM REAL TIME MONITORING XCVI



A Map Of DELTA SMELT

On 05-10-1996

Scaled to ____ %

Draw Map!

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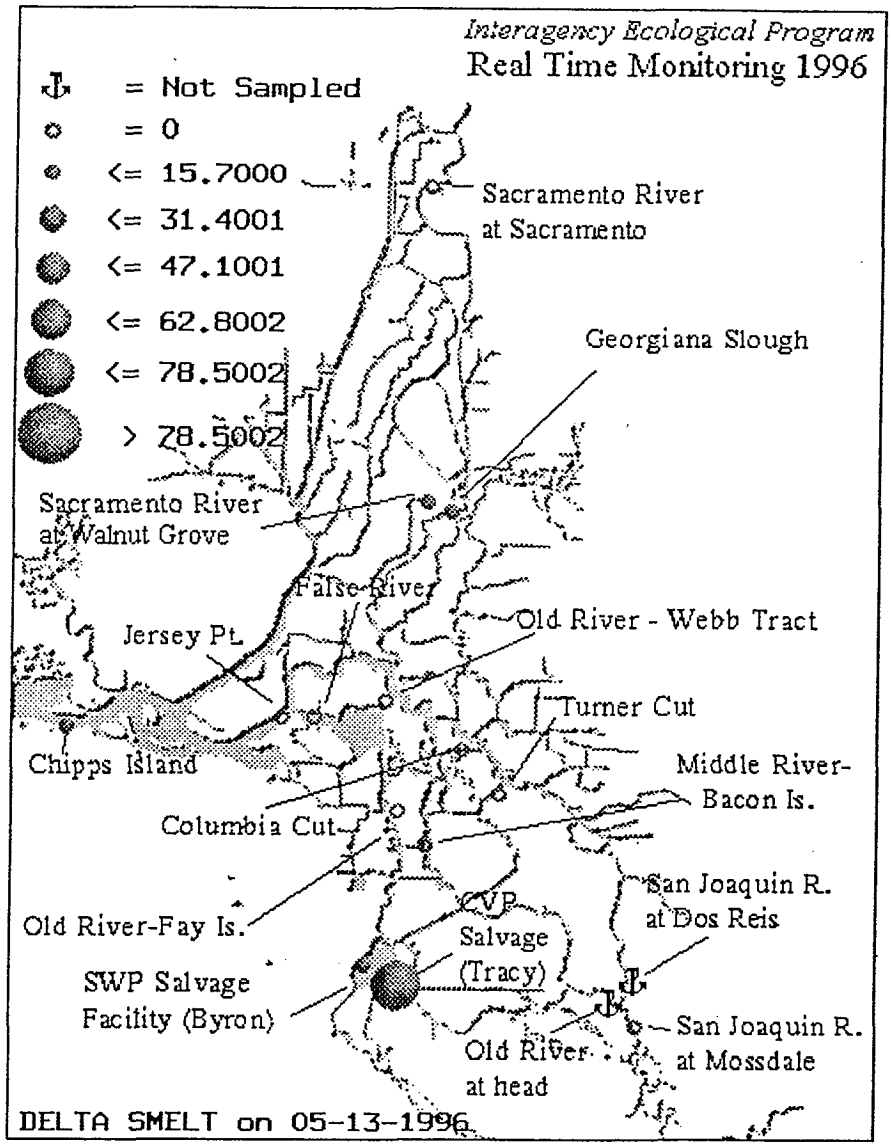
INTERAGENCY ECOLOGICAL PROGRAM REAL TIME MONITORING XCVI



A Map Of DELTA SMELT

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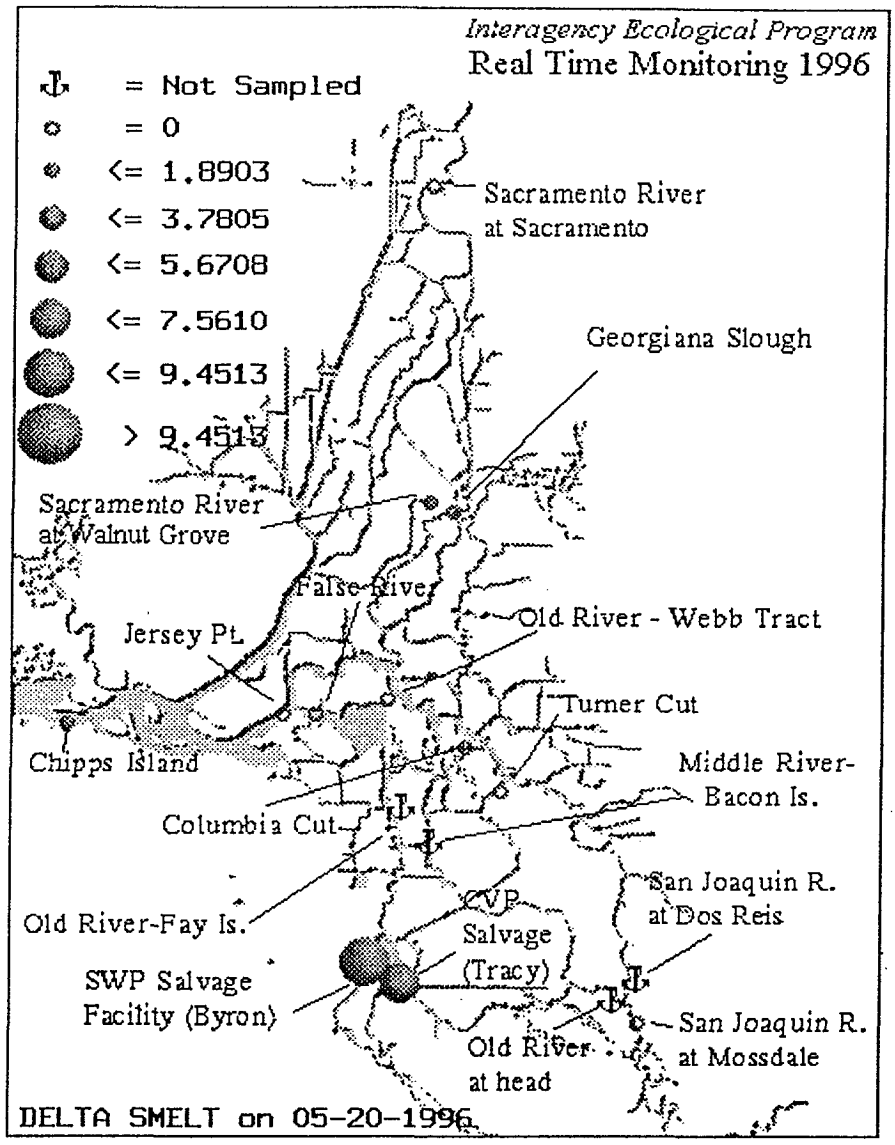

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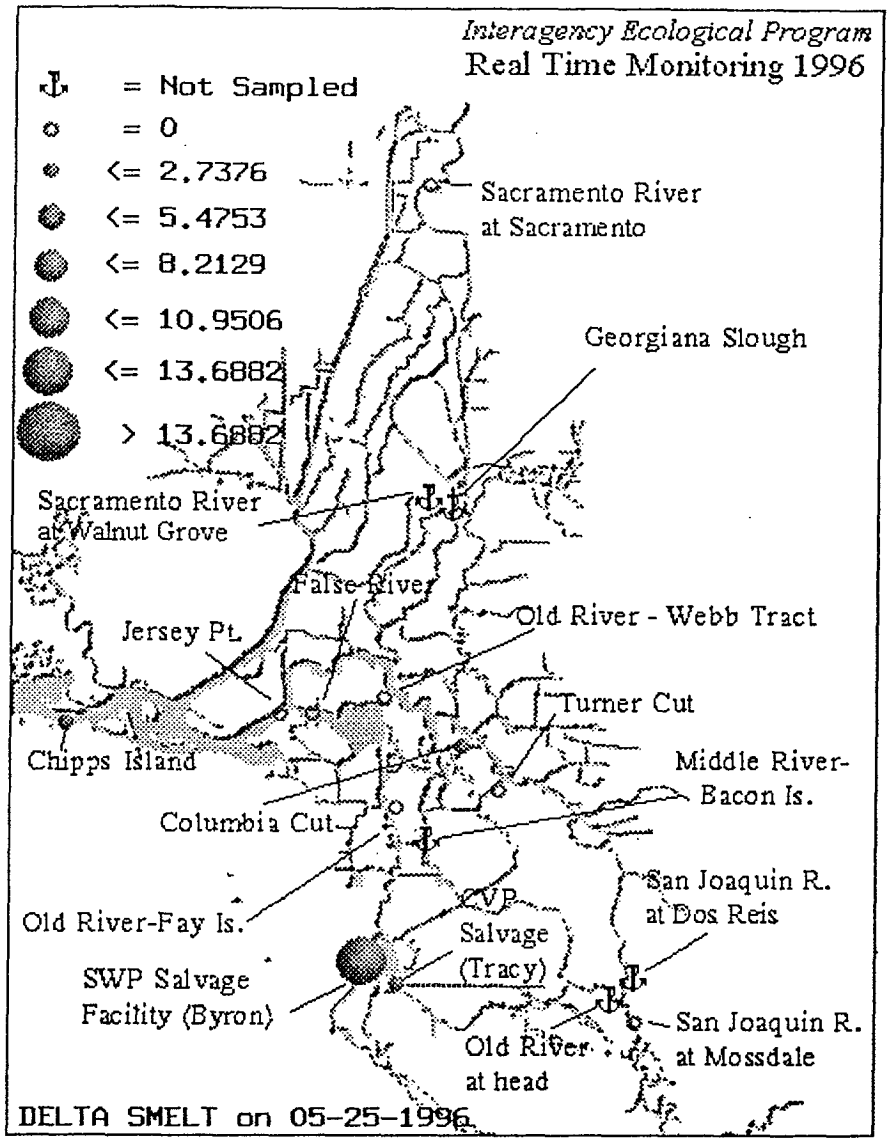
[IEP Home Page] [DFG Bay-Delta] [Dept. of Water Resources] [Resources Agency-Ceres]

INTERAGENCY ECOLOGICAL PROGRAM REAL TIME MONITORING XCVI



A Map Of DELTA SMELT

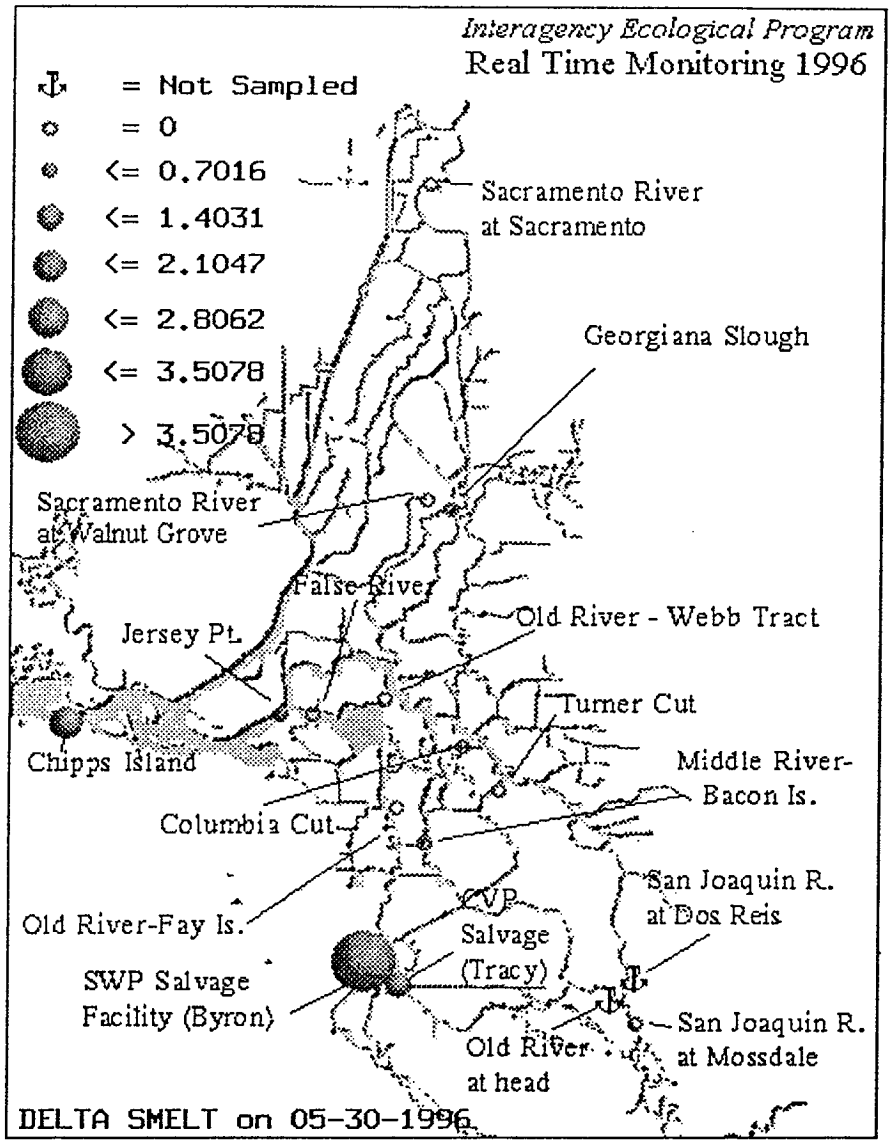
On 05-25-1996

Scaled to _____ %

Draw Map!

[IEP Home Page] [DFG Bay-Delta] [Dept. of Water Resources] [Resources Agency-Ceres]

INTERAGENCY ECOLOGICAL PROGRAM REAL TIME MONITORING XCVI



A Map Of DELTA SMELT

On 05-30-1996

Scaled to _____ %

Draw Map!

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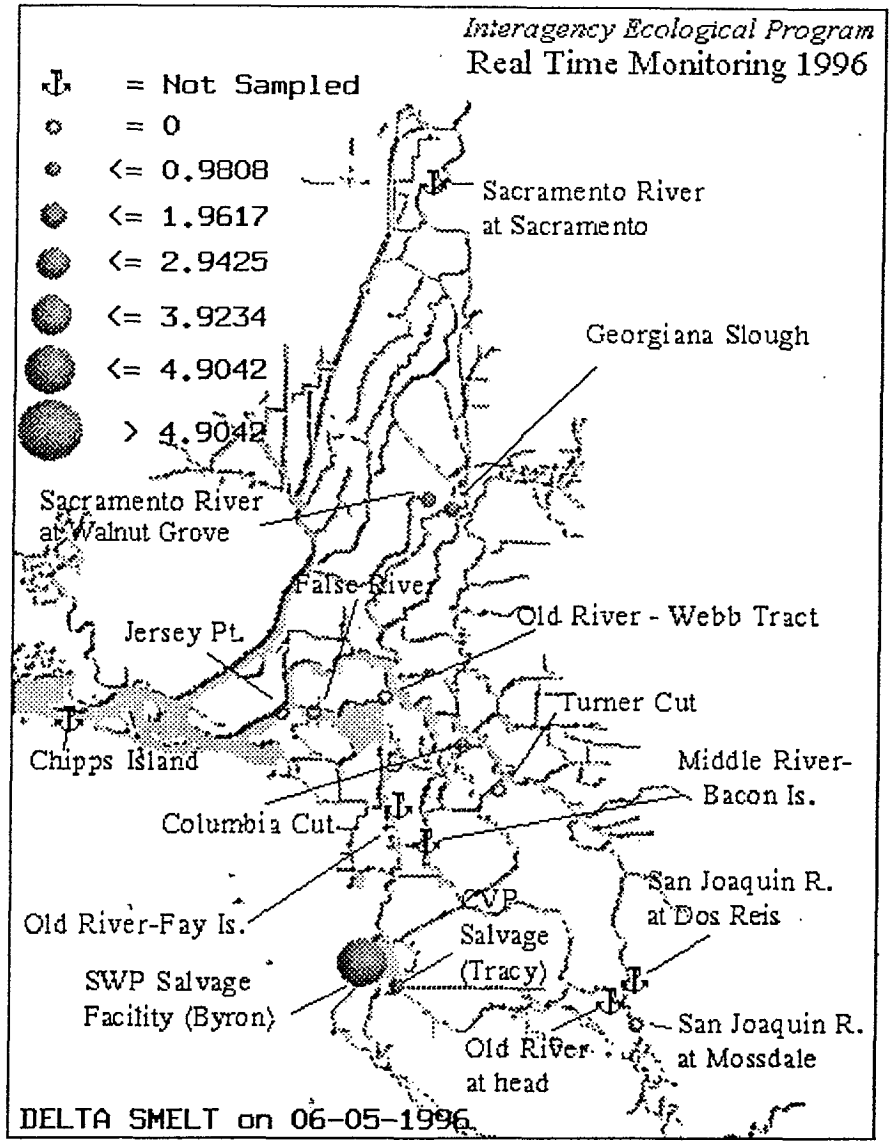
INTERAGENCY ECOLOGICAL PROGRAM REAL TIME MONITORING XCVI



A Map Of DELTA SMELT

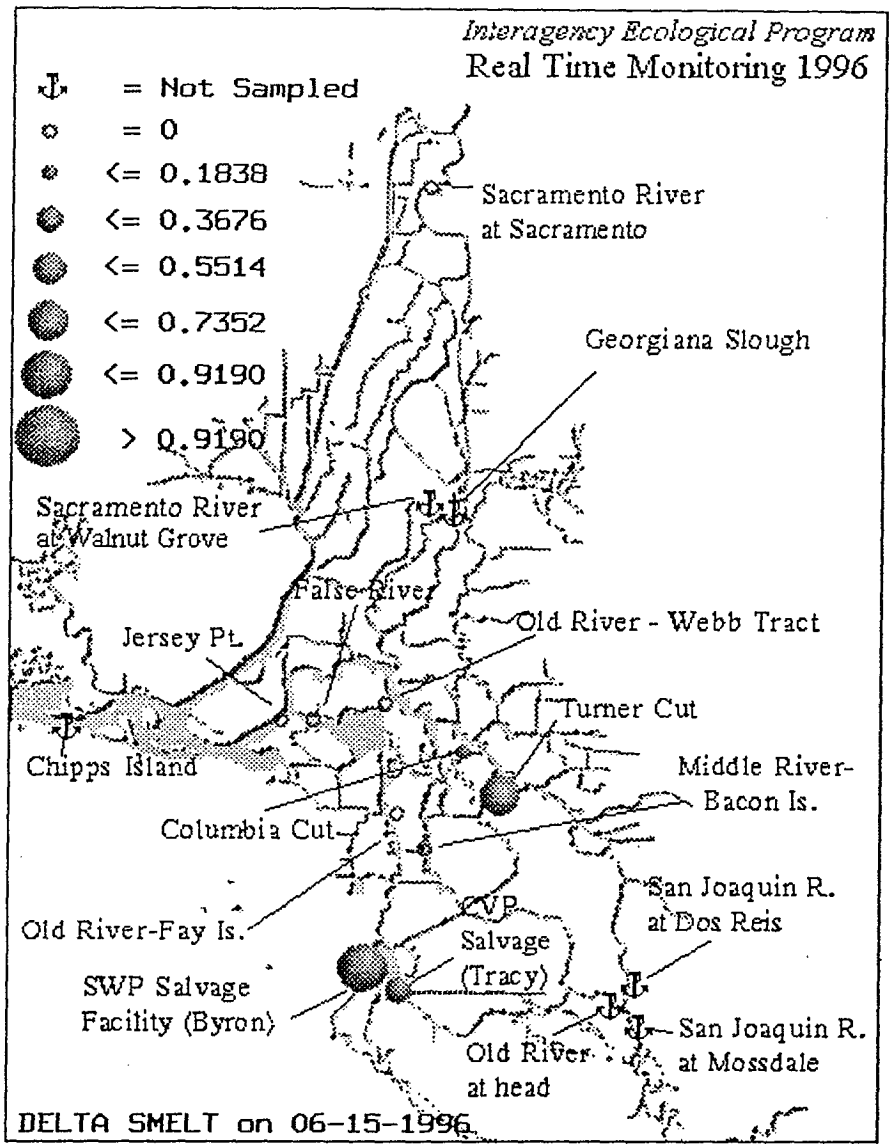
On 06-05-1996

Scaled to ____ %

Draw Map!

[IEP Home Page] [DFG Bay-Delta] [Dept. of Water Resources] [Resources Agency-Ceres]

INTERAGENCY ECOLOGICAL PROGRAM REAL TIME MONITORING XCVI



A Map Of DELTA SMELT

On 06-15-1996

Scaled to ____ %

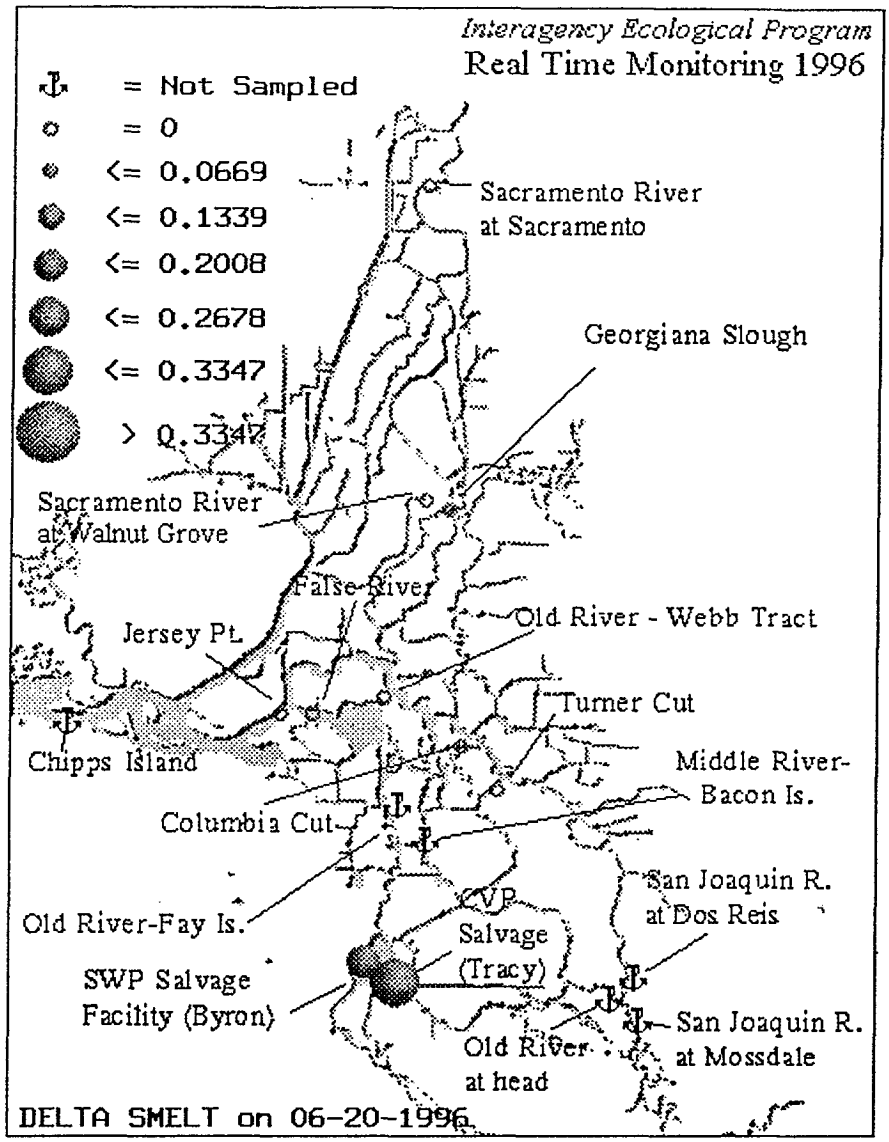
Draw Map!

[IEP Home Page] [DFG Bay-Delta] [Dept. of Water Resources] [Resources Agency-Ceres]

D-016150

D-016150

INTERAGENCY ECOLOGICAL PROGRAM REAL TIME MONITORING XCVI



A Map Of DELTA SMELT

On 06-20-1996

Scaled to ____ %

Draw Map!

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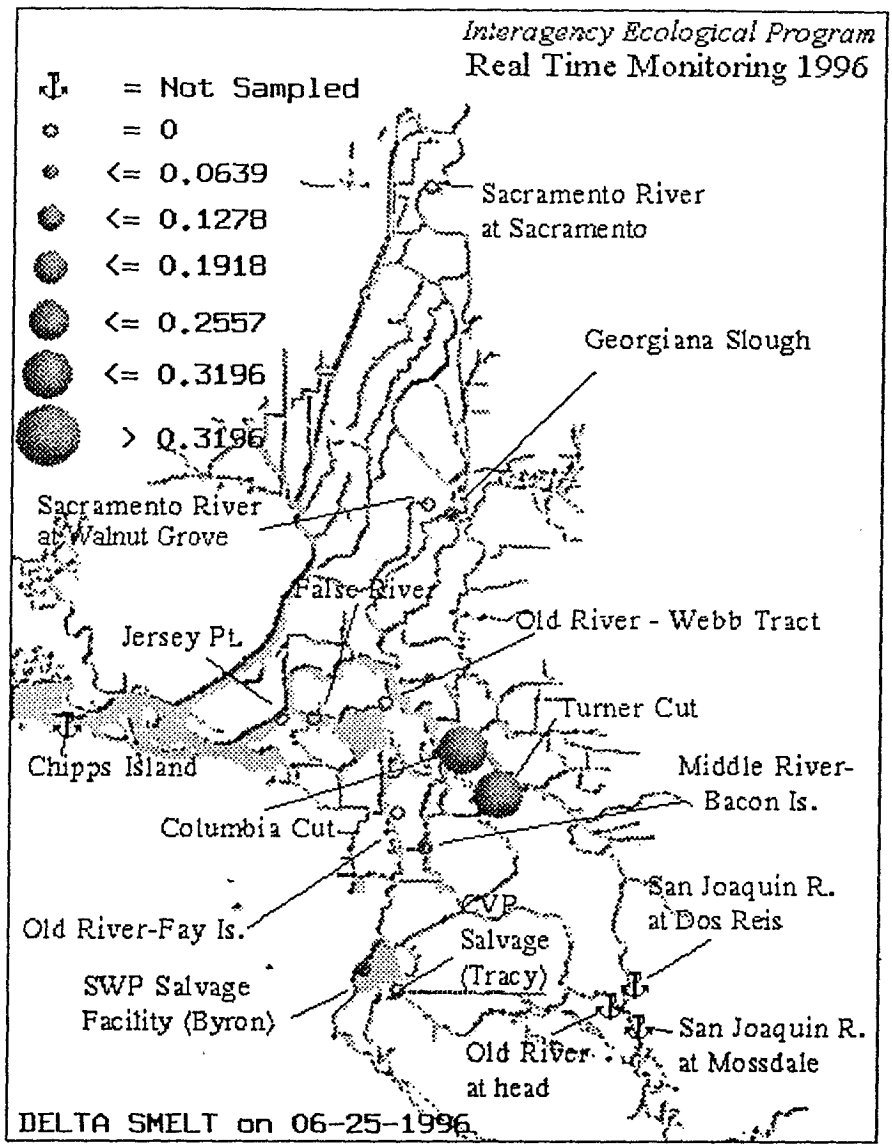
INTERAGENCY ECOLOGICAL PROGRAM REAL TIME MONITORING XCVI



A Map Of DELTA SMELT

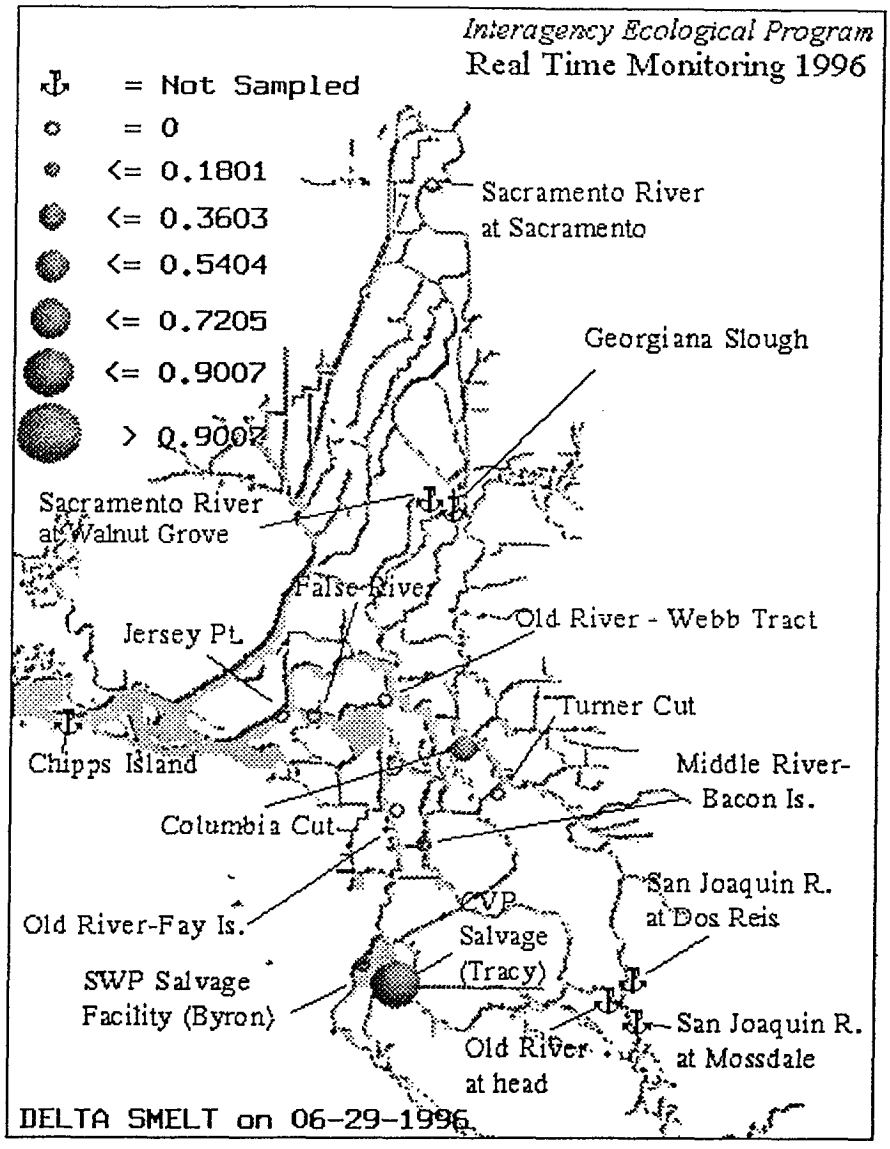
On 06-25-1996

Scaled to %

Draw Map!

[IEP Home Page] [DFG Bay-Delta] [Dept. of Water Resources] [Resources Agency-Ceres]

INTERAGENCY ECOLOGICAL PROGRAM REAL TIME MONITORING XCVI



A Map Of DELTA SMELT

On 06-29-1996

Scaled to ____ %

Draw Map!

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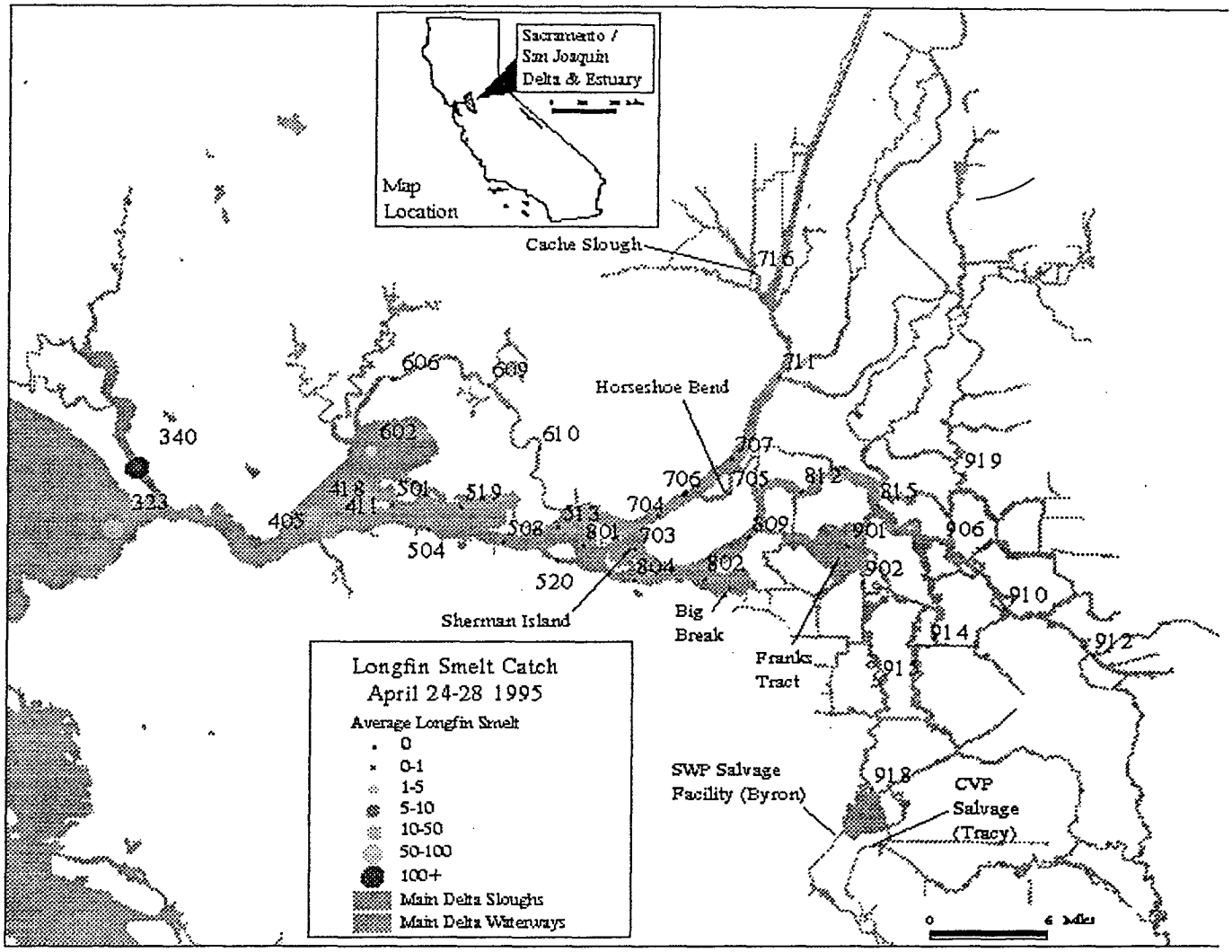


95/96

First Indicator

① winter salvage

② larval distribution (April)

Second Indicator

① Size in 20mm survey

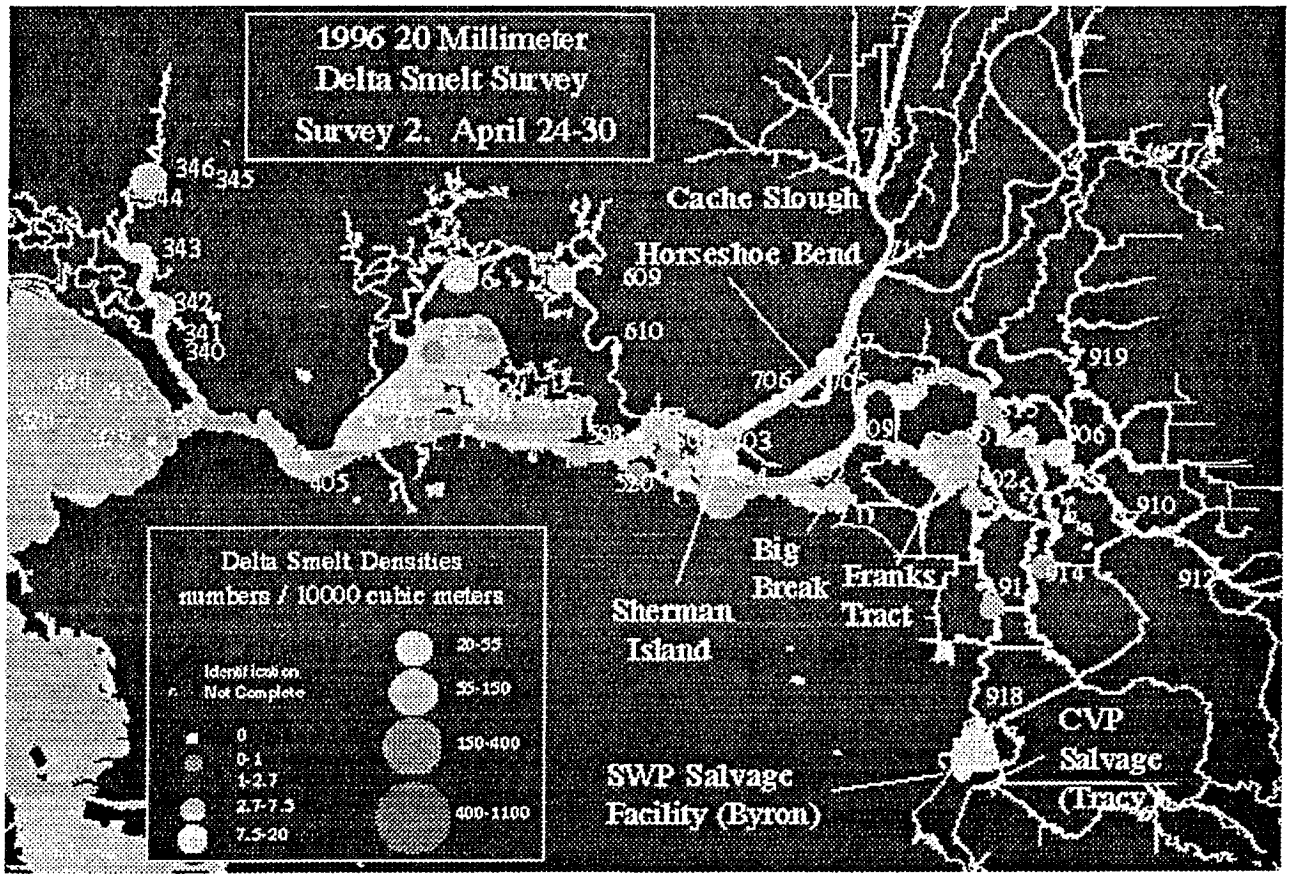
D-016154

D-016154

Survey 2 Results

Spatial and temporal distribution:

A total 165 larval/prejuvenile delta smelt were found predominantly from Napa River to the lower Sacramento River and through the central Delta. No delta smelt were found in San Pablo Bay or the Mokelumne River. Low densities were sampled in Montezuma Slough (12.0 ds/10,000 m³), Honker Bay (15.3 ds/10,000 m³), Confluence of the Sacramento/San Joaquin Rivers (30.7 ds/10,000 m³), Lower Sacramento River (3.9 ds/10,000 m³), Lower San Joaquin River (32.8 ds/10,000 m³), and the South Delta (4.6 ds/10,000 m³). The highest density was found in the Napa River (34.2 ds/10,000 m³).



Changes from last survey:

The delta smelt distribution remained almost unchanged from Survey 1. The entrapment zone was located in the vicinity of the Mothball Fleet with an outflow (5 day running average) of 38,360 cfs during the week of Survey 2. However, there was a significant increase in total delta smelt sampled between Survey 1 (n=78) and 2 (n=165).

Size distribution:

A total of 165 delta smelt ranging in size from 5 to 19 mm were sampled during Survey 2.

D-016155

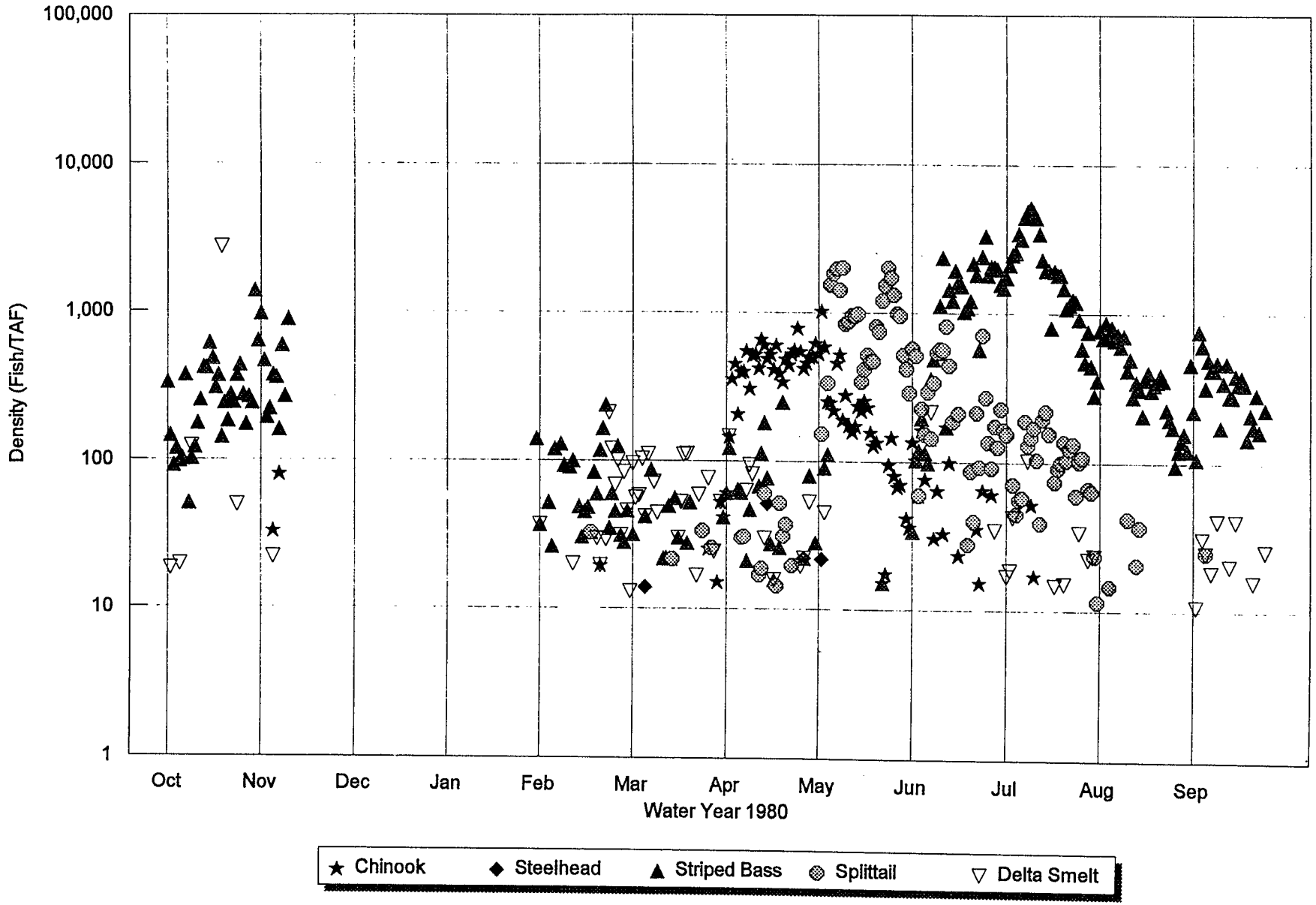
D-016155

CVP and SWP SALVAGE DATA

1979-1996

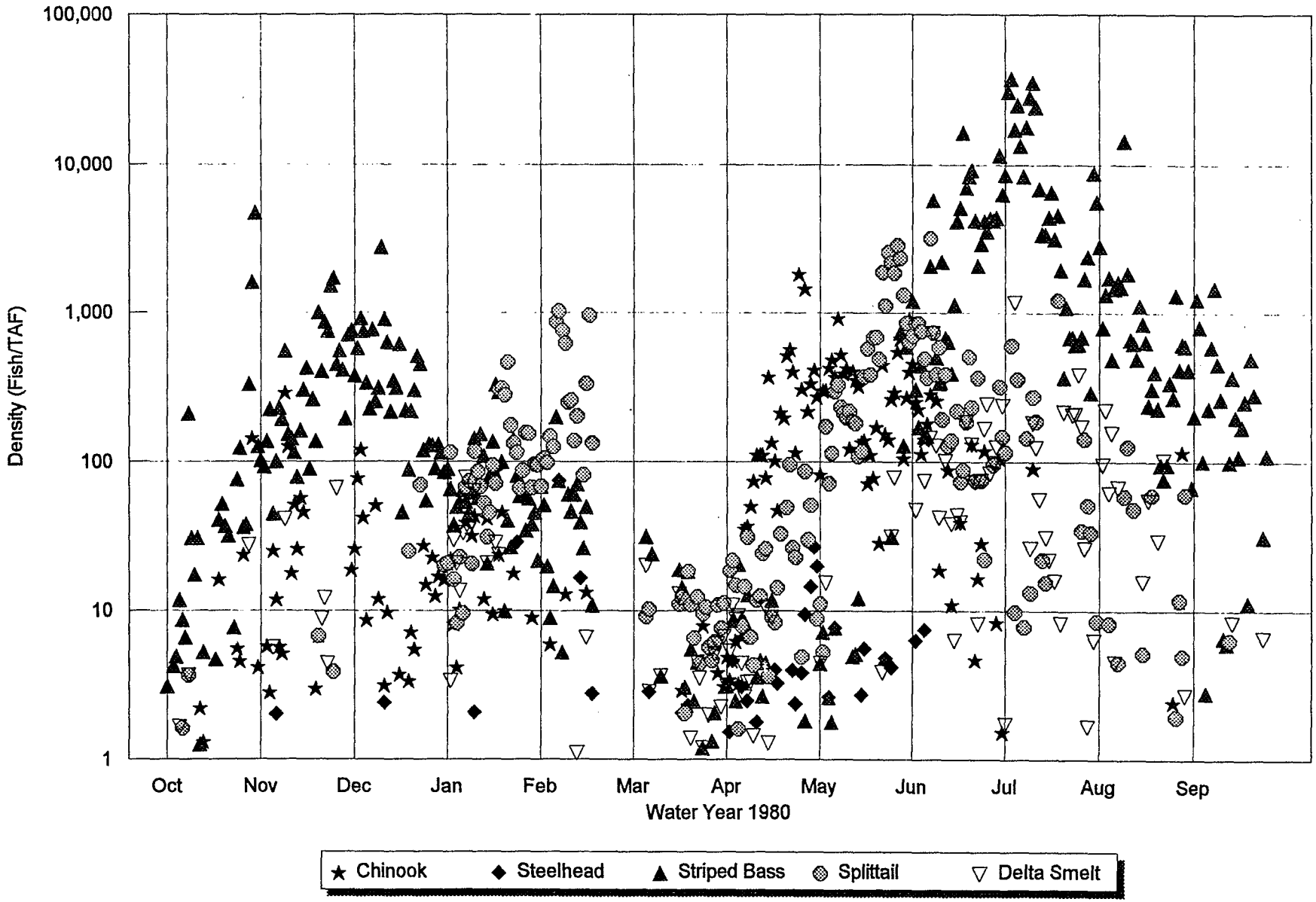
Density of Chinook Salmon, Steelhead, Striped Bass, Splittail, and Delta Smelt

CVP Salvage Density



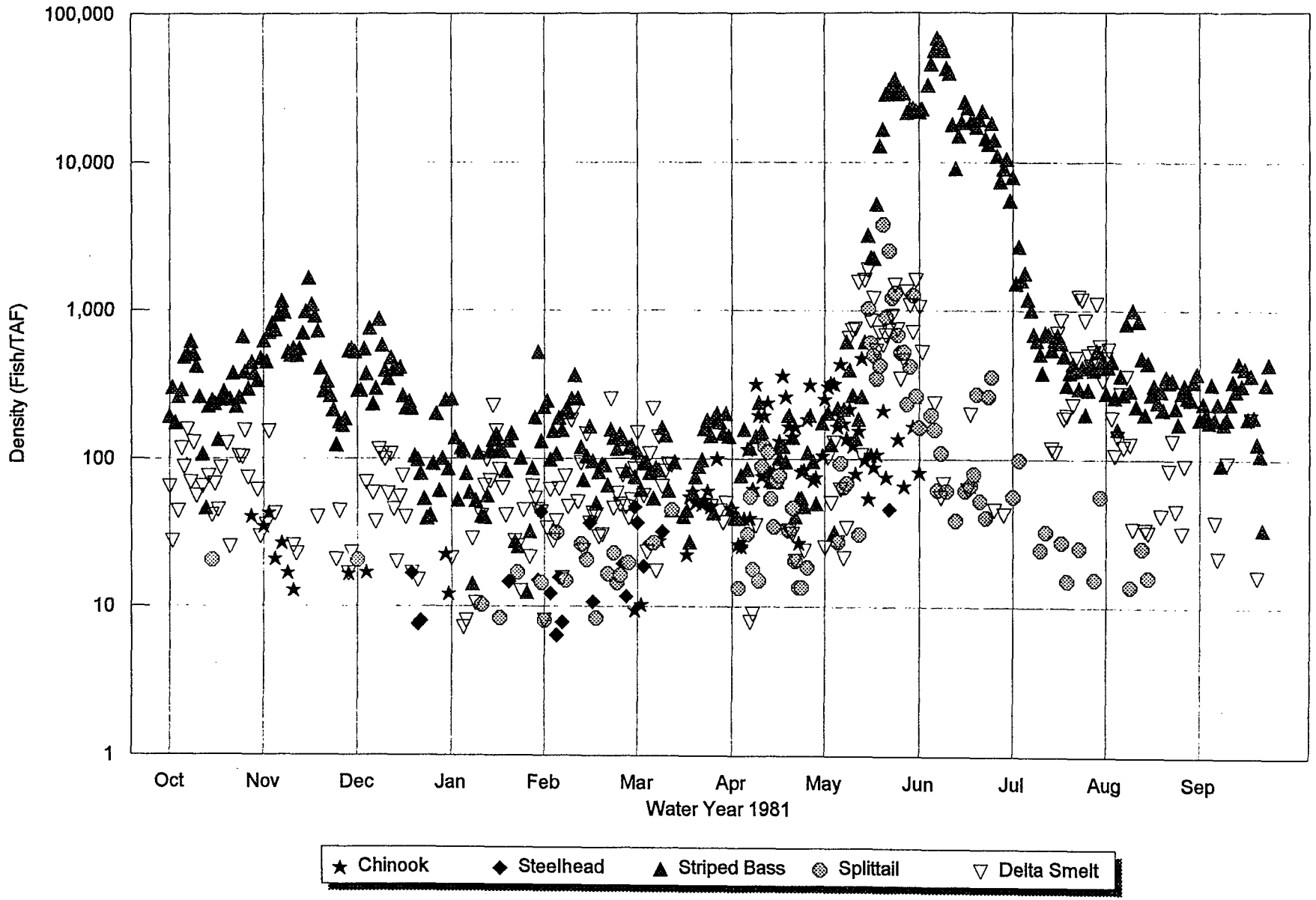
D-016157

SWP Salvage Density



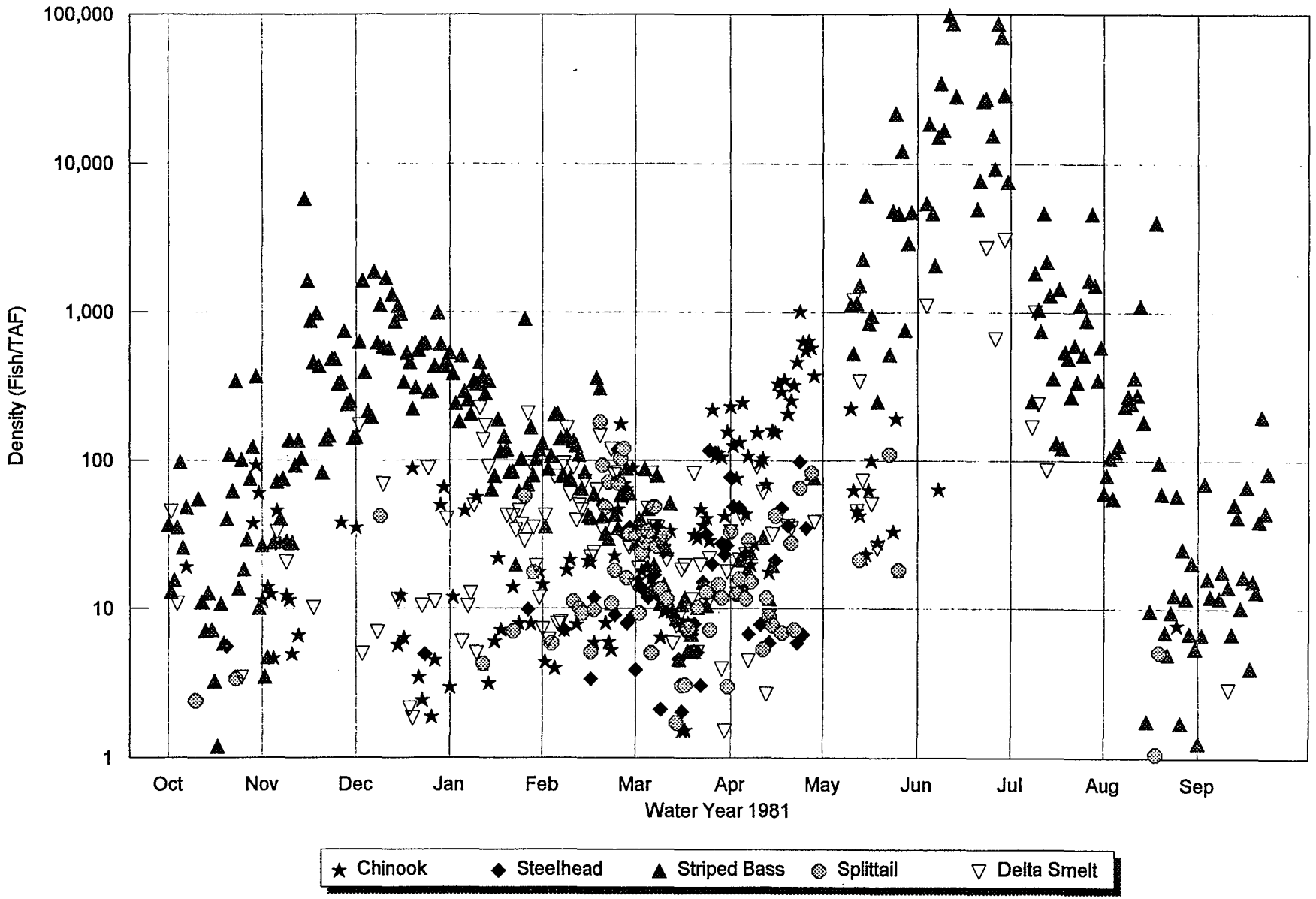
D-016159

CVP Salvage Density



D—016159

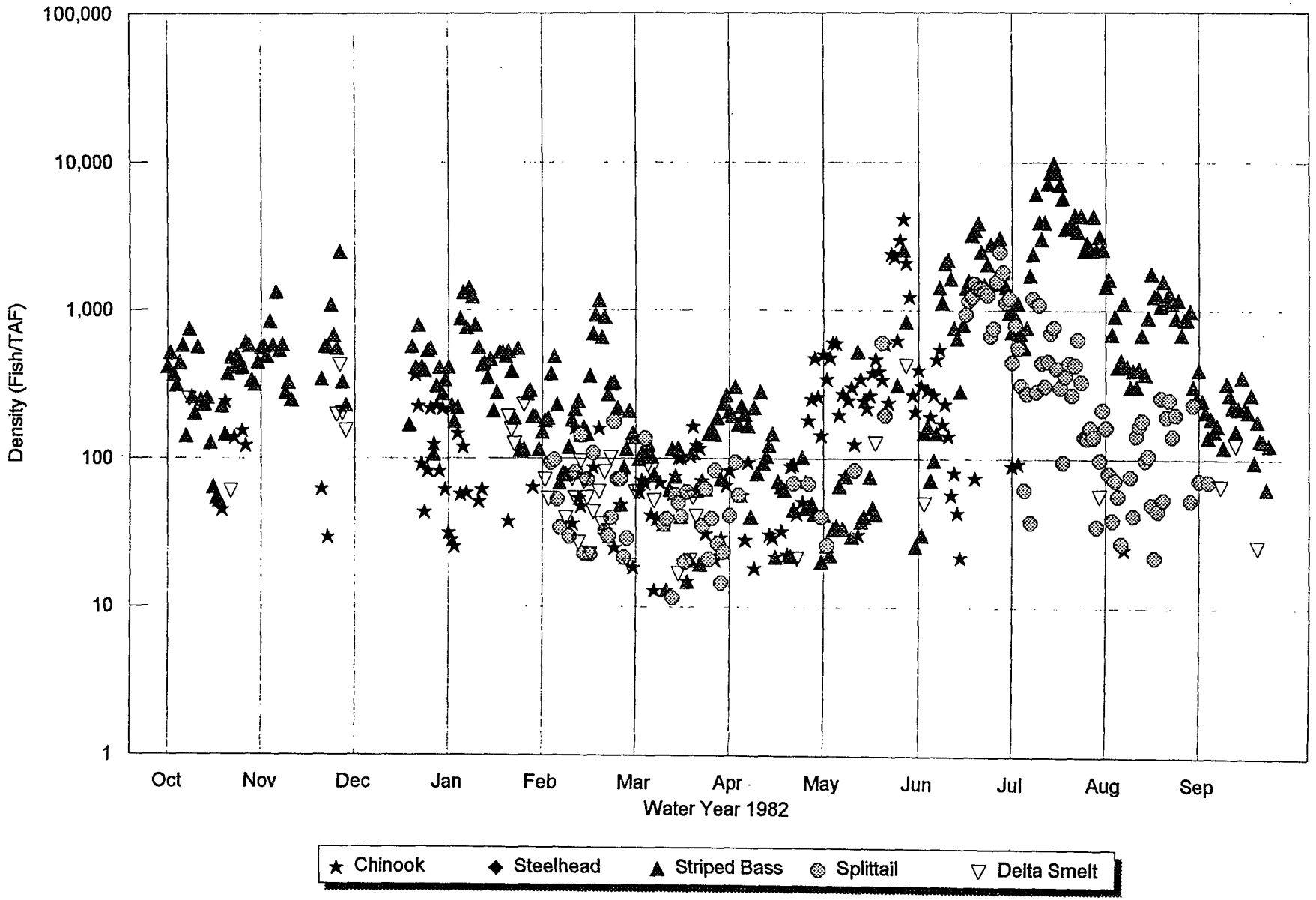
SWP Salvage Density



D-016160

D-016161

CVP Salvage Density



D—016161

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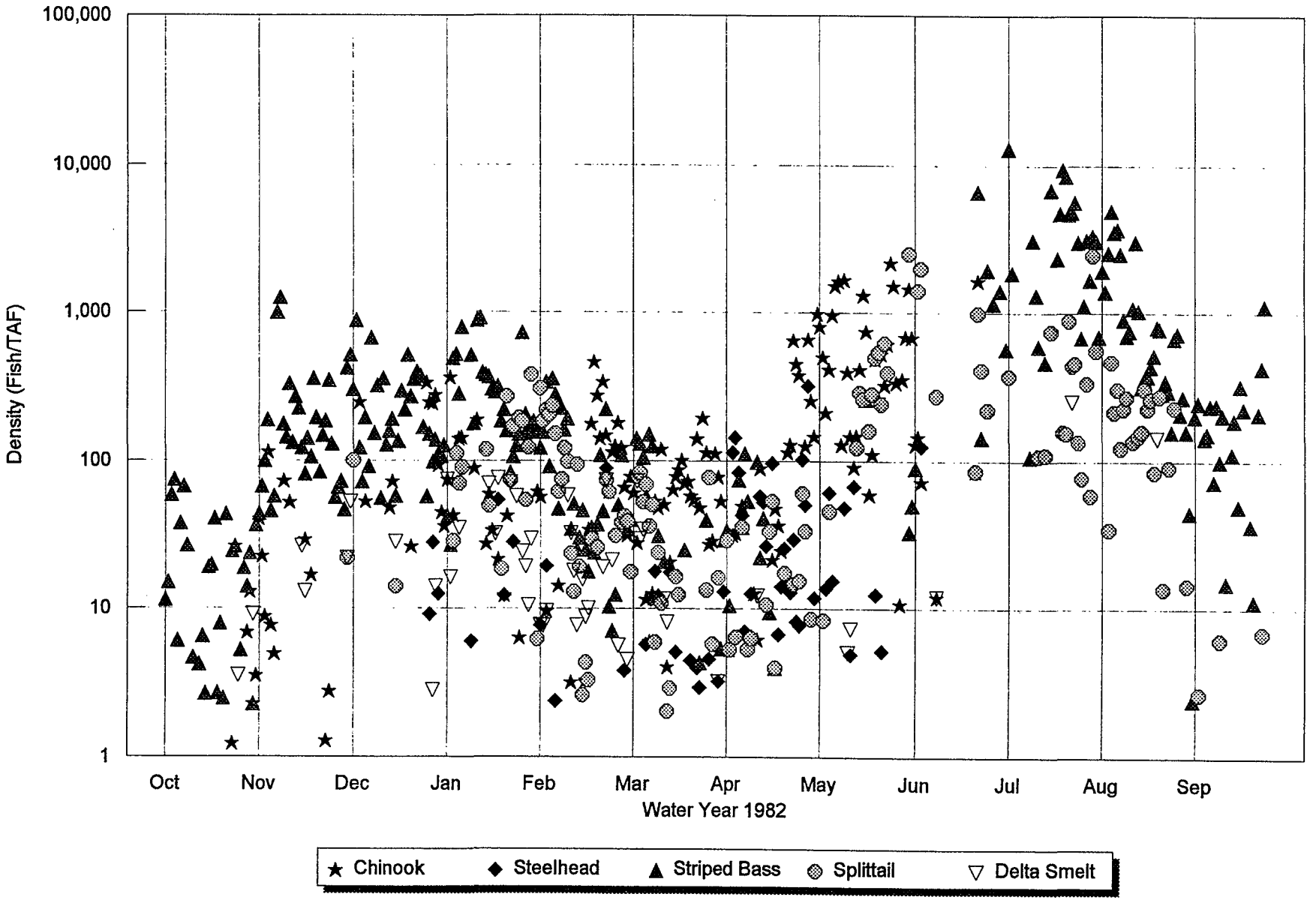
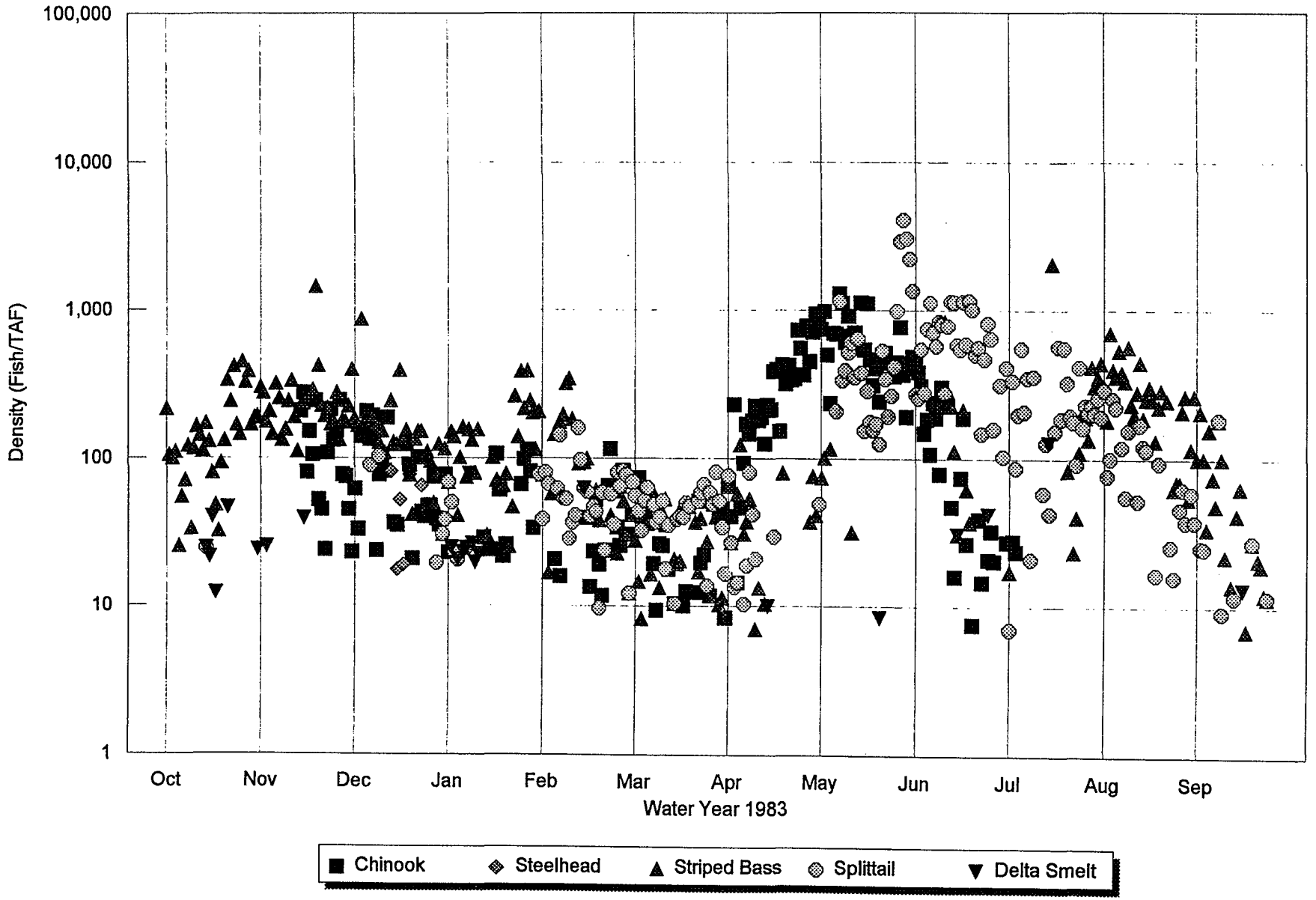


D-016163

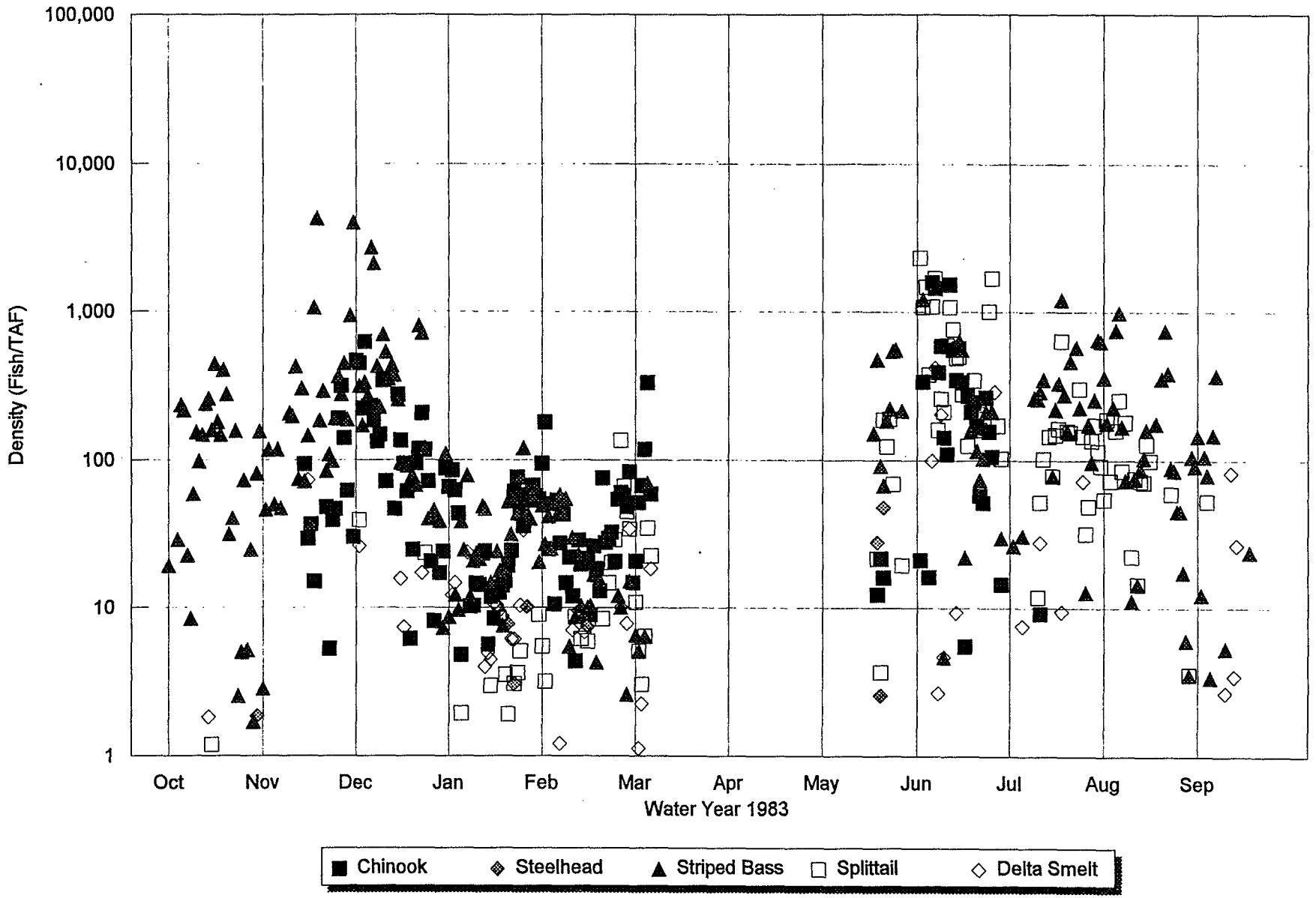
CVP Salvage Density



D—016163

D-016164

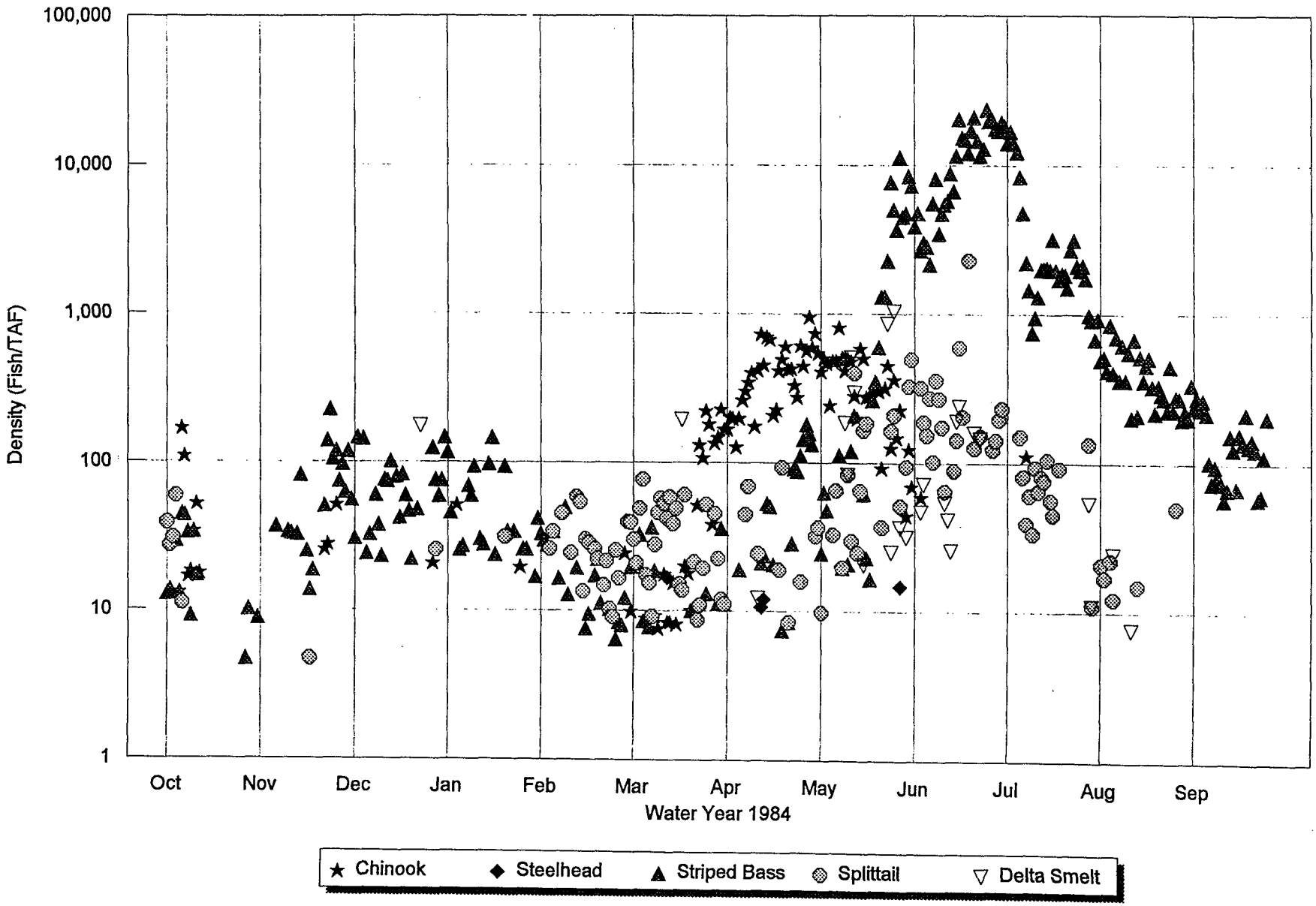
SWP Salvage Density



D—016164

D-016165

CVP Salvage Density



D—016165

D-016166

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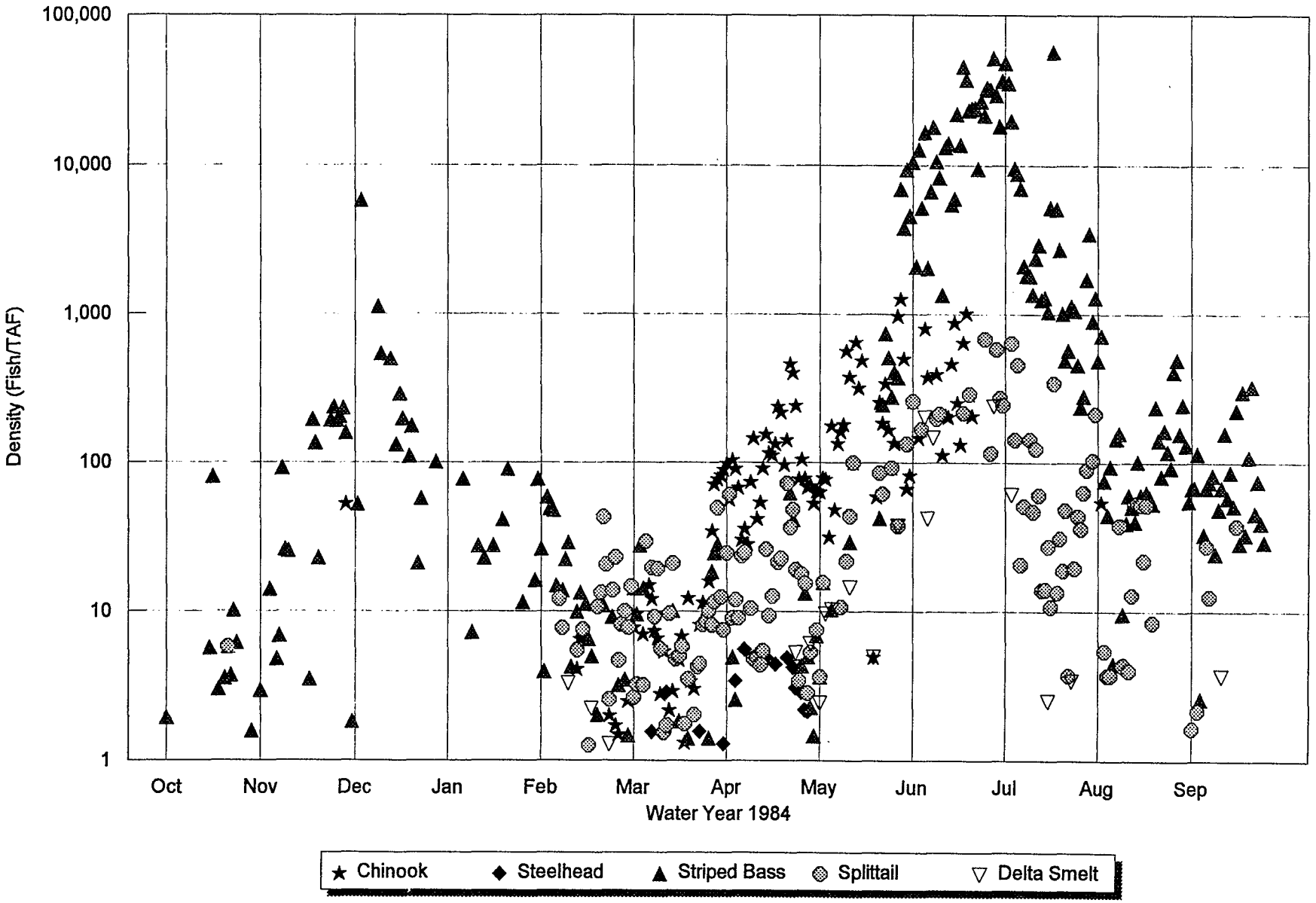

D—016166

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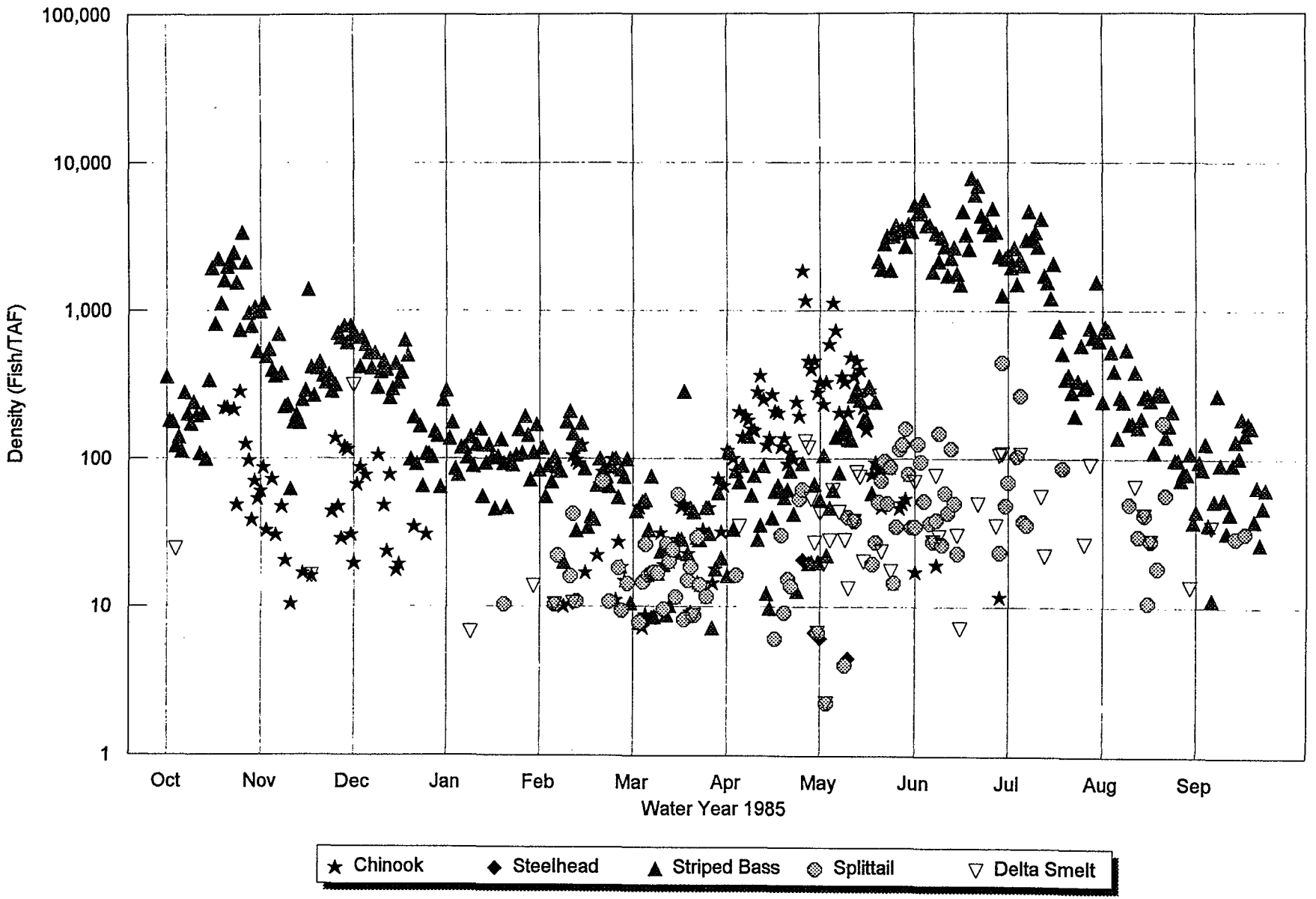
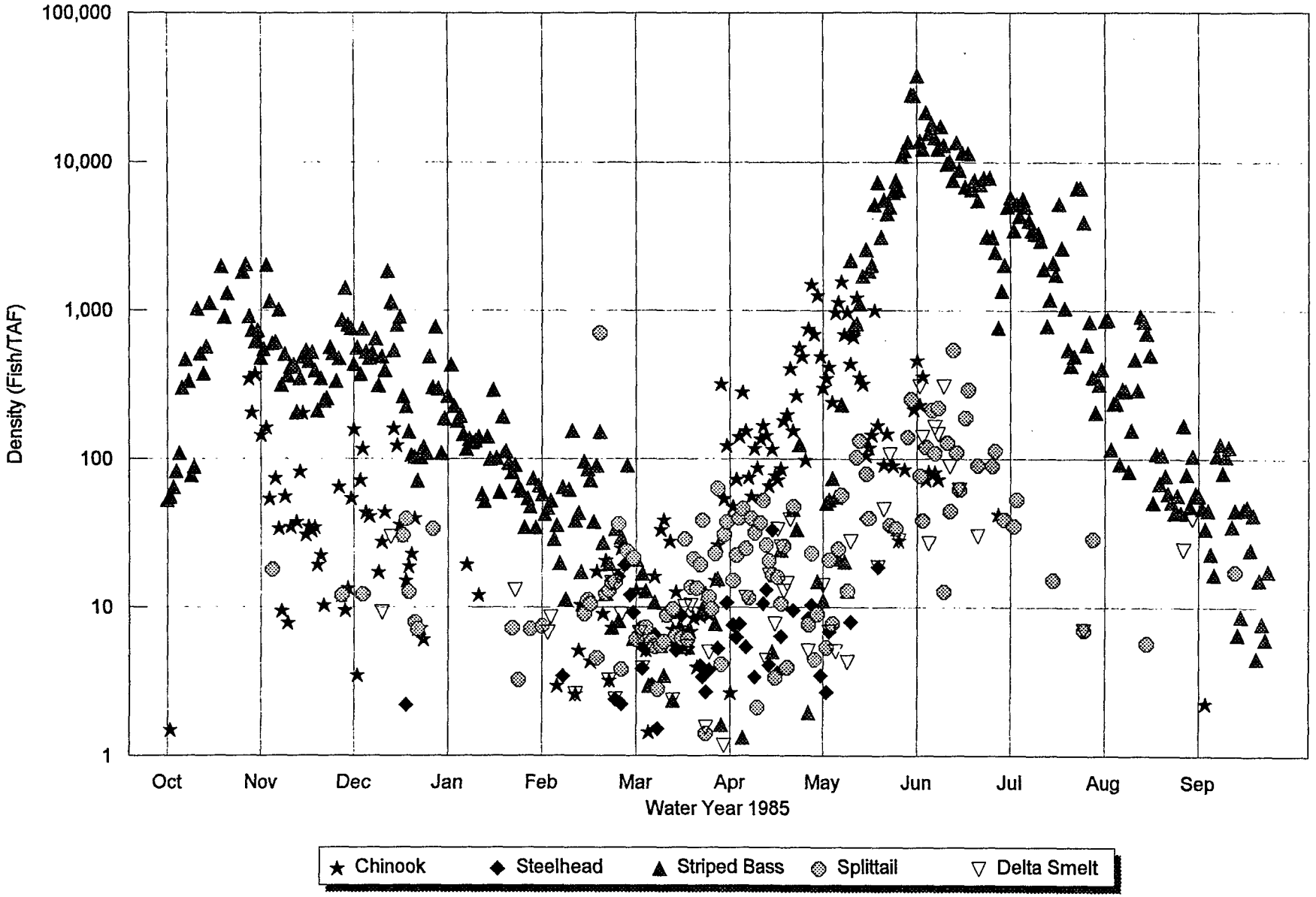


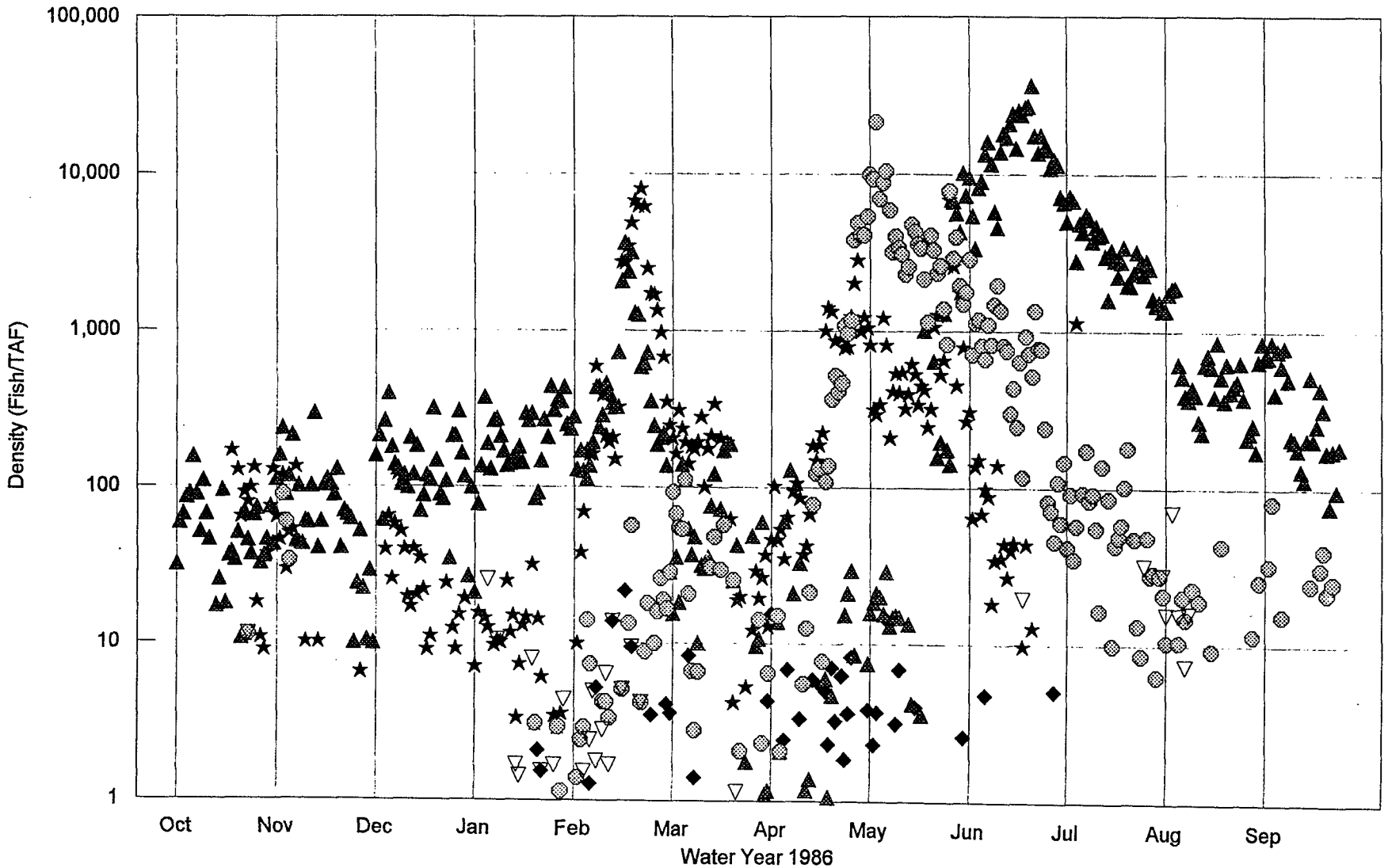
D-016168

SWP Salvage Density



D—016168

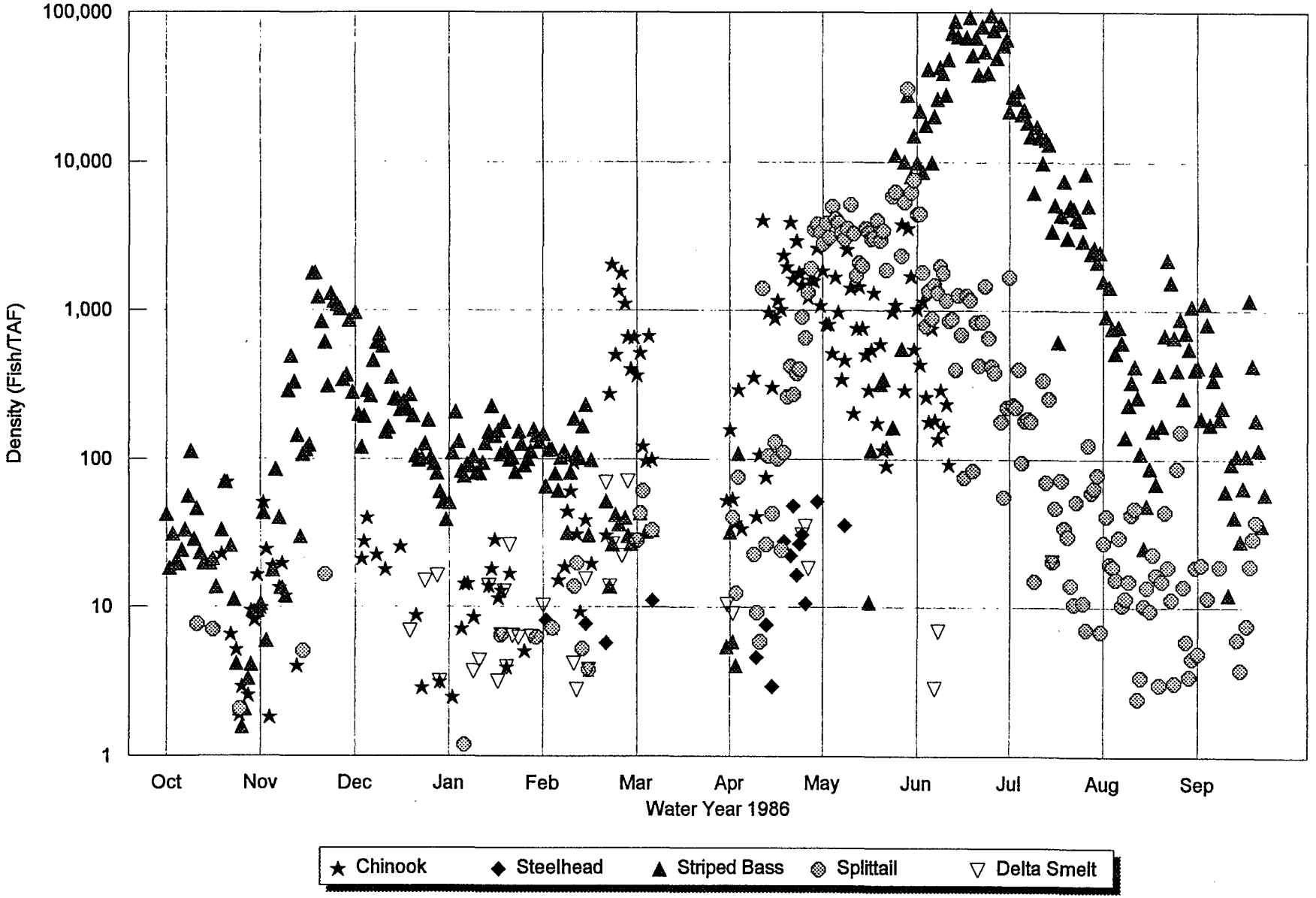
CVP Salvage Density



★ Chinook ◆ Steelhead ▲ Striped Bass ● Splittail ▽ Delta Smelt

D-016170

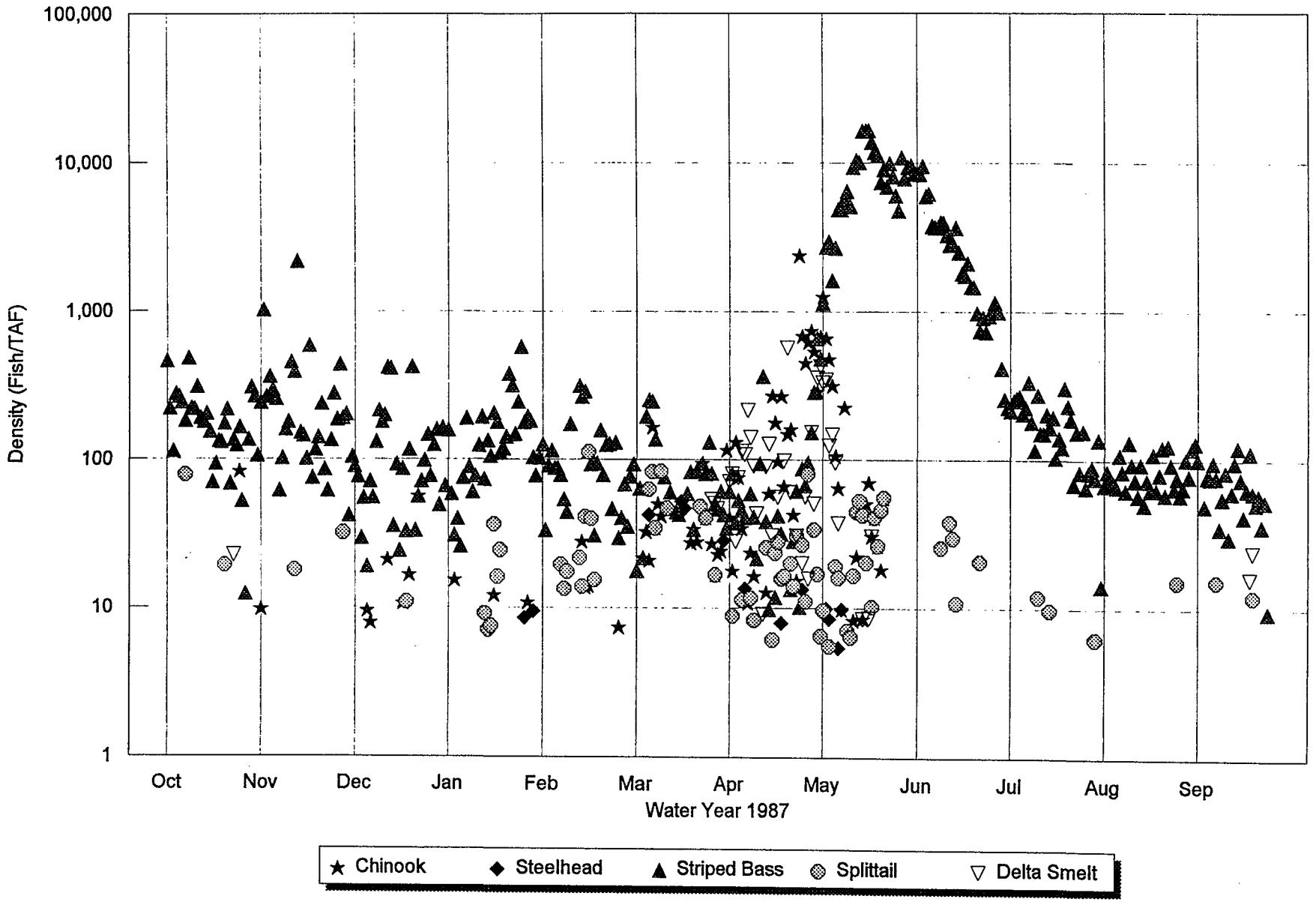
SWP Salvage Density



D—016170

D-016171

CVP Salvage Density



D—016171

D-016172

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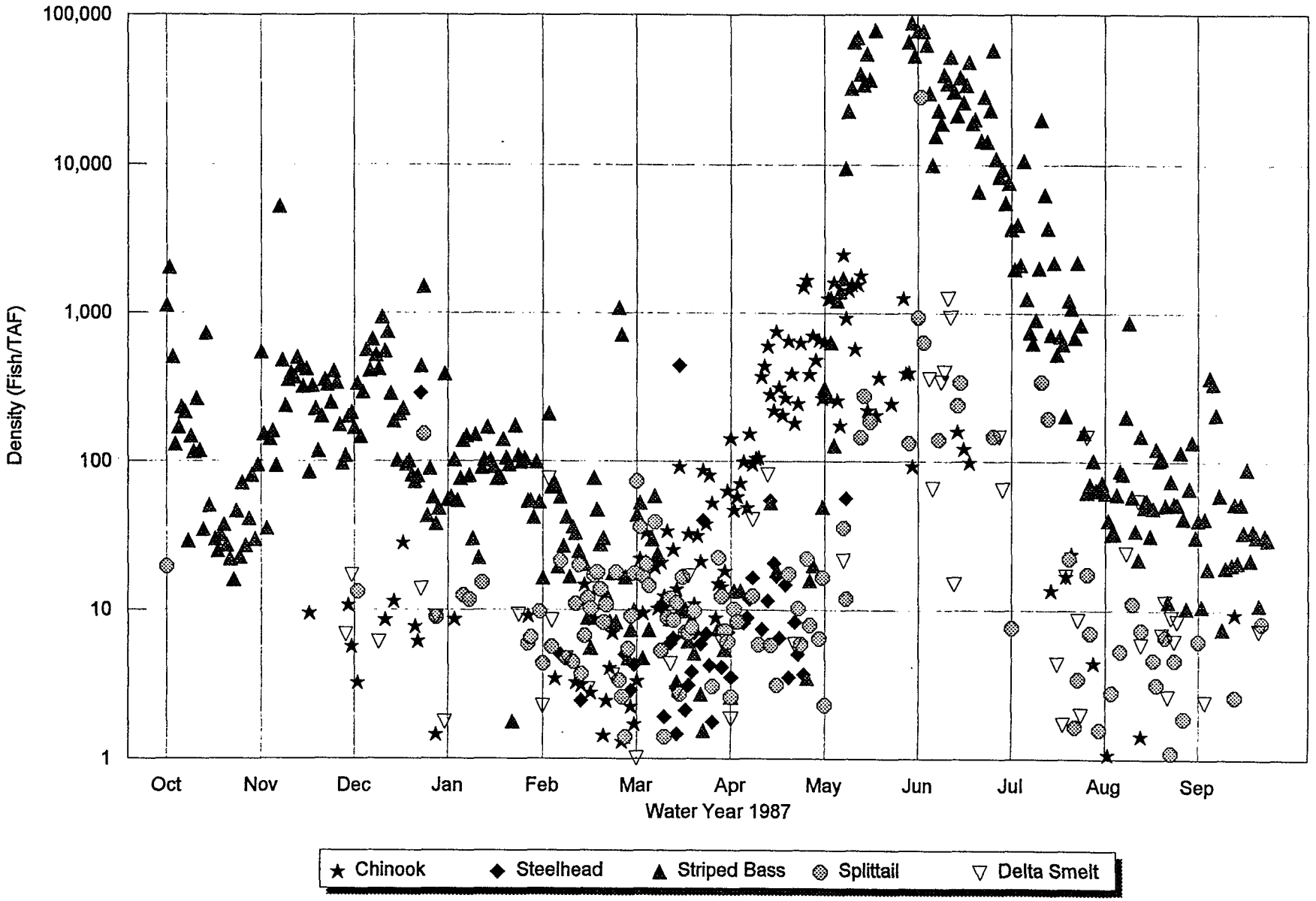

D—016172

D-016173

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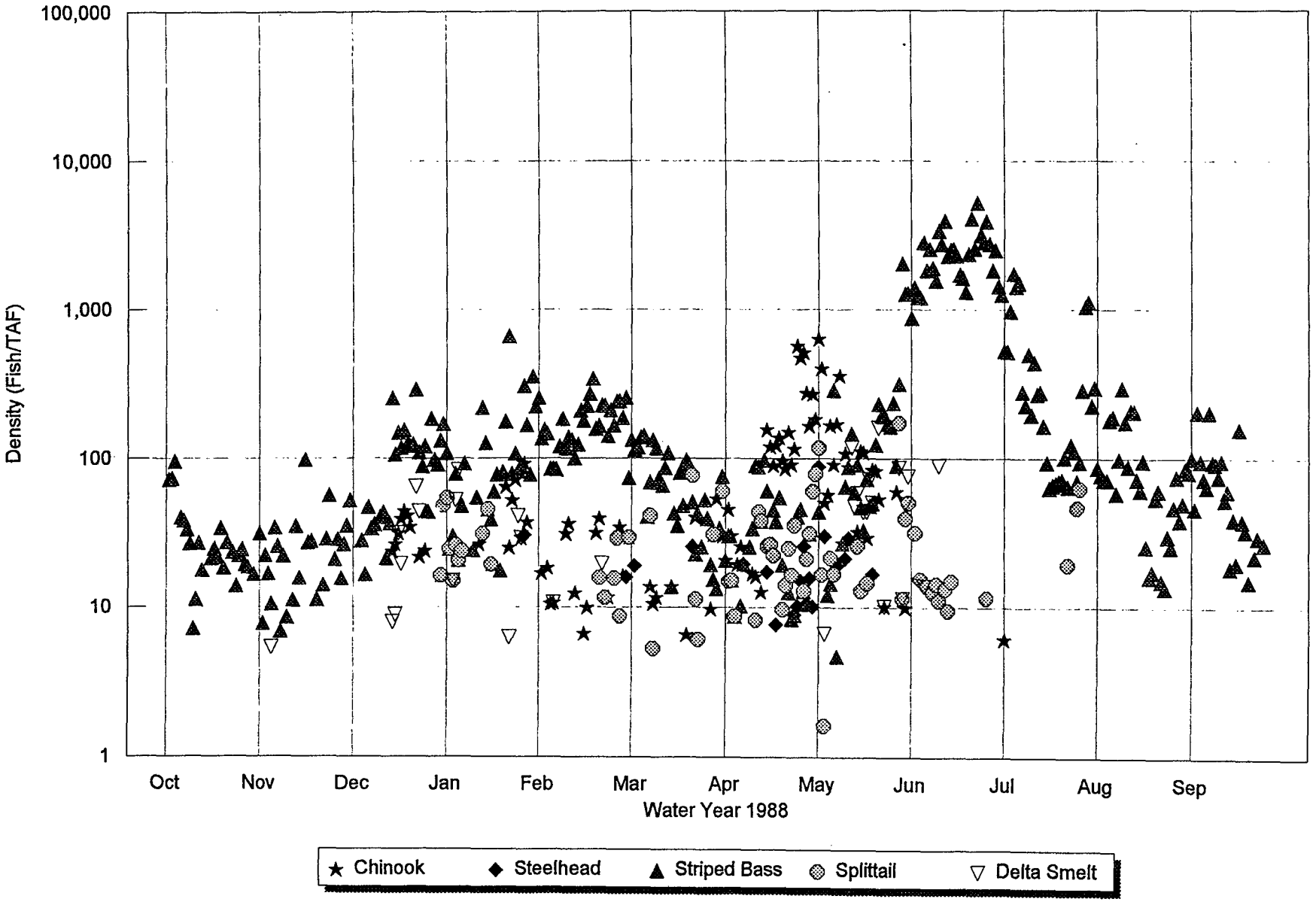

D—016173

D-016174

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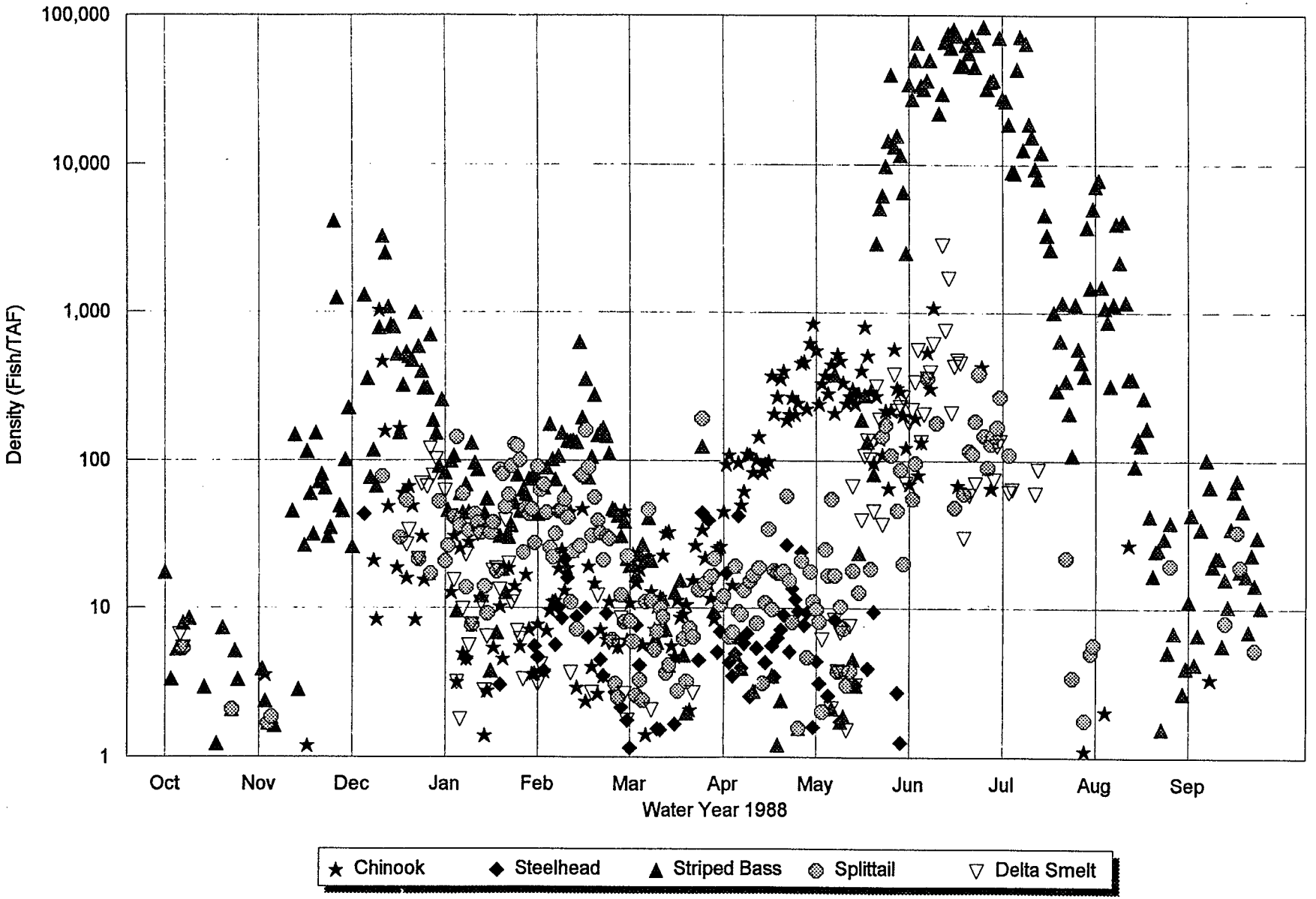

D—016174

D-016175

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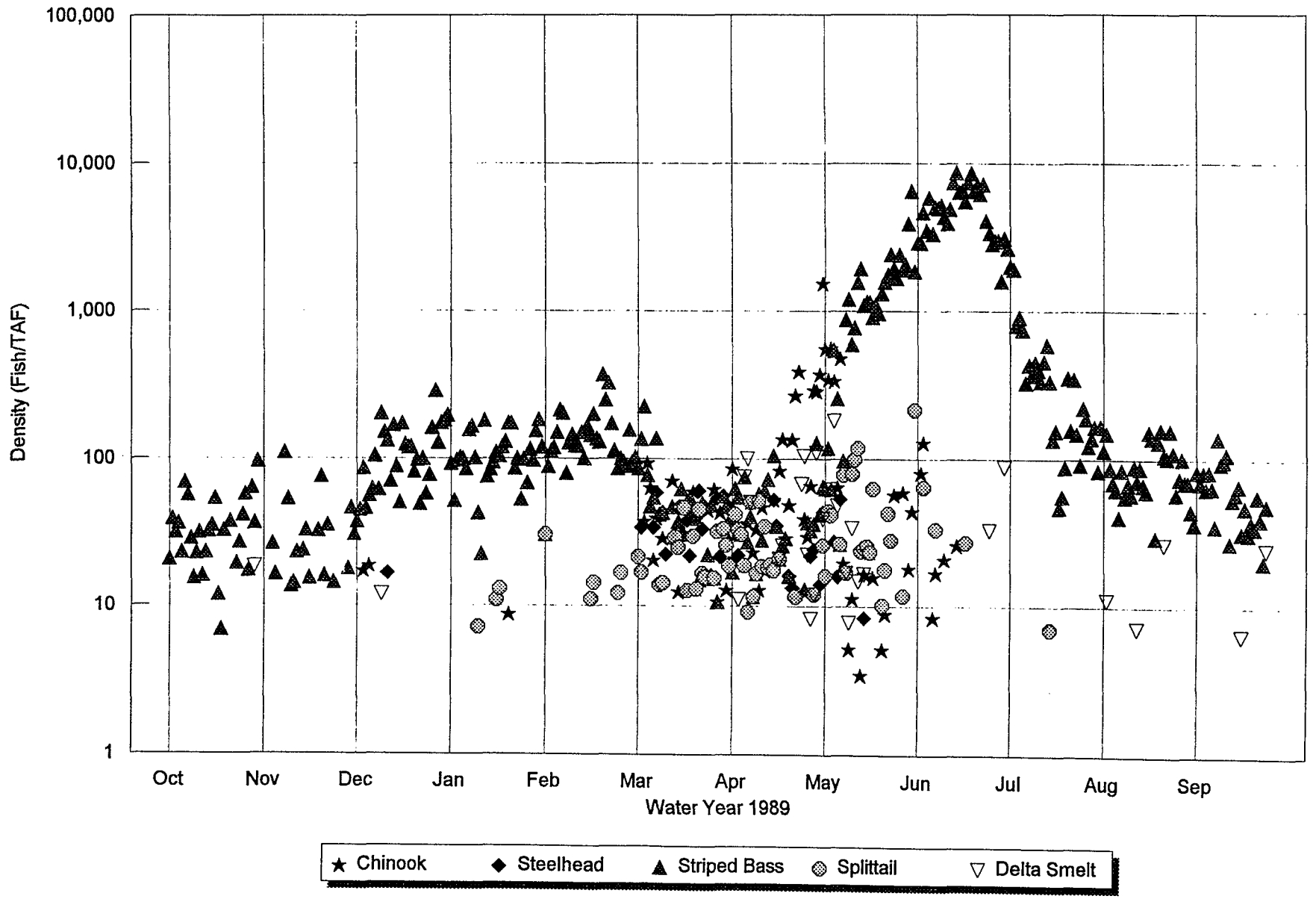

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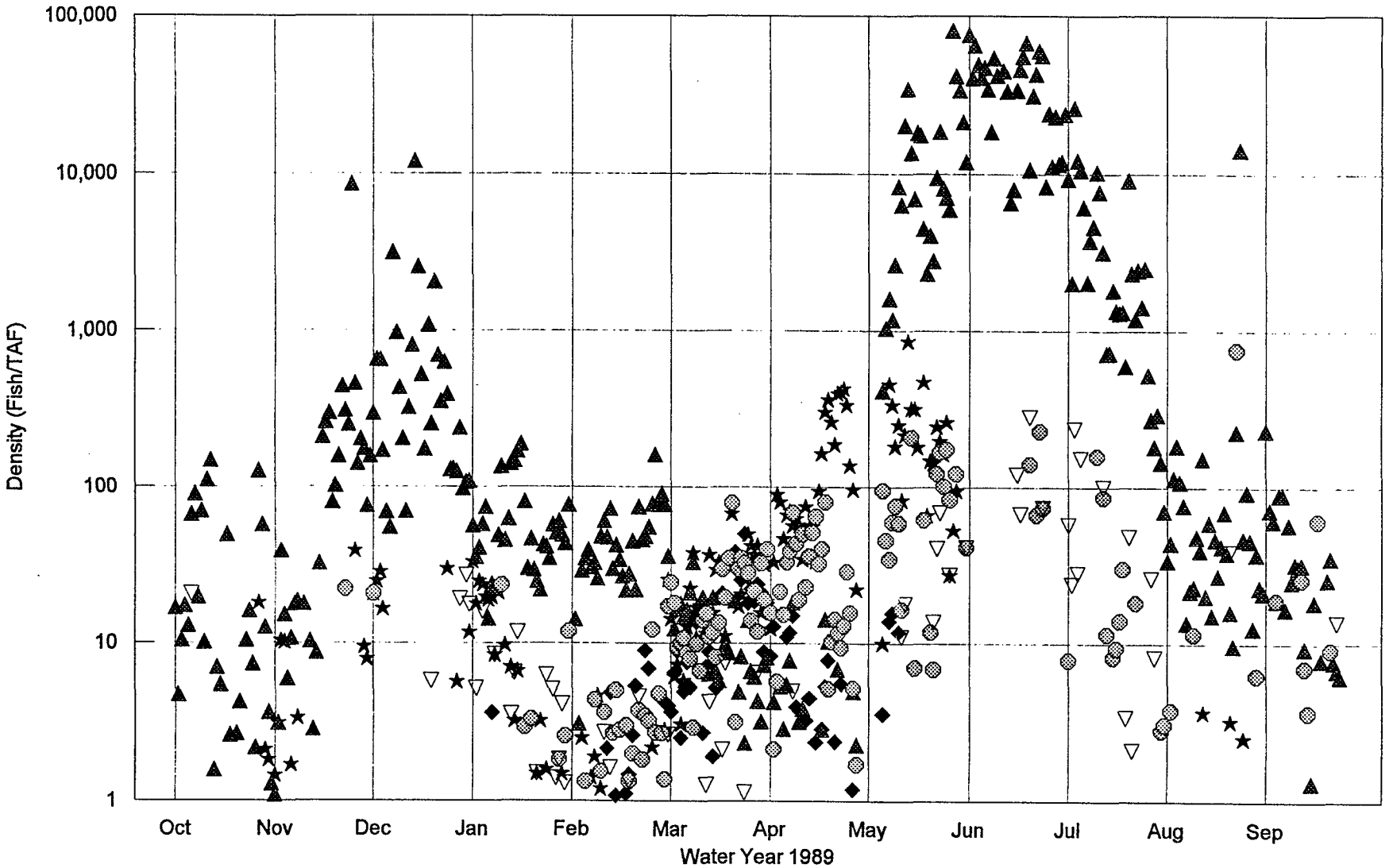

D—016176

D-016177

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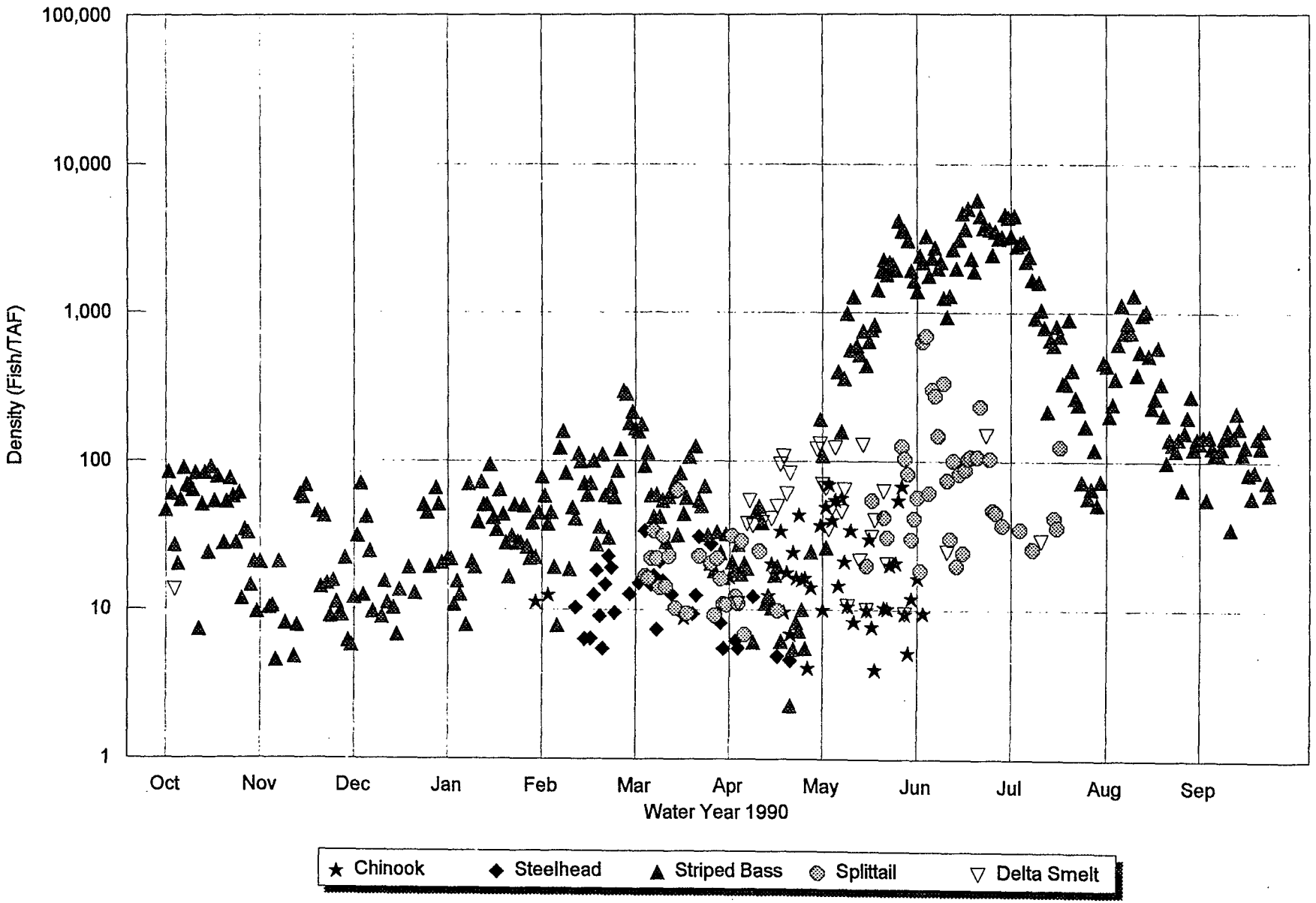

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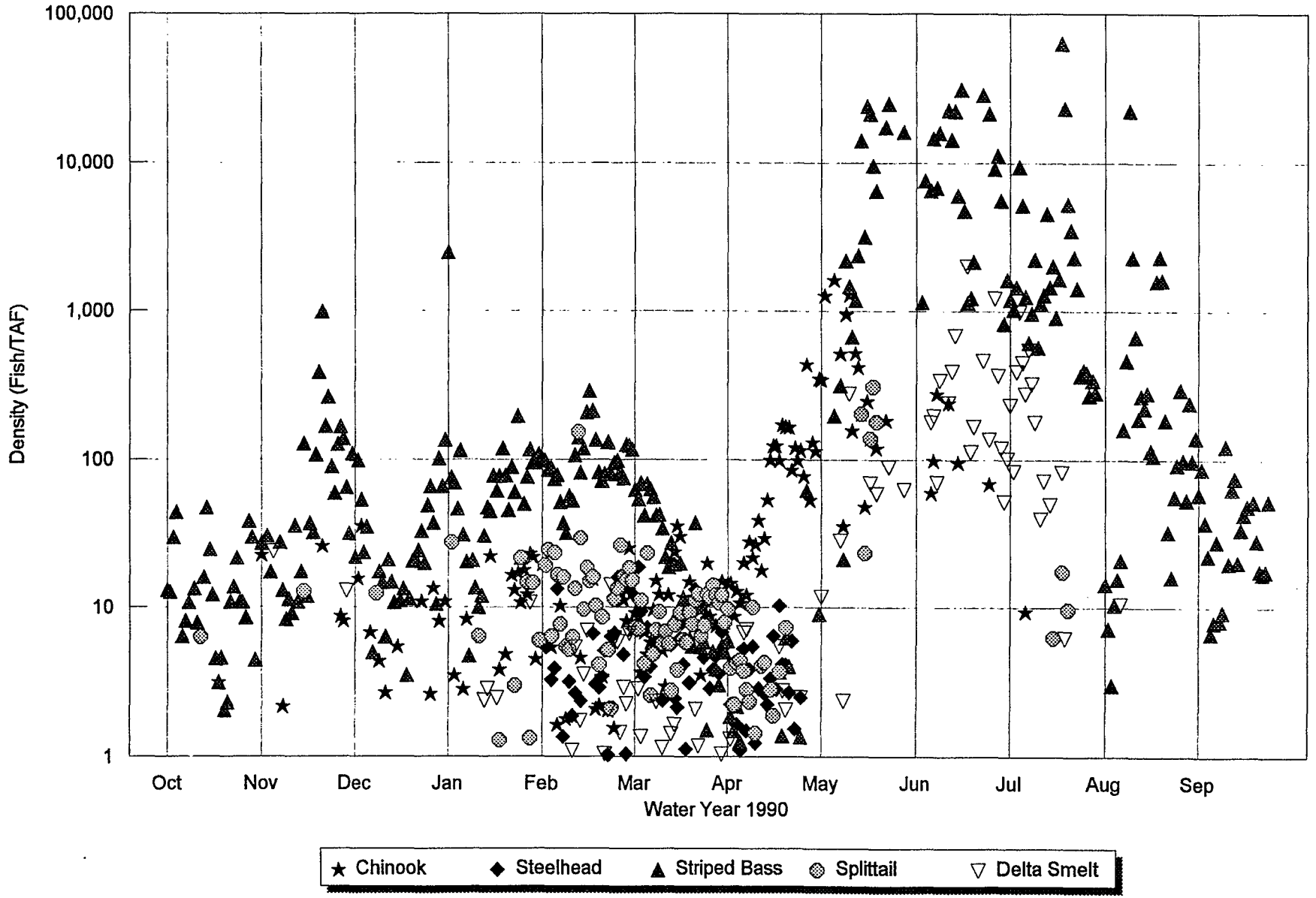

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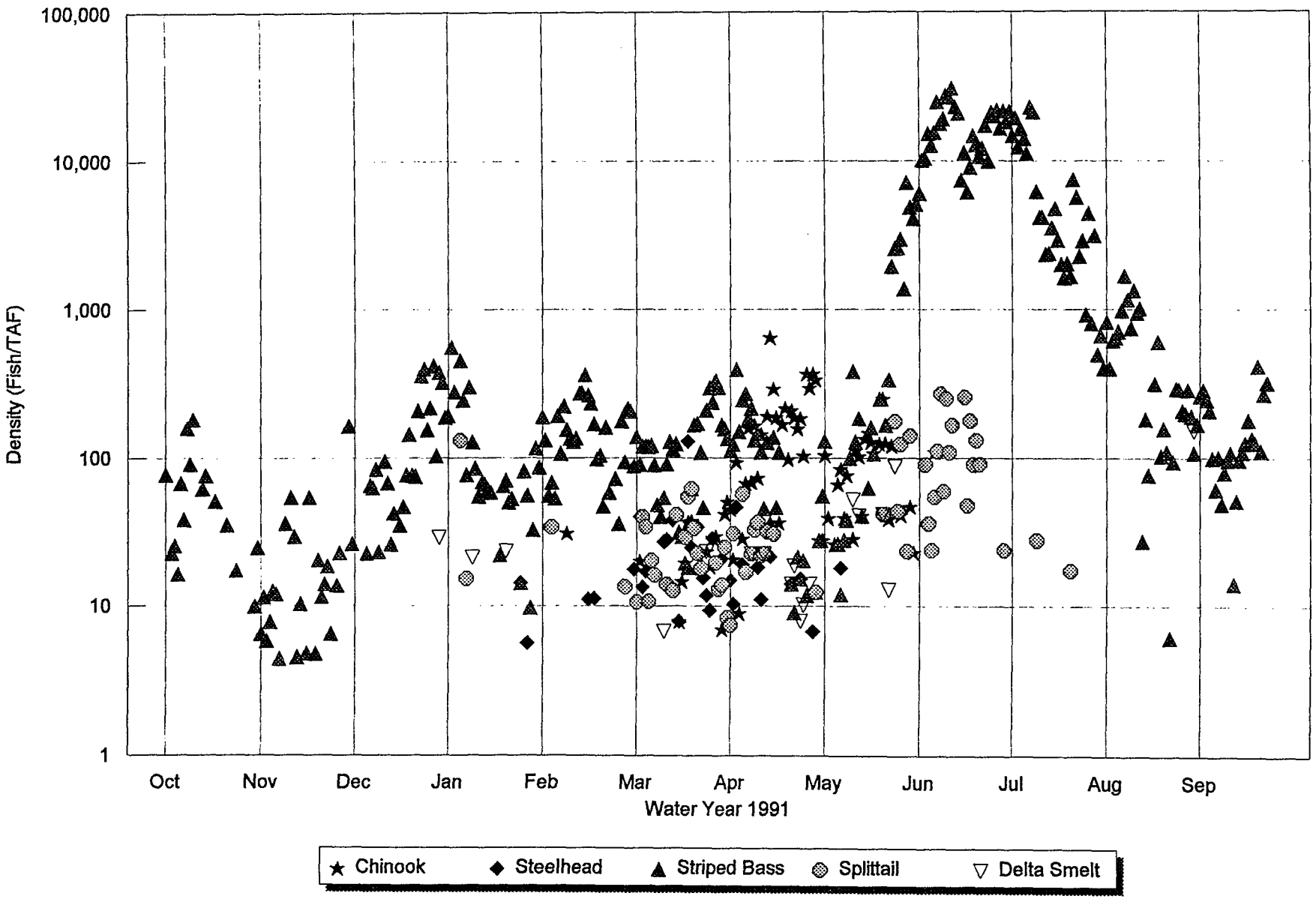

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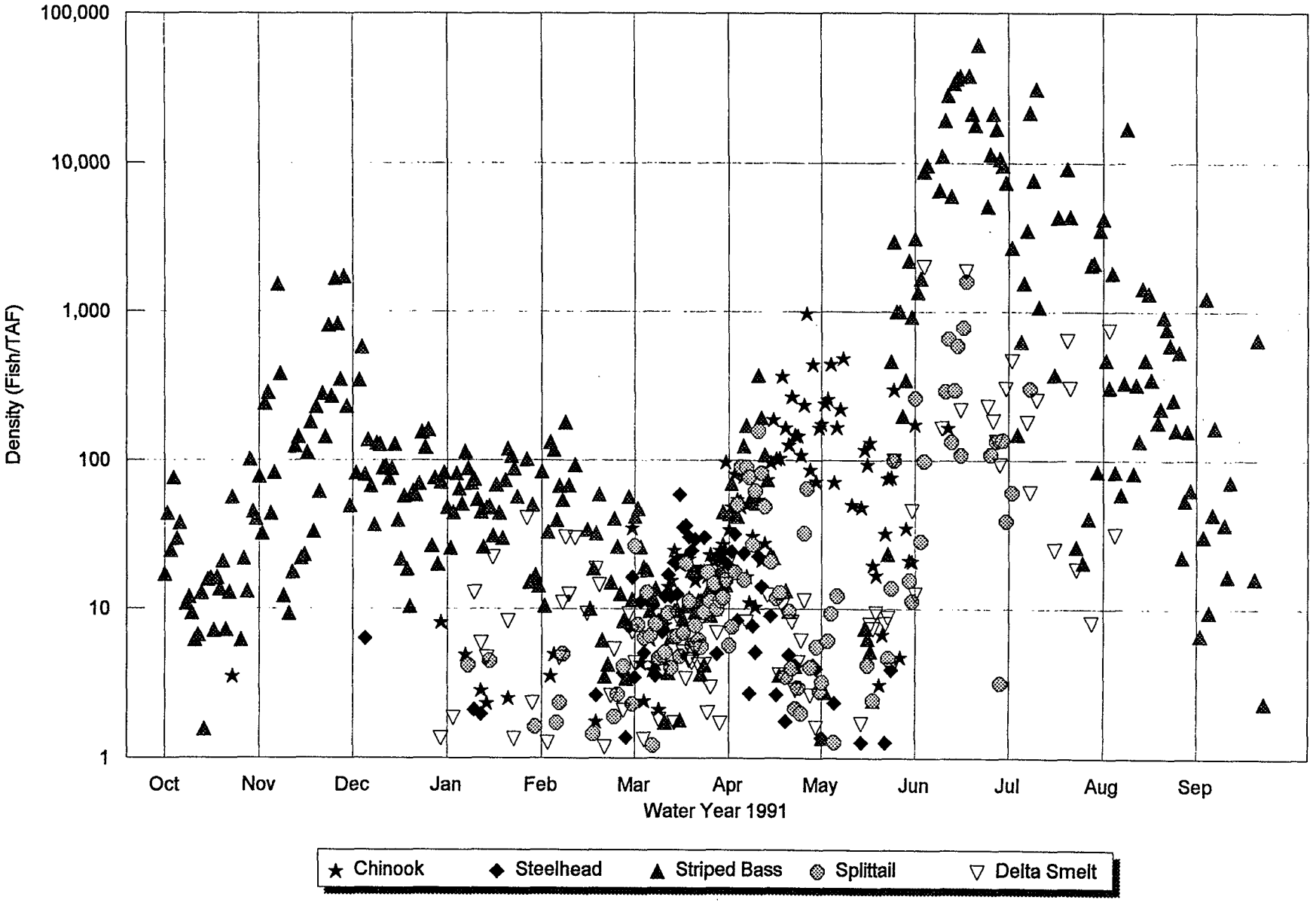

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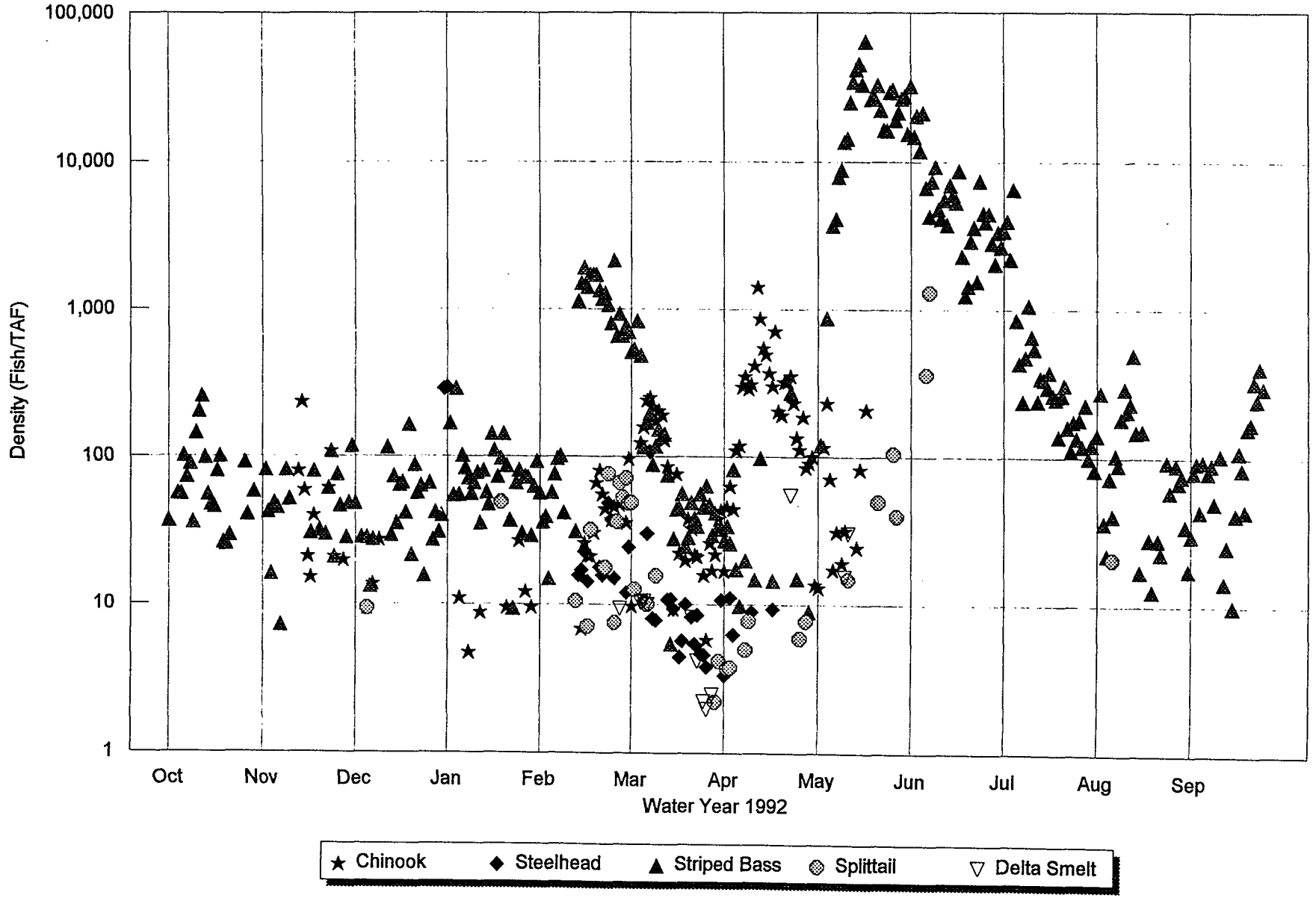

D—016181

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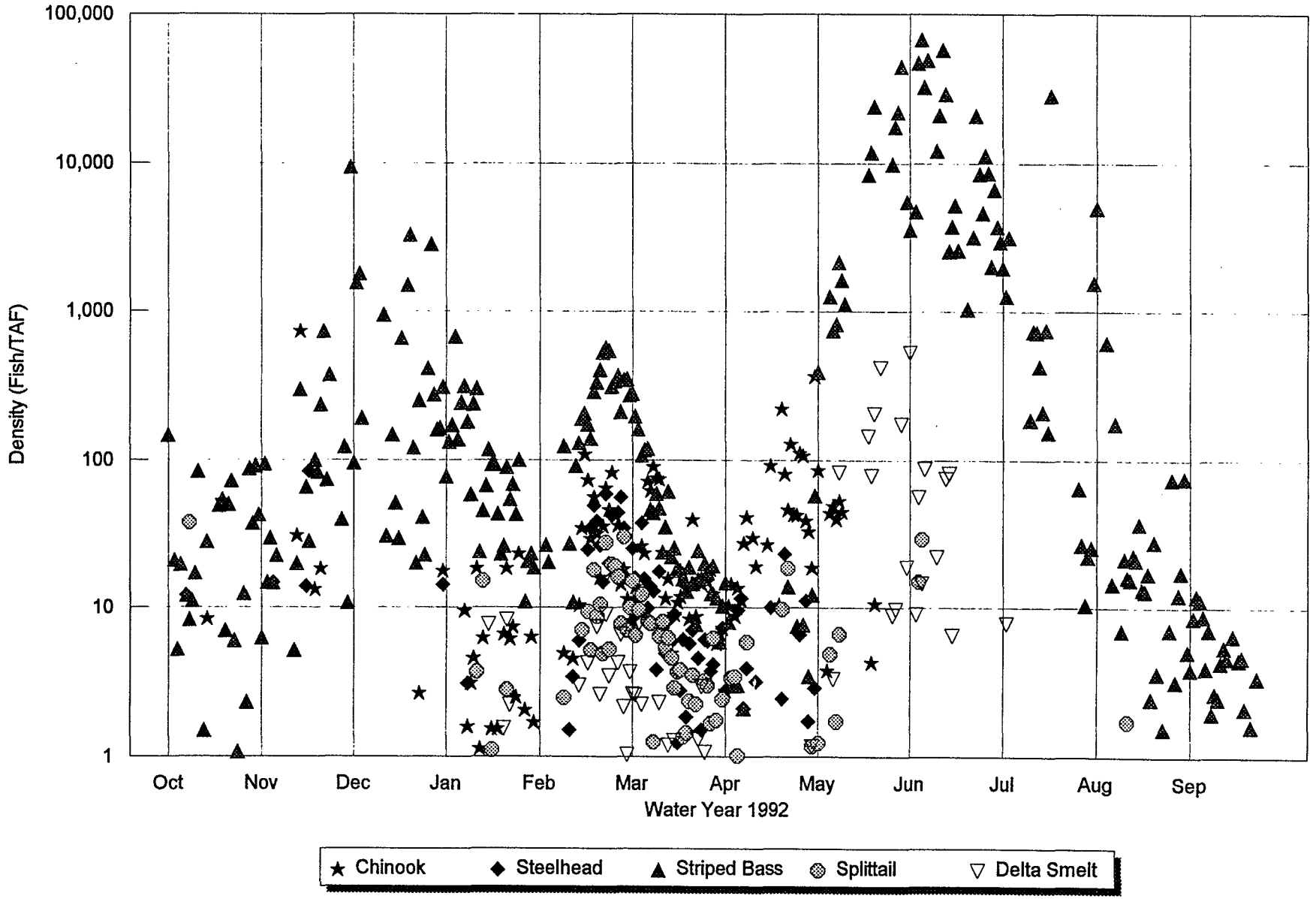

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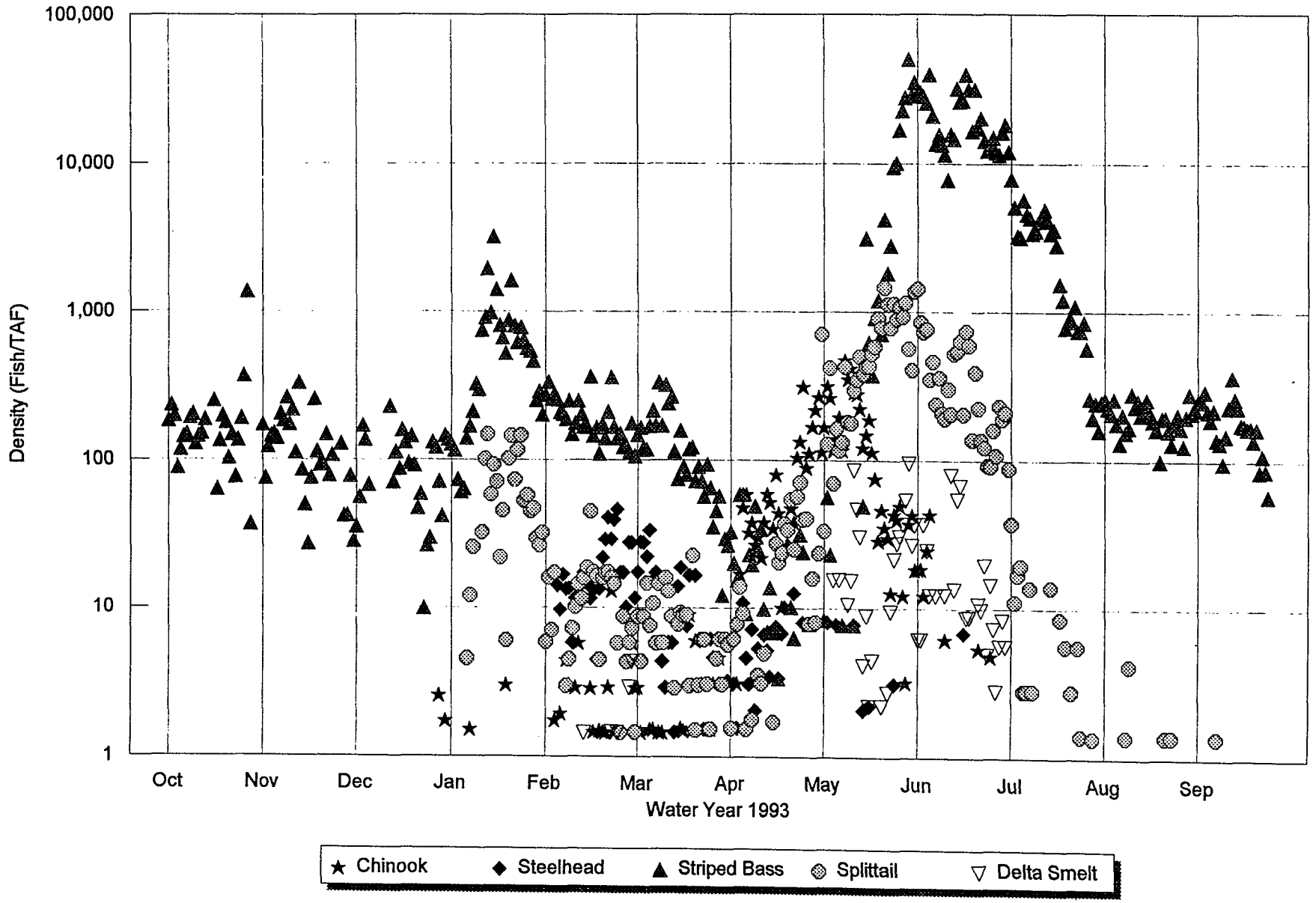

D—016183

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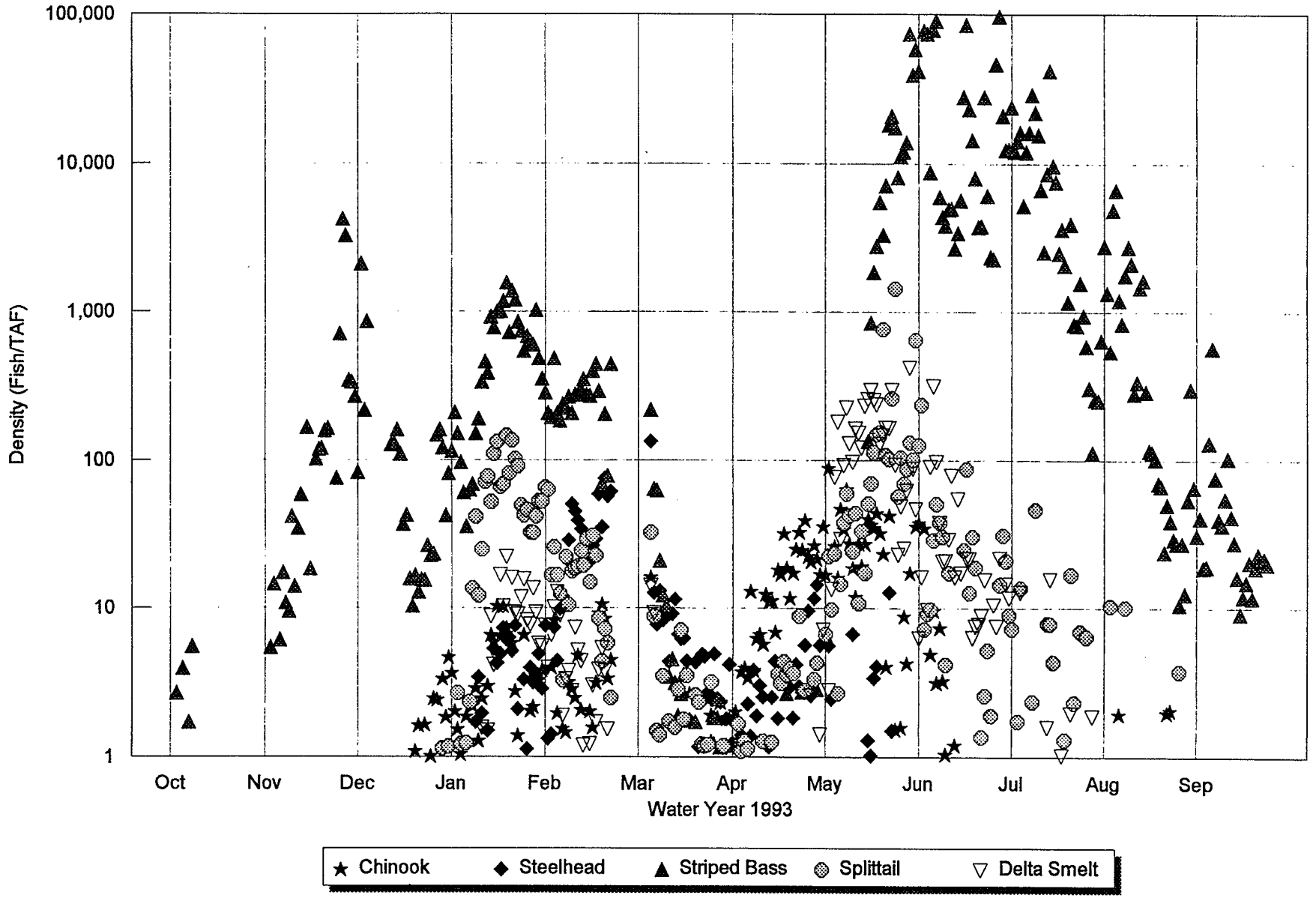

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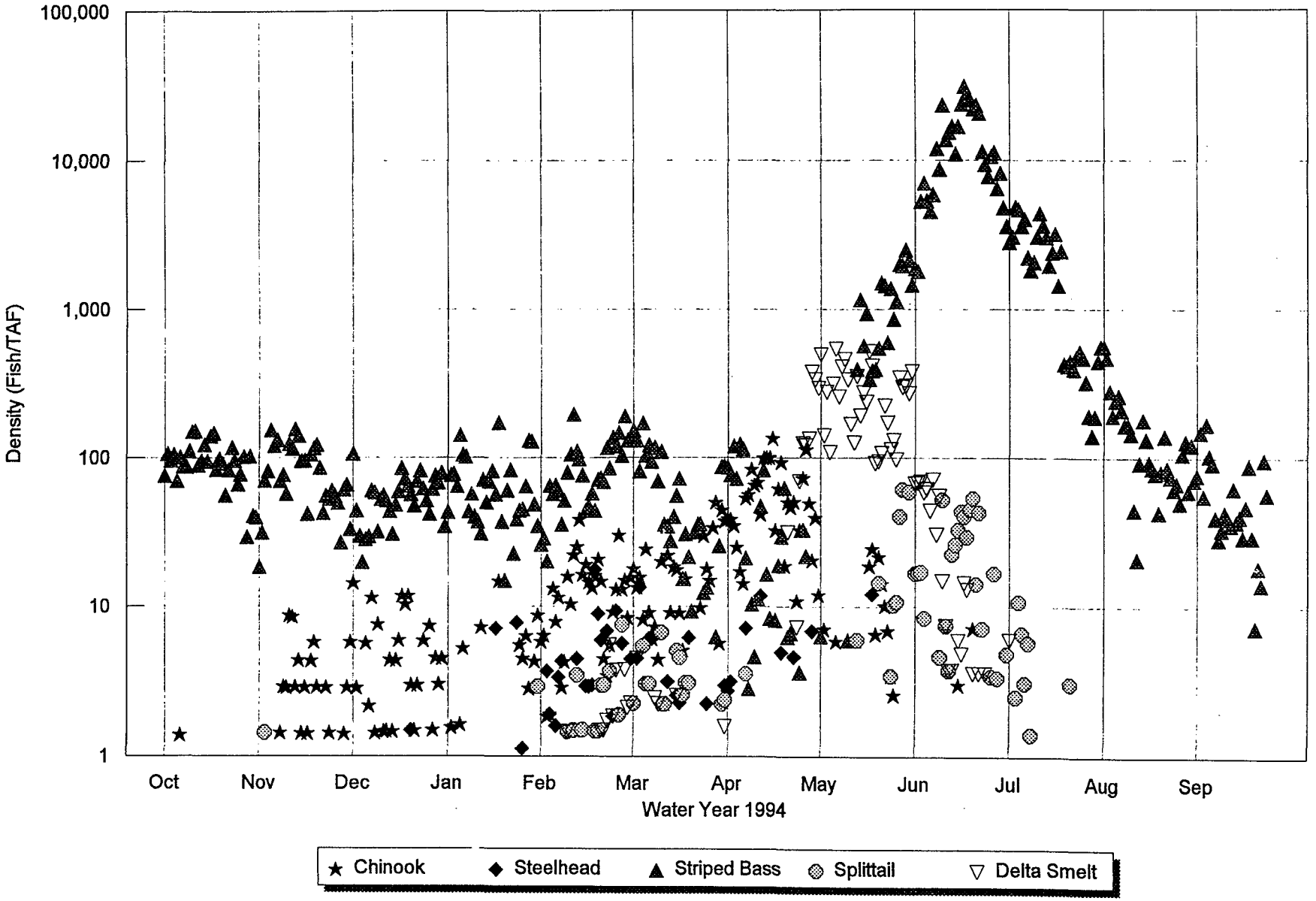

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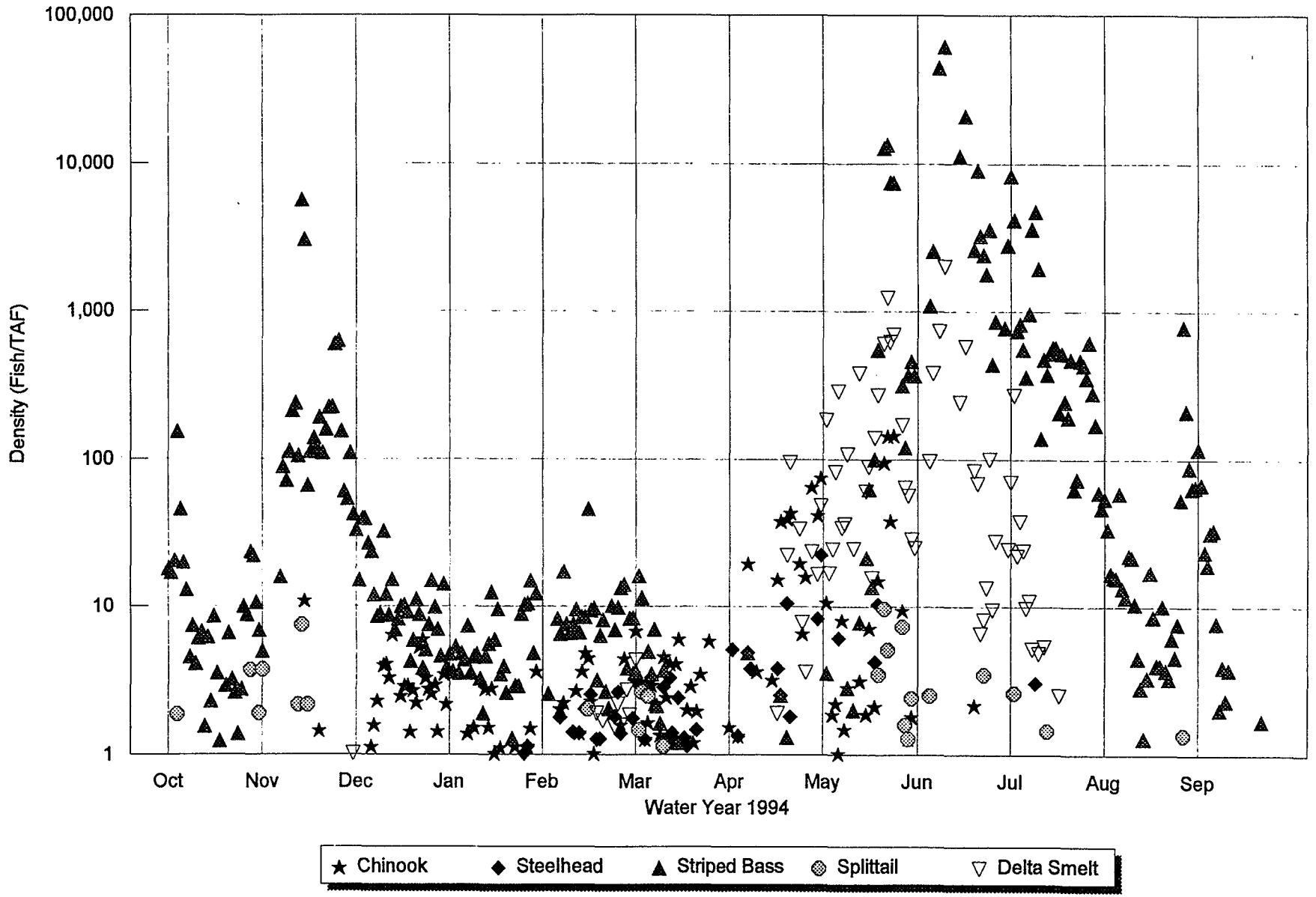

D-016187

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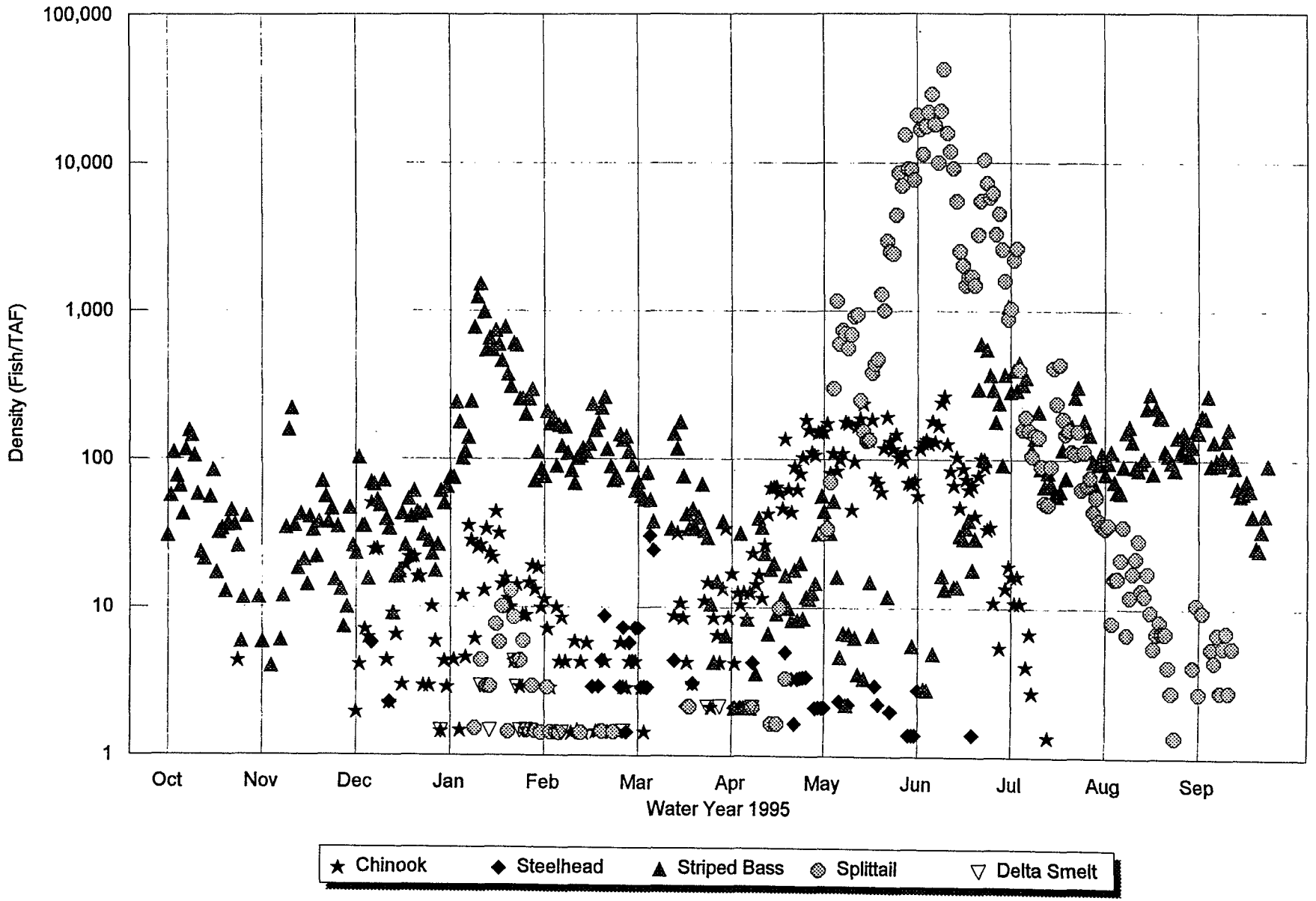

D—016187

D-016188

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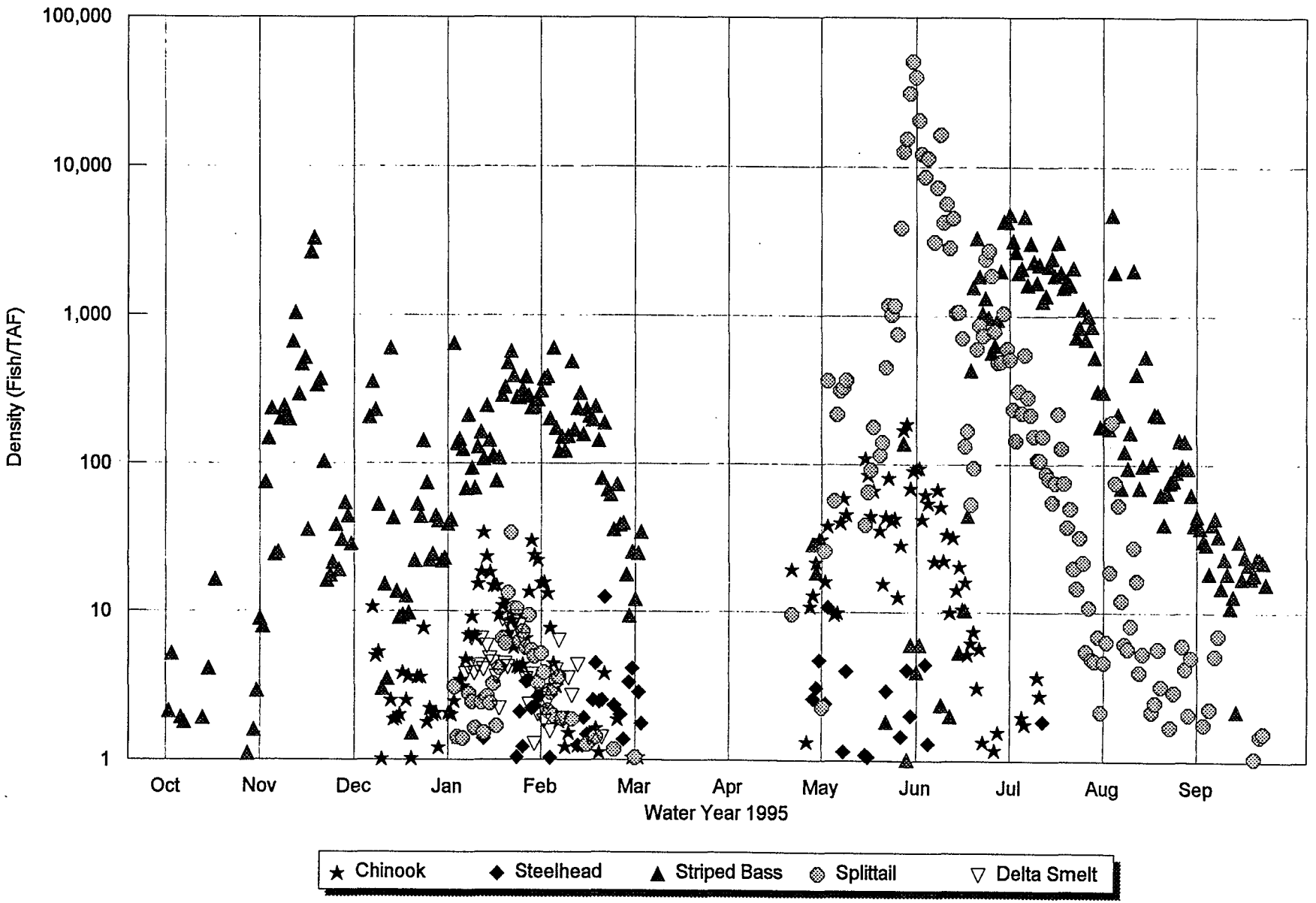
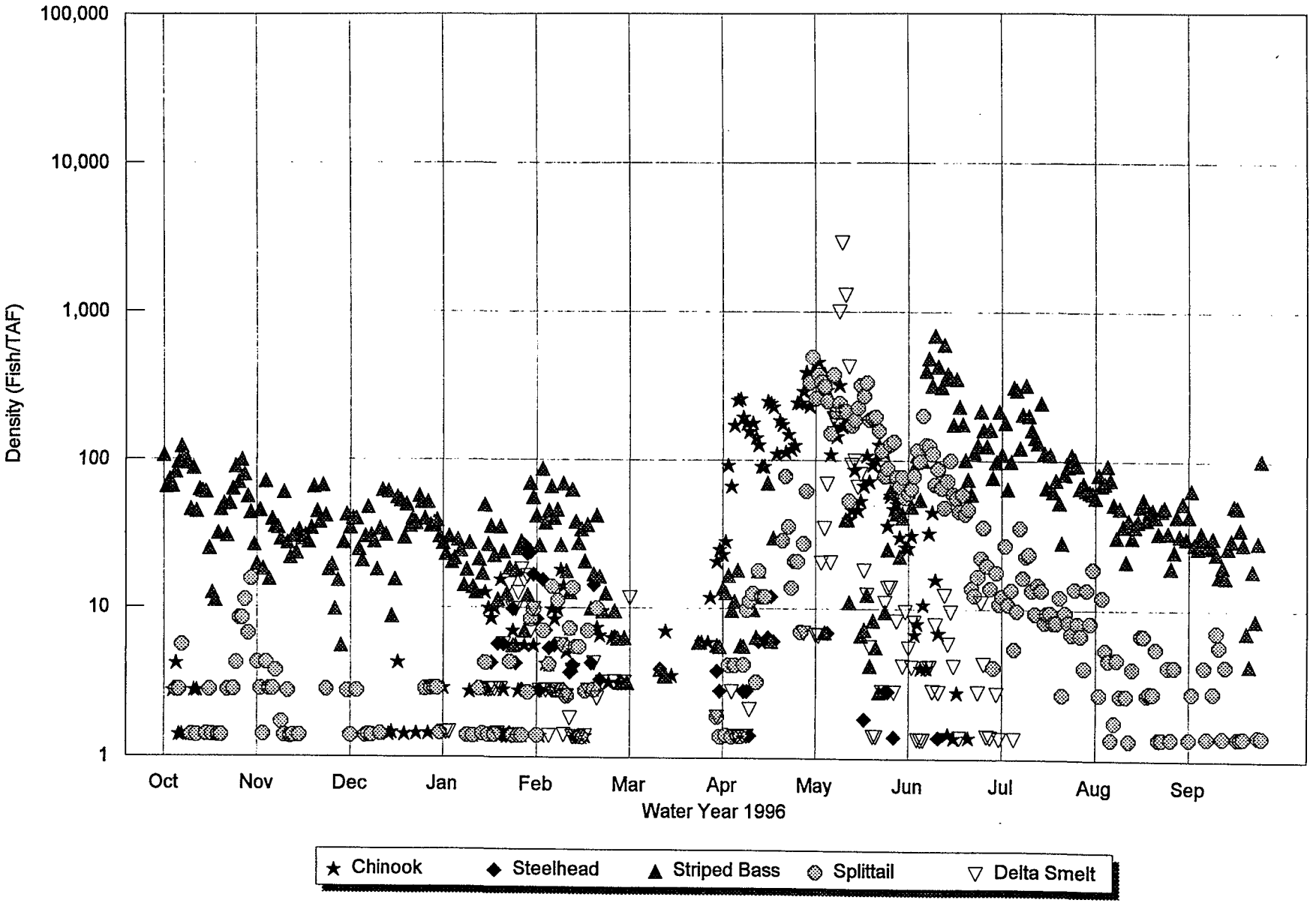


D—016188

D-016189

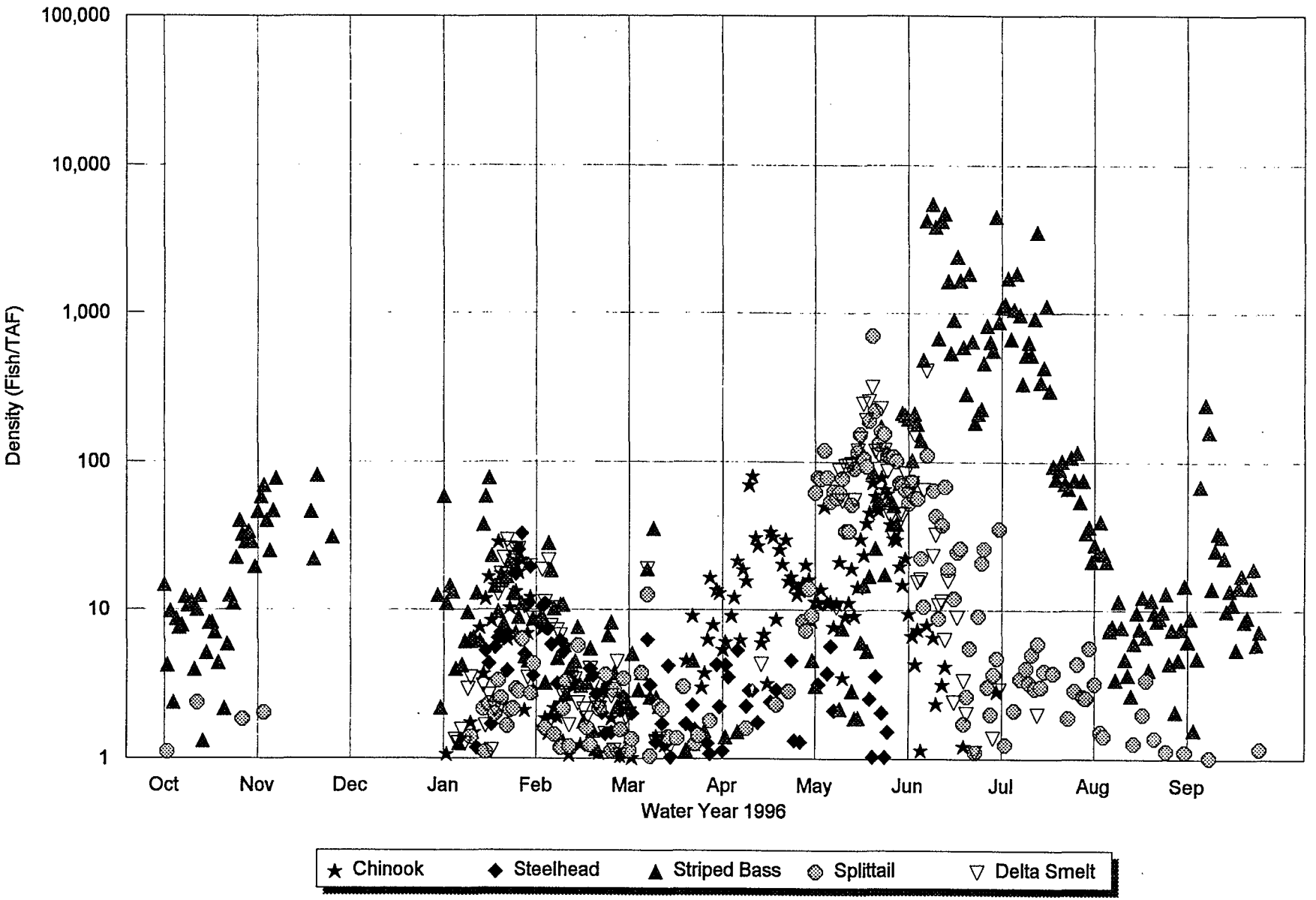
CVP Salvage Density



D—016189

D-016190

SWP Salvage Density



D—016190

Factors to Consider in Developing Scenario Rules for Flexible Operations

1. Salvage Factors

a. Season
b. Hydrology (magnitude and change)
c. Export Rate (magnitude and change, total and at both facilities)
d. Hydrology/Exports Relationship
e. Fish Distribution and Abundance
f. Salvage at both facilities
g. Channel conveyance (DCC, HOR, Hood)

2. Season

(note: Heavy fill cells indicate the specified fish will occur in salvage in abundance in most years. Lighter fill cells indicate the specified fish will occur in salvage in abundance in many years, particularly dry or wet years. Clear cells indicate the specified fish would occur in salvage only sporadically or in low numbers.)

	Winter	Spring	Summer	Fall
Delta Smelt	adults	juveniles	juveniles	
Chinook Salmon	some smolts, many fry	smolts (may extend to early July in wet years)		late fall, winter, spring, and fall run yearling smolts
Steelhead	smolts	smolts		
Splittail	adults	young	young	
Striped Bass	yearling	yearling and young	young	young

3. Hydrology

a. **Wet - dry patterns**
   i. important for most; especially splittail
b. **Inflow/outflow magnitude and pulses**
   i. Chinook salmon - Important factor in all seasons
   ii. Steelhead - important winter determinant
   iii. Striped bass in spring and summer
c. **QWEST - San Joaquin channel flow can be important**

4. Export Rates

a. Magnitude and change (both rate and directions are important). Some are vulnerable to only high exports, while others are vulnerable to both low and high

(e.g., delta smelt young in spring).

b. Very high exports (12,000-15,000) are a serious risk at any inflow.

c. High exports (8,000-12,000) can be a problem at any inflow.

5. Hydrology/Exports Relationship

a. The combination of rising exports and falling inflows is something to always to be wary of and look out for even at high inflows.

b. E/I does not represent the magnitudes of either E or I, or the relationship of salvage to either at varying E's and I's.

c. High exports and high inflows can be a problem for fish like splittail young, steelhead smolts, and chinook fry who come in with the flow and are susceptible tc high exports.

d. Export rates affect outflow and QWEST such that salvage can be further affected indirectly by the effects of export changes on hydrology.

6. Fish Distribution and Abundance

a. Chinook Salmon - River and Delta Beach Seines - fall and winter

Show when to expect them to first show in Delta and what abundance to expect. Also show hydrological conditions the coincide with appearance. (Source - 1995 season data report)

b. Delta Smelt - 20 mm survey; real-time survey (kodiak); summer townet

Good for showing distribution in Bay-Delta, but does not appear good for showing at pumps as early warning.

7. Salvage

Very stable data source that over several days shows magnitude and direction of salvage well. Unstable at very low exports rates (<2,000 cfs).

Delta Smelt Spring-Summer (Apr-Oct) Salvage Analysis

Introduction

One of the salvage data patterns that is consistent from year to year is the salvage of young delta smelt from spring into summer.

Conclusions

1. Young delta smelt are salvaged in large numbers most springs with April through June the predominant months with some carryover into July or even August. Salvage events began in May in some years, particularly wet years.
2. Salvage events occurred even in low export years of 92-94.
3. Salvage was low in wetter years including 82, 83, 86, and 95, presumably due to young being transported into Suisun Bay and the western Delta.
4. Falling outflow; rising QWEST; and moderate-to-high or rising exports often lead to salvage peaks especially in drier years.
5. Low outflow (<10,000) and QWEST (<0), and moderate to high exports (>5,000) often lead to salvage events.
6. Salvage events may occur under moderate to high outflows (20,000-40,000+) even under moderate export levels (4,000-6,000 cfs). Some events appeared to be sparked by pulses in outflow.
7. Salvage events were common in July and August under low outflow and rising or high (8,000+) exports.

Potential Solutions

1. During and immediately following small inflow pulses, particularly during dry years, rising exports to moderate or high level should be avoided..
2. The small inflow/outflow pulses of the springs in dry years could be enhanced with storage releases to facilitate fish moving to Suisun Bay.
3. Dramatically declining inflows in association with increasing or continuing moderate to high exports can be moderated by anticipating the declining inflows and reducing or at least gradually ramping up exports until inflows are stabilized at a controlled level. Declining inflows in the low range (under 20,000 cfs) could also be ramped down more slowly as flows come under control.
4. More gradually ramping declining inflows under high and increasing exports, may reduce limit salvage events in the spring, thus reducing the overall potential for salvage events as flows fall.
5. Anytime fish salvage increases under low to high exports, exports could be reduced until an event passes. Small reductions in exports (e.g., 1,000-2,000 cfs) may be needed to limit or preclude salvage events. If such reductions do not limit or preclude an event, then reductions could be scaled down further.
6. Accord standards should provide additional protections over historic conditions.

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7. VAMP experimental conditions should reduce exports and increase outflows during much of the peak salvage period of mid April to mid May, and reduce salvage. VAMP could be extended at least to mid June of many years to provide protection over most of the peak salvage period..
8. Export limits in wetter years could be lifted in spring and summer if most of the population is located in Suisun Bay.

Summary of Specific Events by Year
The following summaries include general patterns observed and rounded numbers, usually to the nearest 1,000 cfs.

1. 1980:
   a. CVP 4/11-4/13 - outflow 40,000 falling to 28,000; QWEST 15,000 falling to 9,000; exports 5,000.
   b. CVP 4/29-5/2 - Outflow 20,000-22,000; QWEST 8,000-9,000; exports 4,000-5,000
   c. SWP 6/9-6/16 - Outflow 14,000 falling to 12,000; QWEST 5,000 falling to 2,000; exports 7,000.
   d. SWP 6/18-7/5 - Outflow 8,000-11,000; QWEST 0-2,000; exports 6,000-8,000.
   e. CVP 7/6-7/8 - Outflow 15,000 falling to 10,000; QWEST 5,000 falling to 2,000; exports 7,000
   f. SWP 7/28-8/1 - Outflow 11,000 falling to 5,000; QWEST 1,200 falling to 2,700; exports 6,000.
   g. SWP 8/7-8/12 - Outflow 6,000 falling to 4,000; QWEST -2,200 to -3,100; exports 9,000-10,000
   h. SWP 9/30-10/27 - Outflow initially falling from 18,000 to 8,000; QWEST falling from 8,000 to 500; exports rising from 4,000 to 8,000.

2. 1981:
   a. CVP 4/4-4/19 - outflow 30,000 falling to 4,000; QWEST 2,000 falling to -6,000; exports 5,000 rising to 10,000
   b. CVP 4/28-4/26 - Outflow falling from 17,000 to 7,000; QWEST falling from 6,000 to 0; exports at 8,000
   c. CVP 5/6-6/8 - Outflow 7,000 rising to 10,000 then falling to 3,000; QWEST -600 rising to 3,000 then falling to 0; exports at 4,000;
   d. SWP 5/16-5/19 - Outflow 9,000-11,000; QWEST 2,000-3,000; exports SWP 300-3200.
   e. SWP 6/29-7/5 - Outflow 5,000-6,000; QWEST -1000 to 0; exports CVP 4,000, SWP 0-400.
   f. SWP 7/14-7/16 - Outflow 4,000-6,000; QWEST -1,000 to -2,000; exports 6,000.
   g. 8/28-9/2 - Outflow 2,000-4,000; QWEST -2,000 to -4,000; exports 7,000-10,000. Two peaks:
      (1) 4/22-4/23 with outflow 17,000 and QWEST 6,000;

(2) 4/27-5/3 with outflow falling from 7,000 to 200 and QWEST falling from 400 to -3,700.

3. 1982: high flows; moderate to high exports - few smelt salvaged

4. 1983: high flows; low to moderate exports - few smelt salvaged

5. 1984:
   a. CVP 5/12- 5/16 - Outflow 12,000-14,000; QWEST 0-4,000; exports 5,000-6,000.
   b. CVP 5/27-6/2 - Outflow 8,000-10,000; QWEST 0-3,000; exports 5,000 rising to 8,000.
   c. SWP 6/9-6/12 - Outflow 10,000 falling to 8,000; QWEST 1,800 falling to -900; exports rising from 6,000 to 8,000.
   d. CVP 6/15-6/20 - Outflow 6,000-8,000; QWEST 500-1500; exports 5,000-6,000.

6. 1985:
   a. SWP 4/18-4/25 - outflow 9,000 falling to 5,000; QWEST 1400 falling to -900; exports 8,000-9,000.
   b. CVP 5/1-5/10 - outflow 6,000-8,000; QWEST -1700 to 1700; exports 5,000-6,000
   c. CVP 5/12-5/20 - Outflow 9,000 falling to 5,000; QWEST falling from 1900 to -900; Exports rising from 6,000 to 8,000
   d. CVP 6/12-6/14 - Outflow 4,000-5,000; QWEST -500 to -4100; exports 6,000
   e. SWP 6/7-6/17 - Outflow 10,000 falling to 3,000; QWEST 300 falling to -4100; exports 6,000.
   f. CVP 7/3-7/5 - Outflow 5,000; QWEST -3,000; exports 9,000-10,000

7. 1986:
   a. SWP 4/29-5/1 - outflow 22,000 falling to 17,000; QWEST falling from 11,000 to 7,000; exports rising from 7,000 to 8,000.
   b. CVP 8/6-8/14 - Outflow 5,000-6,000; QWEST -2,000; exports 9,000-10,000

8. 1987:
   a. CVP 4/5-5/11 - outflow 4,000-8,000; QWEST -2,000 to 3,000; exports 5,000-9,000 (CVP 4,000). Four peaks:

   (1) 4/8-4/12 outflow 5,000-8,000; QWEST 300 to -2500; exports CVP 4,000.
   (2) 4/17-4/18 outflow 5,000-7,000; QWEST 0-1400; Exports 7,000-8,000 CVP 4,600.
   (3) 4/23-4/25 outflow 6,000-7,000; QWEST 0 - 400; exports 7,000-8,000 (CVP 4400-4600).
   (4) 5/4-5/10 outflow 7,000 falling to 4,000; QWEST 2,000 falling to -100; exports 5,000-6,000.

   b. SWP 6/10-6/18 - outflow 3,000-5,000 QWEST 1200 falling to -1900; exports increasing from 4,000 to 7,000.

c. SWP 7/3-7/4 - Outflow 4,000 falling to 2,000; QWEST -1,500 falling to -3,500; exports 8,000.

d. SWP 8/26-8/31 - Outflow 1,000-2,000; QWEST -4,000 to -5,000; exports 10,000-11,000.

9. 1988:

a. CVP/SWP 5/10-5/27 - outflow 9,000 falling to 3,000; QWEST 500 falling to -6,000; exports at 7,000-8,000. Ended with exports falling to 3,000 (SWP 180).

b. CVP/SWP 5/31-6/13 - outflow intially 6,000 falling to 2,000; QWEST falling 2,000 to -1,500; Exports rising from 3,000 to 6,000. Ended with exports falling to 3,000 (SWP 700).

c. SWP 6/16-6/23 - outflow initially falling from 4,300 to 2,500; QWEST falling from 1,500 to -4,800; exports rising from 3,000 to 7,000.

d. SWP 7/3-7/9 - Outflow 1700-3600; QWEST -2300 to -4200; exports 7000-9000.

10. 1989:

a. CVP 4/28-5/3 - outflow falling from 9,000 to 5,000; QWEST falling from -900 to -2,500; exports 10,000+. Ended with exports falling to 2,000.

b. CVP 5/8-5/10 - Outflow rising 7,000-10,000; QWEST 1600-2800; exports 2,000.

c. SWP/CVP 5/13-5/19 - outflow falling from 9,000 to 6,000; QWEST falling from -1000 to -5000; exports risingfrom 8,000 to 10,000.

d. SWP 5/26-5/28 - Outflow 6,000; QWEST -600 to -2100; exports 7000-9000.

e. SWP 6/21-6/22 - outflow 8,000 falling to 4,000; QWEST 1000 falling to -4,000; exports rising from 4,000 to 7,000.

f. SWP 7/7-7/11 - outflow 2000-4000; QWEST -3000 to -5000; exports 8000-10,000.

11. 1990:

a. CVP 4/11-4/13 - Outflow of 6000-7000; QWEST -2,000 to -3000; exports 9,000-10,000 (CVP 4300)

b. CVP 4/19-4/25 - outflow falling from 9,000 to 5,000; QWEST falling from -1500 to -2800; exports 9000-10,000 (CVP 4300)

c. CVP 5/4-5/14 - outflow 2000-6000; QWEST 1000-2500; exports 2000-3000

d. CVP 5/18-5/27 - outflow 5000-6000; QWEST 400-2000; exports 3000-4000 (CVP 3300)

e. SWP 5/28-6/4 - outlfow 10,000 rising to 28,000; QWEST rising from 3000 to 12,000; exports 4000 (SWP 0-1000)

f. SWP 6/11-6/14 - outflow 2,000; QWEST -170-200; exports 3000 (SWP 200-400)

g. SWP 6/17-6/19 outflow 3000-4000; QWEST 200-500; exports 4000 (SWP 300-400)

h. SWP 6/23-6/28 - outflow 3000-5000; QWEST -500-1400; exports 2000 (SWP 0-400)

i. SWP 7/2-7/20 - outflow 2000-5000; QWEST -400 falling to -3,700; exports

5000-8000.

12. 1991:
    a. SWP/CVP 4/25-5/2 - Outflow 6000 falling to 1000; QWEST 2000 falling to -200; exports 3000-4000. Ended with exports falling to 1000.
    b. SWP 6/29-7/9 - outflow falling from 6000 to 2000; QWEST -200-200; exports 2000-3000.
    c. SWP 7/26-7/27 - outflow falling from 4200 to 2600; QWEST falling from 600 to -400; exports rising from 400 to 1300.

13. 1992:
    a. SWP 5/22-5/26 - Outflow 3000-4000; QWEST -600-2300; exports 0-2000.
    b. SWP 6/5-6/10 - outflow 5,000 falling to 2,000; QWEST falling from -800 to -2100; exports rising from 300 to 3300.
    c. SWP 6/17-6/19 - outflow 3000; QWEST 0-100; exports 2100-2500.

14. 1993:
    a. SWP 5/9-5/16 - outflow 24,000-29,000; QWEST 6000-8000; exports 1500 (SWP 800)
    b. SWP/CVP 5/17-6/5 - Outflow initially falling from 24,000 to 16,000 then rising to 40,000; QWEST initially falling from 6,000 to 2000 then rising to 6,000; exports initially rising from 1500 to 6,000 then falling to 4,000
    c. SWP/CVP 6/10-6/20 - outflow 44,000 falling to 20,000; QWEST 6,000 falling to 2,000; exports 4,000. Ended as QWEST rose to 6,000.
    d. SWP/CVP 6/23-6/28 - outflow 18,000 falling to 12,000; QWEST 6,000 falling to 2,000; exports rising from 3,000 to 5,000.
    e. SWP/CVP 7/1-7/6 - outflow falling from 12,000 to 6,000; QWEST falling from 2,000 to -2000; exports rising from 5,000 to 9,000.

15. 1994:
    a. SWP/CVP 4/29-6/7 - outflow initially falling from 15,000 to 7,000; QWEST falling from 7,000 to 800; exports rising from 2,000 to 3,000.
    b. SWP 6/20-6/24 - outflow 4,000; QWEST -1000 to 1000; exports 2,000
    c. SWP 7/7-7/11 - outflow 5000-7000; QWEST -400 falling to -2000; exports rising from 4,000 to 7,000.

16. 1995: high outflows; low exports until June. Few delta smelt salvaged.

17. 1996:
    a. SWP/CVP 5/11-6/21- Outflow 21,000 rising to 101,000 then falling to 9,000. QWEST 8,000 rising to 26,000 then falling to -4,000. Exports rising from 1500 to 8,000. Three peaks:
    (1) CVP 5/13-5/15 - outflow 20,000; QWEST 8,000; exports 1600 (CVP 700-

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900)
(2) SWP 5/19-5/30 - outflow 100,000 falling to 40,000; QWEST 26,000 falling to 5,000; exports rising from 7,000 to 10,000.
(3) SWP 6/2-6/7 - outflow 26,000 falling to 21,000; QWEST -300 falling to -4000; exports 10,000+.

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Delta Smelt Adult Winter (Jan-Mar) Salvage Analysis

Introduction

One of the salvage data patterns that is consistent from year to year is the salvage of adult delta smelt sometime during the period from mid December to mid March. We looked at each of the salvage events from December 1997 to March 1996 in the Salvage Records and related the events to Delta inflow and exports as seen through Delta inflow/outflow, exports at CVP and SWP, and QWEST.

Conclusions

1. Most of the delta salvage events in winter occur at the SWP.
2. The events are usually associated with falling inflows and increasing or continuing high exports (10,000+ cfs), also characterized by declining and low QWEST. Such conditions are also indicative of rapid upstream movement of X2 into the western Delta and movement of the freshwater habitat zone of the western Delta into the central and south Delta. Adult delta smelt may be drawn in large numbers into the south Delta and toward the pumps under these conditions.
3. Salvage events can also occur at relatively high inflows if inflows are declining and exports are increasing or are continuing high.
4. Events may occur occasionally despite steady or increasing high inflows if exports are high or increasing, particularly export rates exceeding 11,000 cfs. These events are usually preceeded by a low outflow and high export event that draws the fish initially to the south Delta. Once drawn into the interior Delta, these fish appear to be vulnerable to high exports regardless of inflows.
5. At higher population levels as occurred from 1979 through 1983, adult smelt salvage events may occur under almost any circumstances, but peaks in salvage would most likely occur during or following the above described conditions.

Potential Solutions

1. Dramatically declining inflows in association with increasing or continuing high exports can be moderated by anticipating the declining inflows and reducing or at least gradually ramping up exports until inflows are more stable. Declining inflows could also be ramped down more slowly as flows come under control.
2. More gradually ramping declining inflows under high and increasing exports, may reduce the attraction of adult smelt into the south Delta, thus reducing the overall potential for salvage losses later when inflows are low and exports are high.
3. Anytime fish salvage increases under high exports, exports could be reduced until an event passes. This would be especially applicable when exports are in the 11,000-15,000 cfs range. Exports could be ramped down until salvage declines, and then ramped up again as long as salvage stays low.
4. Under low inflows, when QWEST falls into the negative range, high exports will often lead to a salvage event. Under these circumstance, increasing inflow or increasing the

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amount of inflow moving through the central Delta (by increasing San Joaquin portion, opening DCC, or providing a Hood diversion) would potentially alleviate or preclude a salvage event. If these measures fail to solve the problem, then export reductions would be in order.

Summary of Specific Events

The following summaries include general patterns observed and rounded numbers, usually to the nearest 1,000 cfs.

1. 1/4/80-1/11/80 SWP
    1. SWP: 6,000+ cfs
    2. Outflow: falling from 50,000 to 29,000 cfs
    3. QWEST: falling from 11,000 to 2,000 cfs over several days.
    4. Ended: QWEST rose to 28,000 cfs; outflow increased to 67,000 cfs.

2. 2/25/80-3/12/80 CVP
    1. SWP at 0; CVP at 3200.
    2. Very wet: Outflow 150,000 +;
    3. QWEST 40,000+;

3. 1/9/81-3/13/81 CVP/SWP
    1. Exports: variable
    2. Outflow: initially falling from 8,000 to 3,000; variable over period.
    3. QWEST: initially falling from 1,800 to -2,400 cfs.; variable over period.
    4. Peak: 1/12-1/19; QWEST falling from 0 to -2,400; exports 10,000+; outflow falling from 7,000 to 3,000.

4. 11/26/81-11/28/81 CVP
    1. High and increasing flows and QWEST; CVP at 3100.

5. 1/16/82-3/11/82 CVP/SWP
    1. High flows
    2. Peak: 2/11-2/17; QWEST fell from 8,000 to 500; outfall fell from 46,000 to 26,000; export were steady at 10,000+.

6. 1/3/83-1/27/83 SWP
    1. Exports: 10,000+
    2. Outfall: initially falling from 100,000+ to 40,000.
    3. QWEST: initially falling from 33,000 to 10,000.
    4. Ending: when QWEST rose from 15,000 -> 66,000.

7. 2/12/83-2/16/83 SWP
    1. Exports: 10,000+

2. Outflow: 200,000+
3. QWEST: 40,000-60,000

8. 2/24/85-3/8/85 SWP
   1. Exports: 7,000-11,000
   2. Outflow: falling from 30,000 to 0.
   3. QWEST: falling from 6,000 -> -3,000

9. 1/15/86-1/23/86 SWP
   1. Exports: 10,000
   2. Outflow: initially falling from 13,000 -> 5,000
   3. QWEST: Initially falling from 1,800 -> -2,500
   4. Ending: as QWEST increased to 0; Outflow rose from 5,000 -> 32,000; and exports fell to 6,000-8,000.

10. 2/7/86-2/14/86 SWP
    1. Exports: 6,000-7,000
    2. Outflow: falling from 70,000 to 28,000
    3. QWEST: falling from 16,000 to 1,400

11. 12/15/87-1/28/88 CVP/SWP
    1. Exports: 10,000-11,000+
    2. Outflow: falling from 20,000 to 3,000
    3. QWEST: falling from 6,000 to -4,000
    4. Peak: 12/25-12/30; after QWEST fell to -4,000 and outfall fell to 2.000
    5. Ended: Outflow rose to 10,000; QWEST rose to -1,000, under steady 10,000 exports.

12. 12/29/88-1/31/89 SWP
    1. Exports: rising from 5,000 to 11,000+
    2. Outflow: falling initially from 23,000 to 3,000, then steady at less than 4,000
    3. QWEST: falling initially from 8,000 to -3,000.
    4. Ended: Outflow rose to 12,000; QWEST rose to 3,000, and SWP fell from 6,000 to 0.

13. 2/12/90-2/17/90 SWP
    This was the first of a series of three events in Feb and Mar of 1990 with two interruptions that appeared related to small pulses of Delta inflow.
    1. Exports: 10,000+
    2. Outflow: falling initially from 9,000 to 2,000
    3. QWEST: falling initially from -500 to -4,000
    4. Ended: Outflow rose from 1,000 to 20,000; QWEST rose from -4,000 to 5,000, and continuing high exports.

14. 2/23/90-3/7/90 SWP
    1. Exports: 10,000+
    2. Outflow: falling initially from 20,000 to 2,000
    3. QWEST: falling initially from 5,000 to -4,000.
    4. Ended: Outflow rose to 12,000; QWEST rose to 1,400, with continued high exports.

15. 3/12/90-3/18/90 SWP
    Event ended in mid March despite continued poor conditions; appears adult run of smelt gradually ends about this time.
    1. Exports: 10,000+
    2. Outflow: falling initially from 12,000 to 4000
    3. QWEST: falling initially from 1,400 to -3,000.
    4. Ended: no change

16. 2/8/91-2/13/91 SWP
    This was the first of a series of four events in late winter and early spring of 1991 with three interruptions that appeared related to SWP operations and small pulses of Delta inflow.
    1. Exports: SWP at 6,000 and falling to 0.
    2. Outflow: falling initially from 24,000 to 4,000
    3. QWEST: falling initially from 11,000 to 500
    4. Ended: SWP at 0.

17. 2/20/91-2/21/91 SWP
    1. Exports: initially SWP rising to 2500
    2. Outflow: falling initially from 4,000 to 2,000
    3. QWEST: falling initially from1,500 to -600.
    4. Ended: Outflow rose to 4,000; QWEST rose to 1,500, and SWP exports fell to 800.

18. 3/3/91-3/5/91 SWP
    A short period of salvage was associated with a sharp rise in export, but ended quickly as inflow rose sharply under continuing high exports.
    1. Exports: rose from 2,000 to 10,000+
    2. Outflow: rising from 4,000 to 40,000
    3. QWEST: rising from 1,500 to 10,000
    4. Ended: with high inflow

19. 3/8/91-4/5/91 SWP
    The end of the salvage event commenced with the decline in the inflow event. Event

continued despite another inflow pulse from 3/25-3/30.

1. Exports: 10,000+
2. Outflow: falling initially from 40,000 to 4,000
3. QWEST: falling initially from 10,000 to -7,000
4. Ended: no change

20. 1/16/92-1/23/92 SWP

The winter of 1992 was marked by four adult delta smelt salvage events at the SWP coinciding with periods of low inflows and high exports, and separated by pulses of inflow under continuing high exports. The first was a modest event under moderate export rates.

1. Exports: 5,000+
2. Outflow: falling initially form 4,500 to 2,400
3. QWEST: falling initially from 500 to -500
4. Ended: outflow rose to 8,000; QWEST rose to 5,000

21. 2/21/92-3/8/92 SWP

After several weeks of increasing inflow, exports, and QWEST (and few adult smelt), inflows dropped sharply in mid February under continuing high exports, sparking another salvage event, which ended with another inflow pulse.

1. Exports: 10,000+
2. Outflow: falling during the period from 43,000 to 7,000
3. QWEST: falling during the period from 4,000 to -5,500
4. Ended: outflow increased to 26,000 and QWEST increased to 1,500

22. 3/13/92-3/19/92 SWP

After a short respite, the smelt returned to the SWP facilities as inflows dropped again under continuing high exports.

1. Exports: 10,000+
2. Outflow: falling initially from 25,000 to 6,000
3. QWEST: falling initially from 1,300 to -7,000
4. Ended: Outflow rising to 29,000; QWEST rising to -1,500

23. 3/24/92-3/31/92 SWP and CVP

The fourth event occurred as the latest inflow pulse ended under continuing high export. The event and smelt run ended quietly with no marked change in conditions.

1. Exports: 10,000+
2. Outflow: falling initially from 16,000 to 2,000
3. QWEST: falling initially form -1,500 to -7,000
4. Ended: no marked change

24. 1/07/93-1/08/93 SWP

Event of winter 93 began with typical high exports and falling inflow and QWEST,

eventually leading to continous events through late February.

1. Exports: 10,000+
2. Outflow: falling initially from 33,000 to 15,000
3. QWEST: falling initially from 7,000 to -4,000
4. Ended: Outflow returned to 33,000 and QWEST rose to 4,000

25. 1/15/93-2/23/93 SWP

This continuous period of adult smelt salvaged began despite rising inflows. SWP exports rose to new highs as new pumps were put to the test.

1. Exports: SWP rose from 7,000 to 10,000; total of 14,000 initially
2. Outflow: rising initially to 60,000 and then falling to 30,000 in middle of period.
3. QWEST: rising to 20,000 then falling as low as -2,000 in the middle of the period.
4. Ended: Outflow rose to 100,000+; QWEST rose to 16,000; SWP pumping went to 0.

26. 2/22/94-3/6/94 SWP and CVP

1. Exports: 4,000-5,000
2. Outflow: 34,000 falling to 13,000
3. QWEST: 7,000 falling to -700
4. Ended: QWEST rose to 300-900

27. 12/26/94-1/02/95 SWP

Small event started with declining outflows and high exports.

1. Exports: 10,000+
2. Outflow: initially falling from 12,000 to 2,000
3. QWEST: initially falling from 500 to -4,000
4. Ended: sharply rising inflows

28. 1/6/95-2/20/95 SWP

Long event occurred despite rising and high inflows, ending only with low exports. Began under low outflow, high exports, and negative QWEST. Continued despite high inflows under very high exports.

1. Exports: very high at 10,000-12,000+; 8,000+ at SWP
2. Outflow: rising from about 10,000 to 220,000
3. QWEST: initially beginning with -3,000 then rising sharply to 22,000.
4. Ended: when SWP exports fell to 800

29. 1/6/96-1/13/96 SWP

Beginning of two months of nearly continuous salvage events for adult delta smelt. This beginning event was punctuated by falling inflows and rising exports. X2 movement from Suisun Bay well into western Delta.

1. Exports: initially rising from 5,000 to 11,500
2. Outflow: initially falling from 31,000 to 7,000

3. QWEST: initially falling from 6,000 to -7,000
4. Ended: outflow rose to 10,500; QWEST rose from -7,000 to -3,000; and exports declined from 11,000 to 7,000.

30. 1/15/96-2/1/96 SWP and CVP
The second quarter of this period was punctuated by very high exports under rising inflow.
1. Exports: very high at 11,000+
2. Outflow: increasing from 6,000 to 80,000
3. QWEST: increasing from -6,000 to 18,000
4. Peak: 1/20-2/1 when exports were highest at 11,000+
5. Ended: when SWP exports fell from 7,000+ to 0.

31. 2/4/96-3/4/96 SWP and CVP
The last half of the 96 adult delta smelt salvage period was marked by increasing exports and sustain very high inflow.
1. Exports: CVP at 4,300 and SWP varying from 1,000-5,000
2. Outflows: 100,000+
3. QWEST: 30,000+
4. Ended: Exports fell to near 0.

Chinook Salmon Smolts Fall (Oct-Dec) Salvage Analysis

Introduction

One of the salvage data patterns that is consistent from year to year is the salvage of chinook salmon smolts in the fall. Typically these fall events are made up of a combination of spring run smolts (about 150 mm), winter run smolts (60-70mm), late-fall run smolts (100-160 mm), and likely some fall run smolts (about 150 mm) that oversummered from the previous season. We looked at each of the salvage events from December 1997 to December 1996 in the Salvage Records and related the events to Delta inflow and exports as seen through Delta inflow/outflow, exports at CVP and SWP, and QWEST.

Conclusions

1. Many of the larger salvage events occur at the SWP.
2. The events are often associated with the flow pulses, often the first of the fall particularly in dry years, and declining outflow and QWEST, and increased or steady high exports.
3. Many events end with a new pulse of inflow/outflow.
4. Events can occur in wet years under very high flows, particularly if exports are high (10,000+).
5. Large events occur following inflow/outflow pulses and during rapidly declining outflows and QWEST, with high or increasing exports. Some events had outflows declining from 30,000 to 2,000 cfs.

Potential Solutions

1. Dramatically declining inflows in association with increasing or continuing high exports can be moderated by anticipating the declining inflows and reducing or at least gradually ramping up exports until inflows are stabilized at a controlled level. Declining inflows could also be ramped down more slowly as flows come under control.
2. More gradually ramping declining inflows under high and increasing exports, may reduce the attraction of salmon smolts in the fall into the south Delta, thus reducing the overall potential for salvage losses as flows fall.
3. Anytime fish salvage increases under high exports, exports could be reduced until an event passes.
4. During and immediately following small inflow pulses, particularly the first of the fall, the DCC could be closed until fish have past into the western Delta.
5. The first small inflow/outflow pulse of the fall could be enhanced with storage releases to facilitate fish moving through the north Delta to the Bay. This may also stimulate more smolts from tributaries to migrate and take advantage of possibly the only pulse of a dry year.

Summary of Specific Events

The following summaries include general patterns observed and rounded numbers, usually to the nearest 1,000 cfs.

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1. 10/24/79-10/26/79 SWP
   a. Exports increasing: 6,000 -> 8,000 cfs
   b. Outflow: falling from 9,000 to 6,000 cfs
   c. QWEST: falling from 3,000 to 300 cfs

2. 11/3/79-11/15/79 SWP
   a. Exports: 7,000
   b. Outflow increasing from 6,000 to 12,000, then falling to 8,000
   c. QWEST 2,000-4,000
   d. Peak at peak of flow pulse
   e. Ended with end of pulse;

3. 12/1/79-12/6/79 SWP
   a. Exports: 5,000-6,000 at SWP; CVP at 0.
   b. Outflow: falling from 20,000 to 9,000;
   c. QWEST: 2,000 to 4,000 cfs
   d. Ended with end of pulse;

4. 10/29/80-11/13/80 SWP/CVP
   a. Exports initially rising from 4,000 to 7,000
   b. Outflow initially falling from 7,000 to 5,000
   c. QWEST initially falling from 3,000 to -2,000

5. 10/19/81-10/27/81 CVP
   a. Exports 5,000-6,000
   b. Outflow: falling from 4,000 to 2,000
   c. QWEST: falling from 400 to -1,100
   d. Ended with pulse of flow

6. 10/28/81-11/11/81 SWP
   a. Exports: 4,000-5,000
   b. Outflow: Initially rising from 2,000 to 15,000, then falling to 4,000
   c. QWEST: initially rising from 0 to 7,000, then falling to -500
   d. Ending: with new pulse of inflow.

7. 11/14/82-11/29/82 CVP/SWP
   Two salvage peaks on the declining ends of two flow pulses
   a. Exports: 5,000-6,000
   b. Outflow: 20,000-60,000+
   c. QWEST: falling from 14,000 to 5,000 on first pulse; 20,000 to 9,000 on second pulse.

8. 12/2/82-12/28/82 SWP/CVP

Large event possibly including many fry marked by peaks early and late.

a. Exports: Initially rising to 10,000 from 3,000; dropping to 2,000 in mid period; rising again to 10,000 in latter part of period.
b. Outflow: 40,000-200,000.
c. QWEST: 12,000-67,000

9. 10/5/83-10/12/83 CVP
   a. Exports: CVP only at 2,800
   b. Outflow: 35,000 steady
   c. QWEST: 20,000 steady

10. 10/20/84-11/11/84 CVP/SWP
    Large event beginning with pulse and ending with another pulse.
    a. Exports: 4,000-6,000
    b. Outflow: falling from 20,000 to 5,000
    c. QWEST: falling from 10,000 to -1,000
    d. Ended with new inflow pulse: outflow rising to 23,000.

11. 11/13/84-11/22/84 SWP
    a. Exports: 8,000
    b. Outflow: during pulse flow of 30,000+
    c. QWEST: falling from 7,000 to 200

12. 11/25/84-12/25/84 SWP/CVP
    a. Exports: 6,000 to 9,000
    b. Outflow: 30,000+
    c. QWEST: 2,000-8,000

13. 10/18/85-11/10/85 SWP/CVP
    a. Exports: 5,000-7,000
    b. Outflow: began with pulse flow with a rise from 3,000 to 12,000 and back to 2,000 by 10/24
    c. QWEST: initially from -2,000 to +4,000 then back to -4,000 by 10/24
    d. Ended: Outflow rose from 2,000 to 8,000; QWEST rose from -3,000 to 1,500.

14. 12/4/85-12/12/85 SWP/CVP
    a. Exports: 10,000+
    b. Outflow: falling initially from 30,000 to 2,000
    c. QWEST: falling initially from 6,000 to -3,000.

15. 12/9/87-12/28/87 SWP/CVP
    a. Exports: rising from 6,000 to 11,000
    b. Outflow: falling initially from 19,000 to 2000

c. QWEST: falling initially from 6,000 to -4,000.
d. Ended: outflow rose again to 11,000; QWEST rose to 500.

16. 11/2/88-11/4/88 SWP
a. Exports: rose from 2,000 to 4,000
b. Outflow: falling initially from 5,000 to 3,000
c. QWEST: falling initially from 2,300 to -200

17. 11/29/88-12/5/88 SWP
After a flow pulse.
a. Exports: 9,000-10,000
b. Outflow: falling initially from 27,000 to 2,000
c. QWEST: falling initially from 9,000 to -4,000.
d. Ended: Outflow rose from 900 to 3,000; QWEST rose from -4,000 to -1,000; and exports dropped from 10,000 to 6,000.

18. 11/27/89-12/4/989 SWP
After a small flow pulse.
a. Exports: 10,000+
b. Outflow: rising from 4,000 to 14,000, then back to 4,000
c. QWEST: falling from 1,700 to -4,000

19. 1990 -- No October or November flow pulses and then only small flow pulses in December ---no fall salvage pulses of chinook salmon.

20. 11/13/91-11/18/91 SWP/CVP
a. Exports: initially rising from 800 to 4,400
b. Outflow: falling initially from 6,500 to 2,500
c. QWEST: falling initially from 3,900 to 0
d. Ended: outflow rose again - 6,900; QWEST to 3,600

21. 11/23/91-11/25/91 SWP
a. Exports: 2,500-3,000
b. Outflow: falling initially form 5,400 to 3,100
c. QWEST: falling initially from 2,400 to 1,000
d. Ended: exports fell from 3,000 to 2,000; outflow rose 4,900; QWEST rose to 2,200

22. 1992 - Despite pulse of inflow at beginning of November, no salmon smolt pulse; exports were low - usually 2,000 cfs or less.

23. 11/8/93-11/24/93 CVP
a. Exports: exports initially rose from 4,000 to 7,000;

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b. Outflow: initially falling from 8,000 to 5,000;
c. QWEST: initially falling from 700 to -400

24. 11/29/93-12/31/93 CVP/SWP
This salvage event started with a flow pulse and continued through another.
a. Exports: initially rising from 7,000 to 10,000; then steady at 10,000-11,000
b. Outflow: initially rising from 5,000 to 16,000; then falling and rising during period between 5,000 and 30,000
c. QWEST: rising initially from -800 to 5,000; then falling and rising from -3,000 to 5,000.

25. 12/7/94-12/31/94 SWP and CVP
Event started as large flow pulse started to decline and sharply rising exports.
a. Exports: rising from 2,000 to 10,000+
b. Outflow: falling initially from 35,000 to 8,000
c. QWEST: falling initially form 12,000 to -6,000

26. 10/04/95-10/13/95 CVP
a. Exports: 6,000
b. Outflow: falling initially from 22,000 to 10,000
c. QWEST: falling initially from 9,000 to 5,000

Chinook Spring (Apr-Jun) Salvage Analysis

Introduction

One of the salvage data patterns that is consistent from year to year is the salvage of chinook salmon smolts in the spring. Subyearling smolts of both spring and fall run are included. The spring and fall run fish range in size from 60-100 mm.

Conclusions

1. Chinook smolts are salvaged in large numbers in April through June in wetter years and April and May in drier years.
2. Low export years of 92-94 had low salvage of chinook smolts.
3. Falling outflow and QWEST; and high or rising exports often lead to salvage peaks especially in drier years.
4. Low outflow (<10,000) and QWEST (<0), and moderate to high exports (>5,000) often had high salvage numbers.
5. Salvage events occurred in wet years with moderate to high exports even at outflows in excess of 100,000 cfs.

Potential Solutions

1. During and immediately following small inflow pulses, particularly during dry years, the DCC could be closed until fish have passed into the western Delta. DCC closure could impose greater salvage losses on San Joaquin smolts.
2. The small inflow/outflow pulses of the springs in dry years could be enhanced with storage releases to facilitate fish moving through the north Delta to the Bay. This may also stimulate more smolts from tributaries to migrate and take advantage of possibly the only pulses of a dry year.
3. Dramatically declining inflows in association with increasing or continuing moderate to high exports can be moderated by anticipating the declining inflows and reducing or at least gradually ramping up exports until inflows are more stable. Declining inflows in the low range (under 20,000 cfs) could also be ramped down more slowly as flows come under control.
4. More gradually ramping declining inflows under high and increasing exports, may reduce the attraction of chinook smolts in the spring into the south Delta, thus reducing the overall potential for salvage losses as flows fall.
5. Anytime fish salvage increases under moderate to high exports, exports could be reduced until an event passes. Only small reductions in exports (e.g., from 8,000 cfs to 6,000 cfs) may be needed to end or preclude salvage events. If such reductions do not end or preclude an event, then reductions could be scaled down further (e.g., from 6,000 to 4,000 cfs, etc.).
6. Accord standards should provide additional protections over historic conditions.
7. VAMP experimental conditions should reduce exports and increase outflows during

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much of the salvage period for San Joaquin smolts and greatly reduce salvage. VAMP could be extended at least to mid June of wetter years.

Summary of Specific Events by Year

The following summaries include general patterns observed and rounded numbers, usually to the nearest 1,000 cfs.

1. 1980: 4/5-6/21 - outflow 40,000 falling to 12,000-16,000; QWEST 17,000 falling to 2,000-6,000; exports 4,000-6,000 -- peak 4/6-5/6 with outflow 20,000+.

2. 1981: 4/4-6/5 - outflow 30,000 falling to 4,000; QWEST 2,000 falling to -6,000; exports 5,000-9,000 -- peak 4/22-4/23 with outflow 17,000 and QWEST 6,000; peak 4/27-5/3 with outflow falling from 7,000 to 200 and QWEST falling from 400 to -3,700.

3. 1982: 4/25-6/16 - outflow falling from 96,000 to 28,000; QWEST falling from 30,000 to 7,000; exports falling from 10,000 to 3,000. Peak 4/27-4/29 - exports 10,000; 5/10-5/14 - exports 5,000-6,000; 5/28-6/4 - exports 5,000-7,000 all at outflow of 40,000+.

4. 1983: 4/11-6/28 - outflow 115,000 falling to 60,000; QWEST falling from 48,000 to 25,000; exports 3,000-7,000.

5. 1984: 3/26-6/25 - outflow beginning at 36,000; QWEST at 6,000; Exports at 6,000. Five peaks:
   (1) 4/15-4/18 - outflow 18,000 falling to 11,000; QWEST falling from 1,000 to -1,300;
   (2) 4/23-5/6 - outflow falling from 15,000 to 3,000; QWEST falling from 5,000 to -2,000;
   (3) 5/27-6/2 - outflow falling from 11,000 to 6,000; QWEST falling from 3,000 to -2,000.
   (4) 6/9-6/10 - outflow falling from 10,000 to 8,000; QWEST falling from 2,000 to -1,000.
   (5) 6/18-6/23 - outflow 7,000-8,000; QWEST 0-1,000.

6. 1985: 4/1-6/8 - outflow 20,000 to 10,000; QWEST 8,000 to 2,000; exports 5,000-7,000. Peak 4/30-5/5 with outflow 6,000-7,000 and QWEST 600-1700. Peak 5/10-5/18 with outflow of 7,000-9,000 and QWEST of -400-1800.

7. 1986: 4/16-6/16 - outflow 46,000 falling to 7,000; QWEST falling from 26,000 to 3,000; exports 5,000-8,000. Peak 4/22-6/8 with outflow falling from 39,000 to 11,000.

8. 1987: 4/15-6/3 - outflow at 6,000; QWEST at 100; exports at 7,000. Three peaks:
   (1).4/28-4/29 with outflow at 6,000; QWEST at -1,700 to -2,300; exports 6,000-7,000.
   (2) 5/5-5/8 with outflow 5,600 falling to 3,600; QWEST falling from 600 to -100; Exports at 4,000-6,000
   (3) 5/12-5/18 with outflow falling 5,000 to 4,000; QWEST falling from 0 to -4,000; exports at 6,000-7,000.

9. 1988: 4/15-6/13 - begining outflow 10,000; QWEST at 200; exports at 9,000. Five peaks:
(1) 4/20-4/24 with outflow 21,000-24,000; QWEST 6,000-8,000; exports at 10,000
(2) 4/27-4/30 with outflow falling from 12,000 to 4,000; QWEST falling from 1,000 to -3,000; exports at 7,000-10,000.
(3) 5/4-5/5 with outflow at 3,000-4,000; QWEST at -2,000 to -3,000; exports at 5,000.
(4) 5/10-5/14 with outflow falling from 9,000 to 5,000; QWEST falling from 200 to -6,000; exports at 8,000-9,000.
(5) 6/11-6/13 with outflow at 2,000-3,000; QWEST at -500 to -2,000; exports at 6,000.

10. 1989: 4/7-5/30 - beginning outflow 16,000; QWEST at -5,000; exports 10,000. Three peaks:
(1) 4/26-4/29 with outflow falling from 9,000 to 6,000; QWEST falling from -800 to -2,000; exports at 10,000.
(2) 5/11-5/13 with outflow falling from 10,000 to 7,000; QWEST falling from 2,000 to -5,000; exports at 7,000-8,000.
(3) 5/17-5/20 with outflow at 6,000-8,000; QWEST at -400 to -4,400; exports 7,000-10,000.

11. 1990: 4/19-4/27 - Outflow of 8,000; QWEST of -2,000; exports 9,000-10,000

12. 1991: 4/10-5/9 - Outflow 3,000-4,000; QWEST -4,000 rising to 2,000; exports falling from 10,000 to 3,000.

13. 1992: 4/15-4/21 - Outflow 11,000 falling to 9,0000; QWEST 2,000 falling to 1,000; exports 800-1,000.

14. 1993: no substantial salvage period; exports low (<6,000)

15. 1994: no substantial salvage period; exports low (<6,000)

16. 1995: 5/17-6/16 -Outflow 88,000 falling to 33,000; QWEST falling from 33,000 to 6,000; exports rising from 3,000 to 8,000.

17. 1996: 4/8-5/28 - Outflow 40,000-60,000; QWEST 8,000-10,000; exports rising from 6,000 to 10,000.

Chinook Winter (Jan-Mar) Salvage Analysis

Introduction

One of the salvage data patterns that is consistent from year to year is the salvage of chinook salmon fry and smolts in the winter. Fry and subyearling smolts of both spring and fall run are included. The spring and fall run fish range in size from 35-45 mm in early January to 40-100 mm in March. Some winter run smolts occur during the Jan-Mar period, which are relatively large ranging in size from about 100-140 mm. Many of the fry salvaged are believed to be from San Joaquin tributaries.

Conclusions

1. Chinook fry, presmolts, and smolts are salvaged in large numbers most winters over a two-to-four week period most often in February and March, but as early as late December in some years.
2. Salvage events may be continous over winter if inflows/outflows are high all winter.
3. Initial salvage events usually coincide with first winter flow pulse (usually outflows in excess of 20,000 cfs indicate a pulse of inflow from Delta rainfall or upstream sources).
4. Very high inflows appear to lead to the highest numerical salvage events.
5. Salvage events may have short term peaks particularly dry years, and these peaks often follow pulses in inflow/outflow.
6. Outflow pulses as low as 20,000 cfs or even less can lead to winter salvage events.
7. In wet years, salvage events can be continuous, but may slacken if exports are reduced or inflows remain very high.
8. Salvage events often occur under high exports (8,000-14,000 cfs), and ended when exports fell to 4,000-8,000 range.

Potential Solutions

1. Little concern until first flow pulse of winter, then fry are rearing in Delta and subject to entrainment into export facilities.
2. During and following inflow/outflow pulses, salvage could increases at any time, and exports could be reduced until an event passes. Export reductions to levels below 8,000 cfs may end or preclude a salvage event; if reductions aren't effective then they could be scaled down further.
3. During and immediately following inflow/outflow pulses, particularly during dry years, the DCC and HOR barrier could be closed until Sacramento and San Joaquin salmon fry have passed into the western and central Delta, or Suisun Bay. DCC closure could impose greater salvage losses on San Joaquin fry when the HOR barrier is in place.
4. In dry years the first small inflow/outflow pulse of the winter could be enhanced with storage releases to facilitate fish moving through the north Delta to the Bay. This may also stimulate more fry to migrate from tributaries and take advantage of possibly the only pulse of a dry year, assuming migration to the Delta is a positive factor for the populations.

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Summary of Specific Events by Year

The following summaries include general patterns observed and rounded numbers, usually to the nearest 1,000 cfs.

1. 1980: Two salvage events during winter of marked by high outflow.
   a. SWP 12/25/79-1/11/80 - Salvage event coincident with first outflow pulse of winter of 58,000 cfs on 12/28/79; exports were 6,000+ at SWP, 0 at CVP.
   b. SWP 1/14/80-1/21/80 - Salvage event coincident with outflow pulse that peaked at 30,000 cfs on 1/16; exports were 6,000+ at SWP, 0 at CVP.
   c. Salvage low remainder of winter under high inflows/outflows.

2. 1981: Sporadic small events following outflow/inflow pulses.
   a. SWP/CVP 12/29/80-1/1/81 following outflow pulse of 14,000 cfs on 12/25/80; exports 6,000-7,000.
   b. SWP 1/29-2/15: salvage event following pulse of outflow that peaked at 75,000 cfs on 1/31; exports 7,000-8,000.
   c. SWP 2/17-3/16: event coinciding with outflow pulses of 27,000 cfs on 2/17 and 3/7; exports 4,000-8,000

3. 1982: High salvage all winter under high inflow/outflow with distinct peaks in salvage coinciding with or following peaks in outflow.
   a. SWP/CVP 12/22/81-12/29/81 following outflow pulse that reached peak at 218,000 cfs on 12/22/81; exports 6,000-7,000.
   b. SWP/CVP 2/19-3/1 following outflow peak of 238,000 on 2/17; exports were 10,000-11,000.
   c. SWP/CVP 3/20-3/29 following outflow peak of 102,000 cfs on 3/18; exports were 10,000-11,000.

4. 1983: Salvage events all winter under continuous high inflows/outflows with distinct peaks related to inflow/outflow pulses.
   a. SWP/CVP 12/2/82-12/18/82 coinciding with an outflow pulse that peaked at 102,000 cfs on 12/2/82; exports 9,000-10,000.
   b. SWP/CVP 12/22/82-1/3/83 during outflow pulse that peaked at 196,000 cfs on 12/24/82; exports 8,000-10,000.
   c. SWP/CVP 2/2/83-2/3/83 after an outflow peak of 297,000 on 1/30/83; exports 9,000-10,000.

5. 1984: Low salvage despite high inflow/outflows - low exports (0-7,000 cfs)

6. 1985:
   a. SWP/CVP 12/15/84-12/22/84 following outflow pulse of 41,000 on 12/6/84; exports 9,000-11,000.

b. SWP/CVP 2/13/85-3/2/85 following outflow pulse that peaked at 39,000 on 2/10/85; exports 8,000-11,000.

c. SWP/CVP 3/10-3/23 following outflow peak of 13,000 on 3/10; exports 8,000-10,000.

7. 1986: late winter flood and large salvage event.

a. SWP/CVP 1/15-1/22 coincident with outflow pulse that peaked at 32,000 on 1/19; exports 9,000-10,000.

b. SWP/CVP 2/4-2/14 coincident with outflow pulse that peaked at 75,000 on 2/5; exports 5,000-7,000.

c. SWP/CVP 2/17-3/16 very high salvage numbers coinciding with outflow pulse that peaked at 629,000 cfs on 2/22; exports 4,000-7,000.

8. 1987:

a. SWP/CVP 2/15-2/17 - coinciding with outflow pulse that peaked at 43,000 on 2/15; exports 7,000-9,000.

b. SWP/CVP 3/7-3/31 - coinciding with another pulse that peaked at 43,000 on 3/8; exports 2,000-6,000.

9. 1988:

a. SWP/CVP 12/9/87-12/23/87 coinciding with outflow pulse that peaked at 19,000 on 12/8/87; exports 9,000-12,000.

b. SWP 1/4-1/11 - coinciding with outflow pulse that peaked at 34,000 on 1/6; exports 10,000-11,000

c. SWP/CVP 1/20-1/29 following pulse that peaked at 37,000 on 1/18; exports 10,000-11,000.

d. SWP/CVP 2/3-2/22 following outflow peak of 11,000 on 2/1; exports 10,000-11,000.

e. SWP/CVP 2/29-3/11 following outflow peak of 7,000; exports 9,000-10,000.

10. 1989:

a. SWP 1/1-1/16 following pulse of outflow that peaked at 23,000 on 12/26/88; exports 9,000-11,000

b. SWP 3/4-3/31 coinciding with outflow pulse that peaked at 61,000 on 3/14; exports 9,000-11,000.

11. 1990:

a. SWP 1/23-1/30 - coinciding with outflow pulse that peaked at 32,000 on 1/16; exports 10,000-11,000.

b. SWP 2/19-3/31 following outflow pulse that peaked at 20,000 on 2/18; exports 10,000-11,000.

12. 1991:

a. SWP 3/4-3/31 - coinciding with outflow pulse that peaked at 40,000 on 3/5; exports 9,000-11,000.

13. 1992:
    a. SWP/CVP 1/8-1/14 - coinciding with outflow pulse that peaked at 16,000 on 1/7; exports 10,000-11,000.
    b. SWP/CVP 2/15-3/31 - coinciding with outflow pulse that peaked at 61,000 on 2/15; exports 10,000-11,000.

14. 1993:
    a. SWP/CVP 1/9-2/1 - coinciding with outflow pulse that peaked at 132,000 on 1/23; exports 11,000-14,000.
    b. SWP/CVP 2/8-2/14 - coinciding with outflow pulse that peaked at 58,000 on 2/12; exports 10,000-12,000.
    c. SWP/CVP 2/20-2/24 - outflow rising from 54,000 to 108,000; exports 12,000 falling to 6,000 at end.

15. 1994:
    a. SWP/CVP 12/10/93-1/1/94 - coinciding with pulse of outflow that peaked at 25,000 on 12/14/93; exports 8,000-11,000, ending with exports fallling to 7,000.
    b. CVP 1/26-2/3 coinciding with outflow pulse that peaked at 24,000 on 1/26; exports 7,000-9,000, ending when exports fell to 4,000.
    c. SWP/CVP 2/6-3/22 coinciding with outflow pulses with peaks of 36,000 on 2/10 and 35,000 on 2/23; exports 10,000 falling to 4,000.

16. 1995:
    a. SWP/CVP 1/8-2/5 - coinciding with outflow pulse that peaked at 248,000 on 1/12; exports 11,000-12,000, ended when exports fell to 8,000-9,000.
    b. CVP 2/6-3/7 - continuing high inflows; exports 8,000-9,000, ended when exports fell below 6,000.

17. 1996:
    a. SWP/CVP 1/16-1/28 - coinciding with first outflow pulse that peaked at 51,000 on 1/22; exports 10,000-12,000, ended when exports fell to 4,000-6,000.
    b. CVP 2/5-2/15 coinciding with outflow pulse that peaked at 158,000 on 2/7; exports 5,000-8,000.
    c. CVP 2/21-2/27 coinciding with outflow pulse that peaked at 211,000 on 2/23; exports 4,000-8,000, ended when exports fell to 4,000.

Steelhead (Feb-May) Salvage Analysis

Introduction

One of the salvage data patterns that is consistent from year to year is the salvage of steelhead smolts in the winter and early spring. Many of these event likely coincide with large releases of State and federal hatchery fish during the winter, which is usually in February. These are relatively large smolts ranging in size from about 200 mm and larger. Their survival during salvage is high (95+%). This paper summarizes the pattern of salvage events at the SWP and CVP fish facilities in the Delta.

Conclusions

1. Many of the steelhead salvage events occur at the SWP.
2. Most of the salvage events occurred in March and April, with a few in February and May, and one each in December, January, and June.
3. Events were common even in wet years, with the exception of 1983.
4. The events are often coincident and/or follow inflow/outflow pulses, particularly in dry years; events also associated with rising and then declining outflow and QWEST, and increased or steady high exports (8,000+ cfs).
5. Many events end with a new pulse of inflow/outflow, or a decline in exports (often 4,000-6,000)
6. Events can occur in wet years under very high flows, particularly if exports are high (10,000+ cfs), under maximum SWP pumping (6,000+cfs). Higher experimental pumping (6,000-10,000 cfs SWP pumping in 1993 and 1995 coincided with steelhead salvage events. Events can occur at CVP Tracy facilities when it is pumping at its maximum level of 4,100-4,400 cfs.
7. Large events occur during rapidly declining outflows and QWEST, with high or increasing exports. Some events had outflows declining from 30,000 to 2,000 cfs.

Potential Solutions

1. Sharply declining inflows in association with increasing or continuing high exports can be moderated by anticipating the declining inflows and reducing or at least gradually ramping up exports until inflows reach a stable or controlled level. Declining inflows in the low range (under 20,000 cfs) could also be ramped down more slowly as flows come under control.
2. More gradually ramping declining smaller inflow pulses under high and increasing exports, may reduce the potential for drawing steelhead smolts in the winter and and spring into the south Delta, thus reducing the overall potential for salvage losses as flows fall.
3. Anytime fish salvage increases under moderate to high exports, exports could be reduced until an event passes. Only small reductions in exports (e.g., from 10,000 cfs to 8,000 cfs) may be needed to end or preclude salvage events. If such reductions do not end or preclude an event, then reductions could be scaled down further (e.g., from 8,000 to 6,000

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cfs, etc.).

4. Exports above 10,000, particularly 12,000-15,000 bring high risk of salvage events; such high exports could be ramped up slowly to minimize hydrological effects that may increase risk of steelhead to salvage. In addition, salvage events could be anticipated even at high inflows.
5. During and immediately following small inflow pulses, particularly during dry years, the DCC could be closed until fish have past into the western Delta.
6. The first small inflow/outflow pulse of the winter could be enhanced with storage releases to facilitate fish moving through the north Delta to the Bay. This may also stimulate more smolts from tributaries to migrate and take advantage of possibly the only pulse of a dry year.

Summary of Specific Steelhead Salvage Events

The following summaries include general patterns observed and rounded numbers, usually to the nearest 1,000 cfs.

1. 2/27/81-3/5/81 CVP/SWP
   a. Exports: 6,000 - 9,000 cfs
   b. Outflow: falling from 16,000 to 14,000 cfs
   c. QWEST: falling from 0 to -2,400 cfs
   d. Ending: outflow rose to 20,000

2. 3/28/81-4/10/81 SWP
   a. Exports: rising from 3,000 to 9,000
   b. Outflow: falling to 48,000 to 8,000
   c. QWEST: falling from 13,000 to -5,000

3. 4/22/81-4/30/81SWP
   a. Exports: 9,000-10,000
   b. Outflow: falling from 17,000 to 500;
   c. QWEST: 7,000 to -4,000 cfs

4. 4/6/82-4/11/82 SWP
   Large event.
   a. Exports: SWP at 6,000+
   b. Outflow initially falling from 181,000 to 103,000
   c. QWEST initially falling from 46,000 to 30,000

5. 4/16/82-5/2/82 SWP
   a. Exports: 9,000-10,000
   b. Outflow: falling from 200,000 to 80,000
   c. QWEST: falling from 40,000 to 30,000
   d. Ended when SWP exports fell from 6,000+ to 2,000

6. 12/14/82-12/20/82 CVP
   a. Exports: rising from 2,000 to 10,000
   b. Outflow: falling from 50,000 to 37,000
   c. QWEST: falling from 22,000 to 12,000

7. 4/17/84-5/1/84 SWP
   a. Exports: 8,000-9,000
   b. Outflow: initially falling 16,000 to 3,000
   c. QWEST: falling from 3,000 to -1,000
   d. Ended: Outflow rising to 10,000 and exports falling to 6,000.

8. 2/25/85-3/12/85 SWP
   a. Exports: Initially rising from 7,000 to 10,000
   b. Outflow: initially falling from 12,000 to 10,000
   c. QWEST: initially falling from -1,000 to -7,000
   d. Ended: Outfall rose to 13,000; QWEST rose to -1,000; exports dropped to 6,000.

9. 3/17/85-3/26/85 SWP
   a. Exports: initially rising from 6,000 to 8,000
   b. Outflow: initially falling from 12,000 to 8,000
   c. QWEST: intially falling from 2,700 to 1,100

10. 3/26/85-4/10/85 SWP
    a. Exports: 7,000
    b. Outflow: initially rising from 6,000 to 20,000 and then falling to 8,000
    c. QWEST: initially rising from 1,000 to 9,000, then back to 1,000

11. 4/16/85-4/26/85 SWP
    a. Exports: 7,000-9,000
    b. Outflow: initially rising from 4,000 to 8,000, then returning to 4,000
    c. QWEST: initially rising from -100 to 1,400, then falling to -800

12. 4/17/86-4/30/86 SWP
    a. Exports: initially rising from 4,000 to 7,000
    b. Outflow: falling from 40,000 to 17,000
    c. QWEST: falling from 22,000 to 8,000

13. 3/1/87-3/4/87 SWP
    a. Exports: 8,000-9,000
    b. Outflow: falling from 6,000 to 2,000
    c. QWEST: falling from 0 to -2,600
    d. Ended: Outflow rose from 22,000.

14. 3/13/87-4/30/87 SWP
    a. Exports: 4,000-7,000
    b. Outflow: initially rising from 21,000 to 42,000, then falling to 5,000
    c. QWEST: falling from 6,000 to -2,000.

15. 5/5/87-5/15/87 SWP/CVP
    a. Exports: 6,000
    b. Outflow: falling initially from 7,000 to 4,000
    c. QWEST: falling initially from 2,000 to -100.

16. 2/1/88-2/19/88 SWP
    a. Exports: 10,000+
    b. Outflow: gradually falling from 11,000 to 0
    c. QWEST: falling from -1,000 to -4,000

17. 2/23/88-3/7/88 SWP
    a. Exports: 8,000-9,000
    b. Outflow: initially rising from 0 to 7,000, then falling to 3,000
    c. QWEST: initially rising from -4,000 to 900; then falling to -2,000

18. 3/27/88-4/3/88 SWP
    After a small flow pulse.
    a. Exports: 8,000
    b. Outflow: rising from 7,000 to 11,000
    c. QWEST: rising from -800 to 1,900 then falling to -500

19. 4/15/88-5/15/88 SWP/CVP
    a. Exports: initially 9,000; rising to 10,000+, then falling to 6,000-8,000
    b. Outflow: initially rising from 10,000 to 24,000, then falling to 2,000
    c. QWEST: initially rising from -200 to 8,000, then falling -2,700

20. 2/13/89-2/27/89 SWP
    a. Exports: 8,000-10,000
    b. Outflow: falling initially from 8,000 to 2,000
    c. QWEST: falling initially from 200 to -5,000

21. 3/3/89-3/22/89 CVP/SWP
    a. Exports: exports initially rose from 9,000 to 11,000;
    b. Outflow: initially rose from 20,000 to 61,000, then falling to 29,000;
    c. QWEST: initially rising from -2,000 to 6,000, then falling to -2,000

22. 3/24/89-4/13/89 CVP/SWP

a. Exports: 10,000-11,000
b. Outflow: initially rising from 30,000 to 68,000; then falling 10,000
c. QWEST: rising initially from -1,200 to 5,000; then falling to -6,000.

23. 4/16/89-4/25/89 SWP and CVP
a. Exports: 10,000+
b. Outflow: 4,000-7,000
c. QWEST: -1,000 to -3,000

24. 5/1/89-5/11/89 CVP
a. Exports: 10,000+
b. Outflow: 6,000 to 8,000
c. QWEST: -3,000
d. Ended: Exports fell to 2,000; QWEST rose to 5,000

25. 5/12/89-5/15/89 SWP
a. Exports: rose from 5,000 to 8,000
b. Outflow: fell from 10,000 to 6,000
c. QWEST: fell from 2,000 to -5,000

26. 2/3/90-2/15/90 SWP
a. Exports: 10,000+
b. Outflow: initially rose from 6,000 to 9,000, then fell to 1,000
c. QWEST: initially rose from -1,400 to -500, then fell to -4,200

27. 2/18/90-4/29/90 CVP/SWP
a. Exports: 10,000+
b. Outflow: initially fell from 20,000 to 2,000
c. QWEST: initially fell from 5,000 to -4,000
d. Ended: exports fell to 2,000

28. 3/3/91-4/16/91 CVP/SWP
a. Exports: initially rose from 2,000 to 10,000+
b. Outflow:initially rose from 12,000 to 40,000, then fell to 6,000, then rose again to 59,000, then fell to 0
c. QWEST: initially rose from 7,000 to 10,000, then fell to -7,000, then rose again to 11,000, then fell to -6,000
d. Ended: exports fell to 6,000.

29. 4/24/91-4/28/91 CVP/SWP
a. Exports: 4,000
b. Outflow: fell from 6,000 to 1,000
c. QWEST: fell from 3,000 to -300

30. 1/1/92-1/2/92 CVP/SWP
    a. Exports: rising from 8,000 to 10,000 (recently had risen from 4,000)
    b. Outflow: falling from 18,000 to 2,000 (recently had risen from 5,000)
    c. QWEST: fell from 7,000 to 500 (recently had risen from 0)
    d. Ended: exports fell to 2,000

31. 2/15/92-4/9/92 CVP/SWP
    a. Exports: initially rose from 900 to 10,000+
    b. Outflow: initially rose from 12,000 to 61,000, then fell to 7,000; rising again to 26,000, then falling to 6,000, then rising again to 29,000, and falling again to 1,000.
    c. QWEST: initially rising from 5,000 to 16,000, then fell to -6,000; rising again to 1400, then falling to -7,000, then rising again to -2,000, falling again to -7,000
    d. Ended: exports fell to 1,100.

32. 1/9/93-4/24/93 CVP/SWP
    six subperiods and two peaks
    a. Exports: 10,000 to 14,000 to 6,000 to 12,000 to 12,000
    b. Outflow: 16,000 to 131,000 to 20,000 to 58,000 to 40,000 to 108,000
    c. QWEST: -4,000 to 14,000 to -400 to 7,000 to -1,700 to 17,000
    d. Peaks: 1/16-1/23; exports 13,000-14,000 --- 2/8-2/24; exports 11,000-12,000
    e. Ended: SWP exports fell to 0

33. 2/4/94-3/1/94 CVP
    five subperiods
    a. Exports: CVP at 4,100 during most of period; 4,000 to 6,000-10,000 to 7,000 to 5,000 to 6,000;
    b. Outflow: 9,000 to 36,000 to 14,000 to 35,000 to 14,000
    c. QWEST: -150 to 7,000 to -2,000 to 7,000 to -700

34. 3/4/94-3/11/94 CVP/SWP
    a. Exports: 4,000-5,000
    b. Outflow: 12,000-14,000
    c. QWEST: -200 to 900

35. 1/23/95-2/6/95 SWP
    a. Exports: 12,000+
    b. Outflow: 100,000+
    c. QWEST: 10,000+
    d. Ended: exports fell to 8,000

36. 2/16/95-2/23/95 CVP/SWP

a. Exports: 6,000-8,000
b. Outflow: fell from 70,000 to 40,000
c. QWEST: fell from 10,000 to 4,000

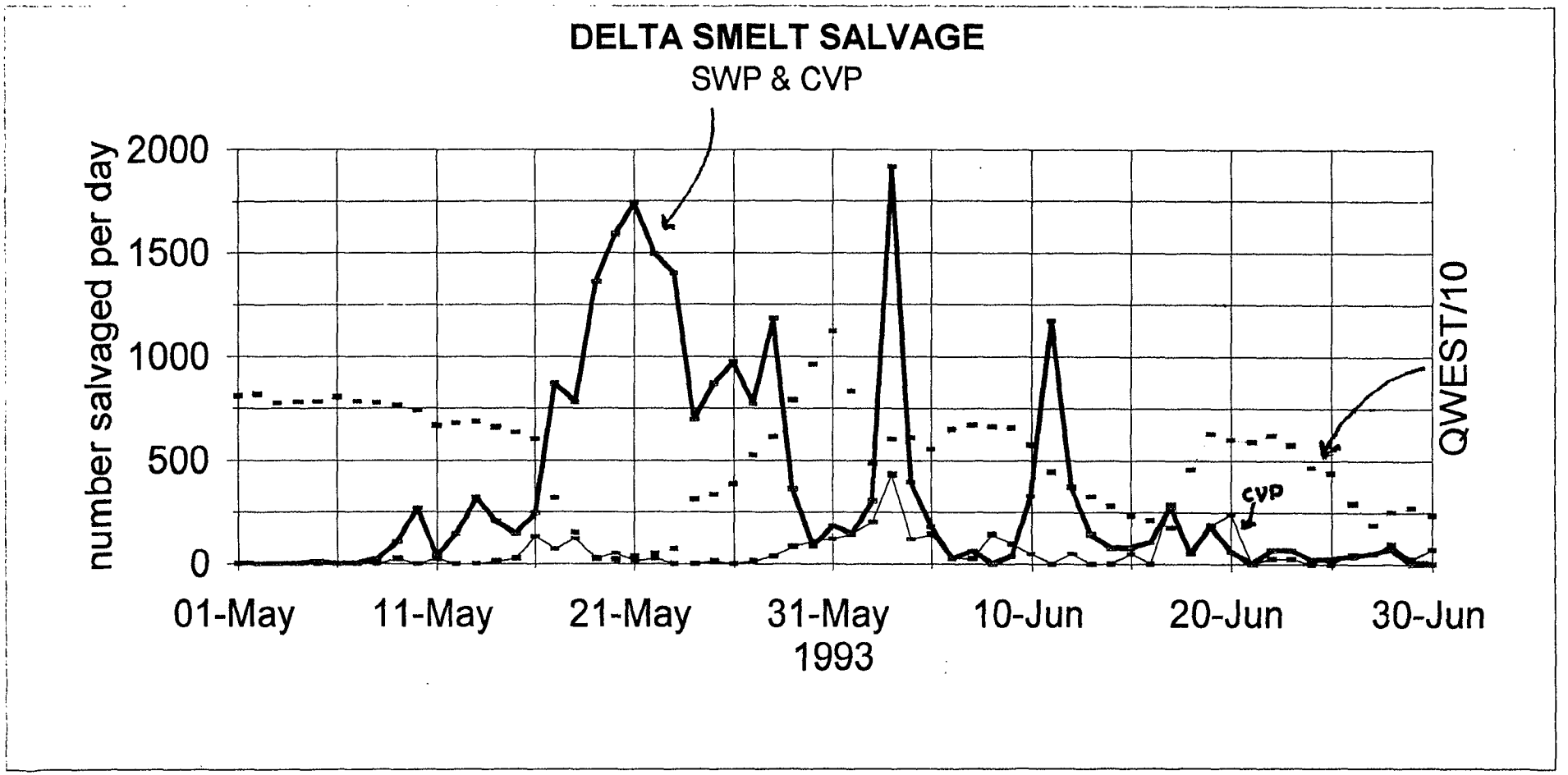
37. 2/27/95-3/10/95 CVP
a. Exports: CVP 4,200
b. Outflow: rose from 30,000 to 120,000
c. QWEST: rose from 3,000 to 30,000

38. 4/25/95-4/30/95 CVP
a. Exports: 3,700 at CVP
b. Outflow: 57,000-67,000
c. QWEST: 27,000-28,000

39. 6/3/95-6/6/95 CVP/SWP
a. Exports: initially rose from 5,000 to 10,000+
b. Outflow: 60,000
c. QWEST: 20,000
d. Ended: exports fell to 8,000

40. 1/16/96-2/15/96 CVP/SWP
a. Exports: initially rose to 10,000+ then fell off to 5,000-9,000
b. Outflow: rising from 7,000 to 158,000
c. QWEST: rising from -6,000 to 28,000

41. 4/2/96-4/14/96 CVP/SWP
a. Exports: 5,000-8,000; CVP 4,300
b. Outflow: falling from 57,000 to 32,000
c. QWEST: falling from 14,000 to 3,000
d. Ended: exports fell to 2,500



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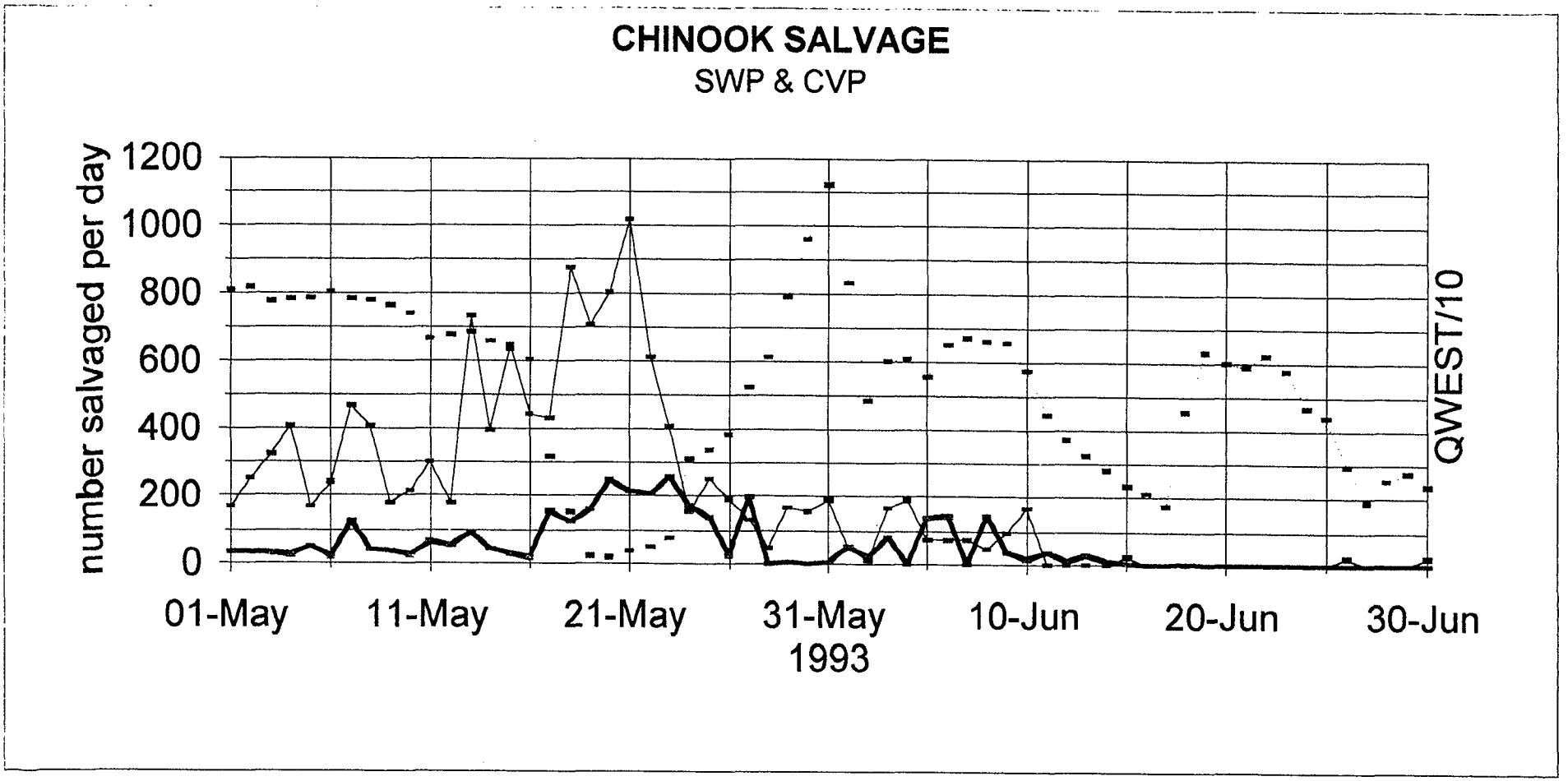

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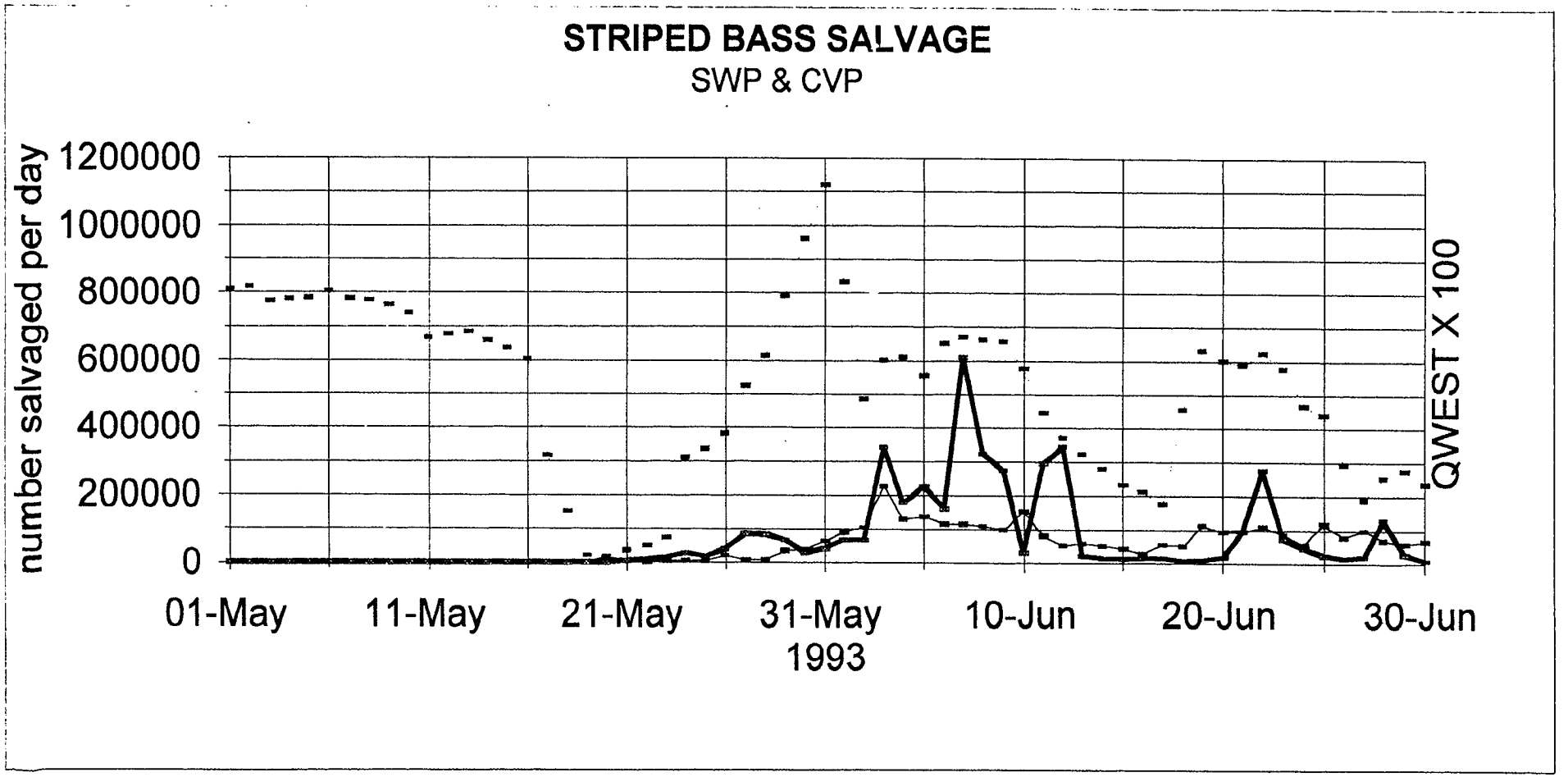

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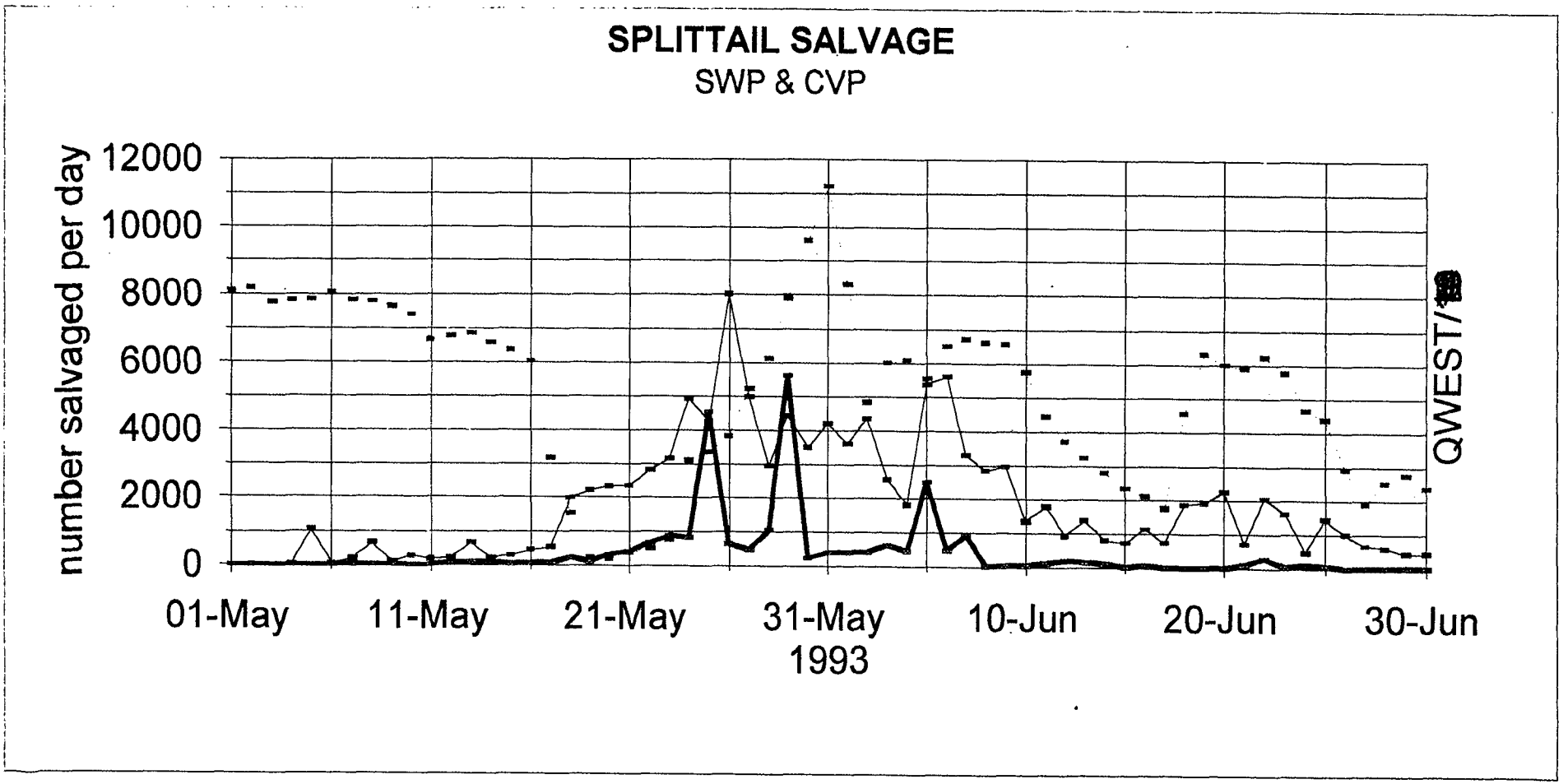

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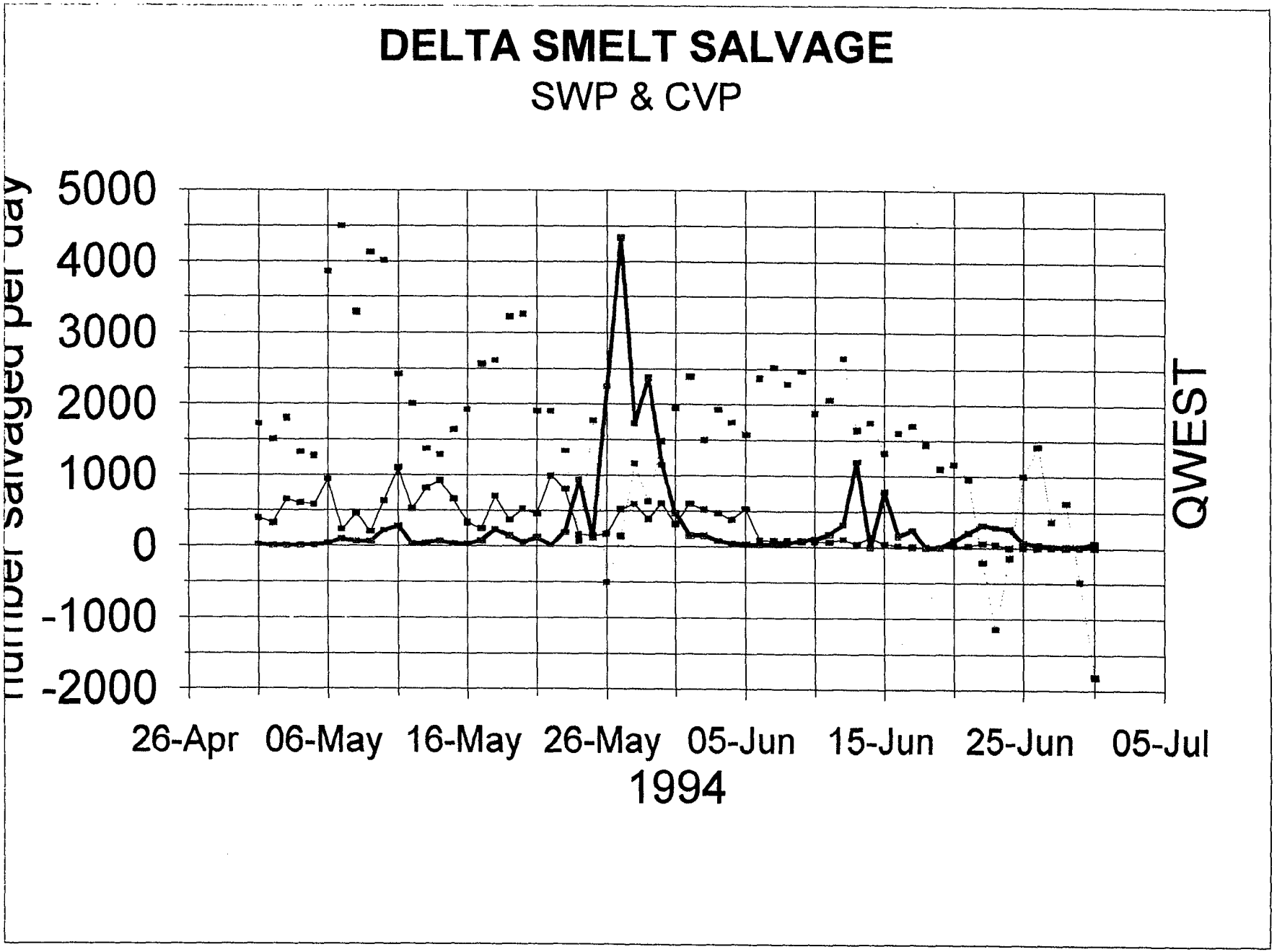

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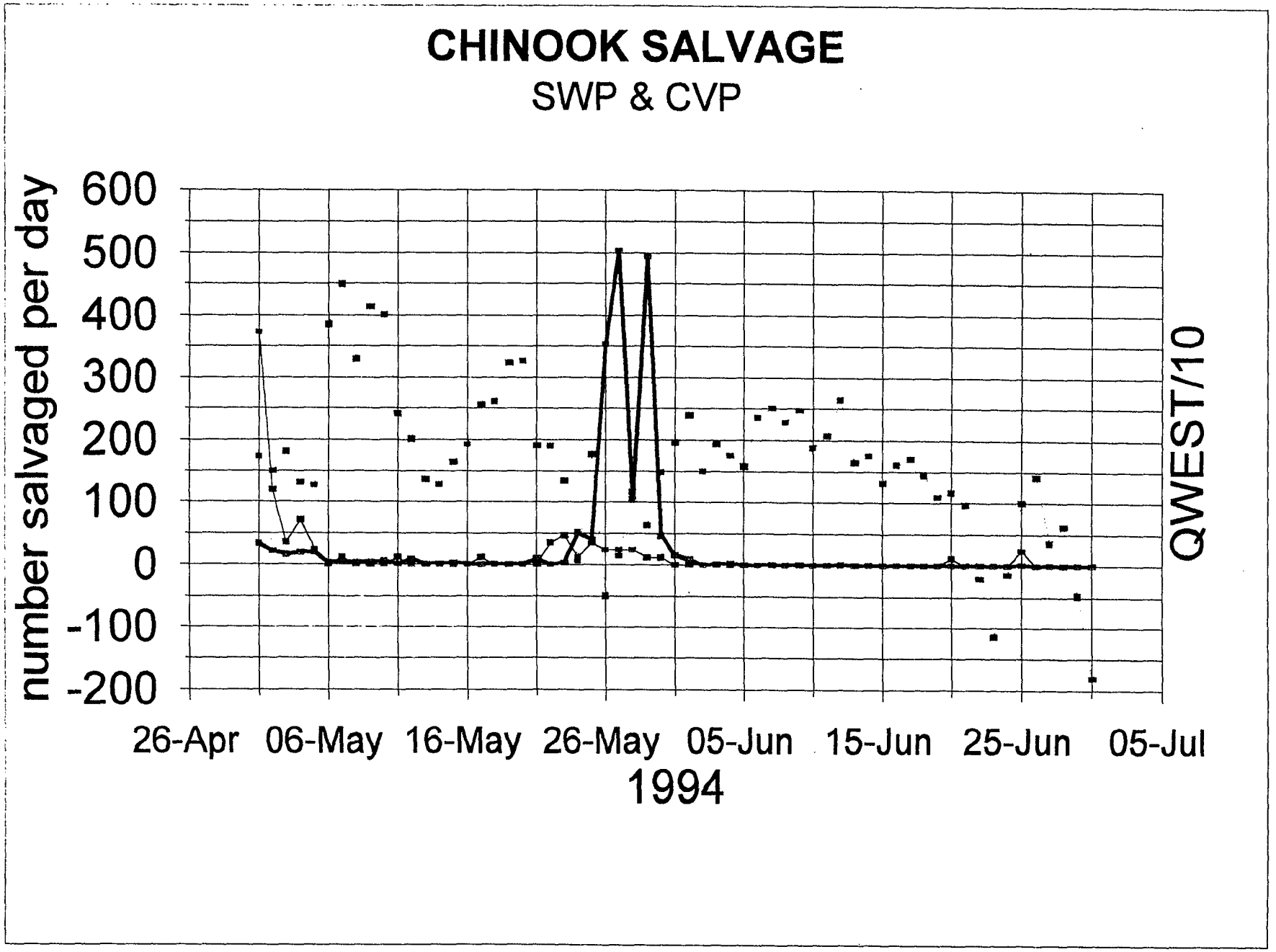

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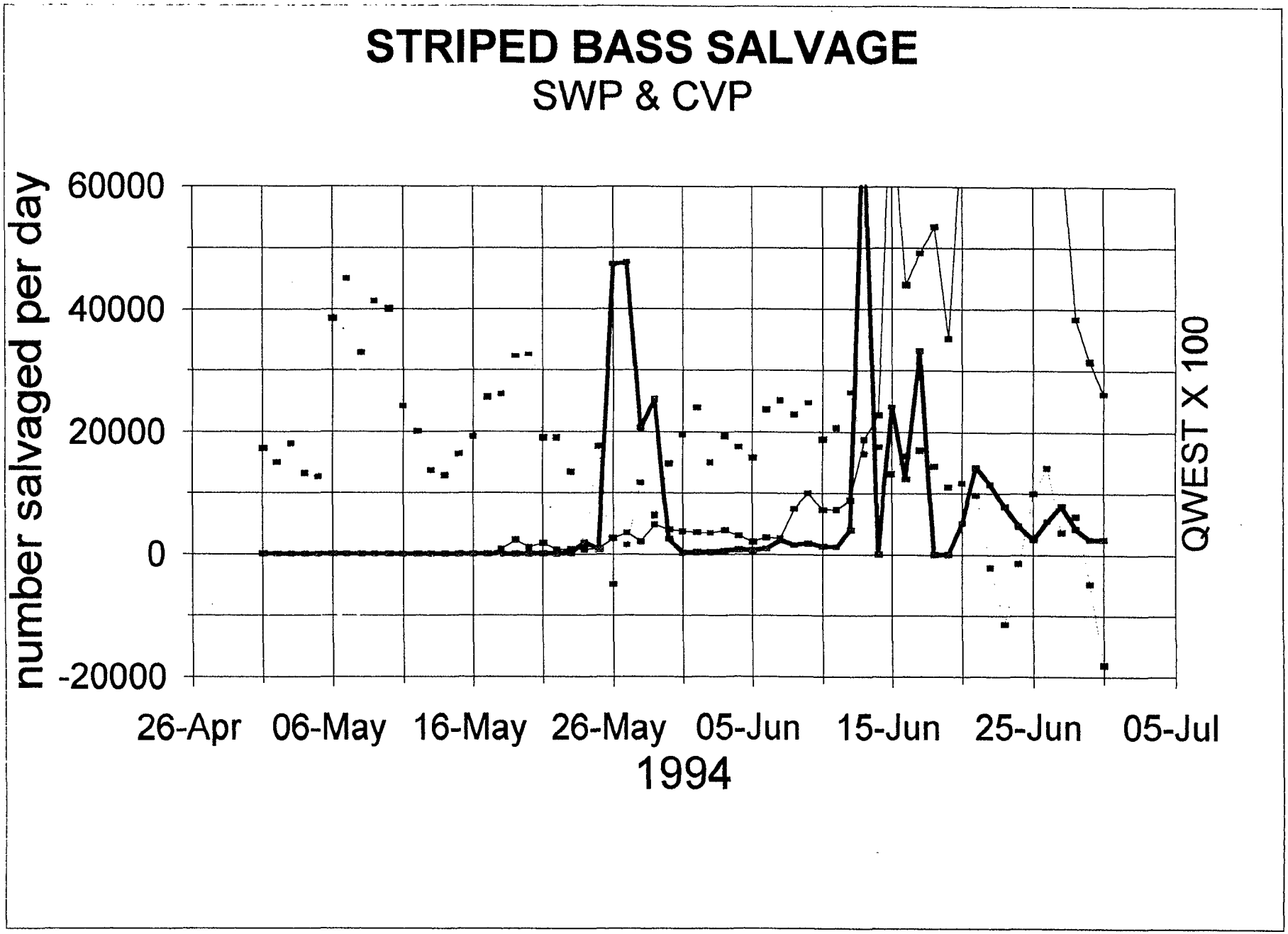

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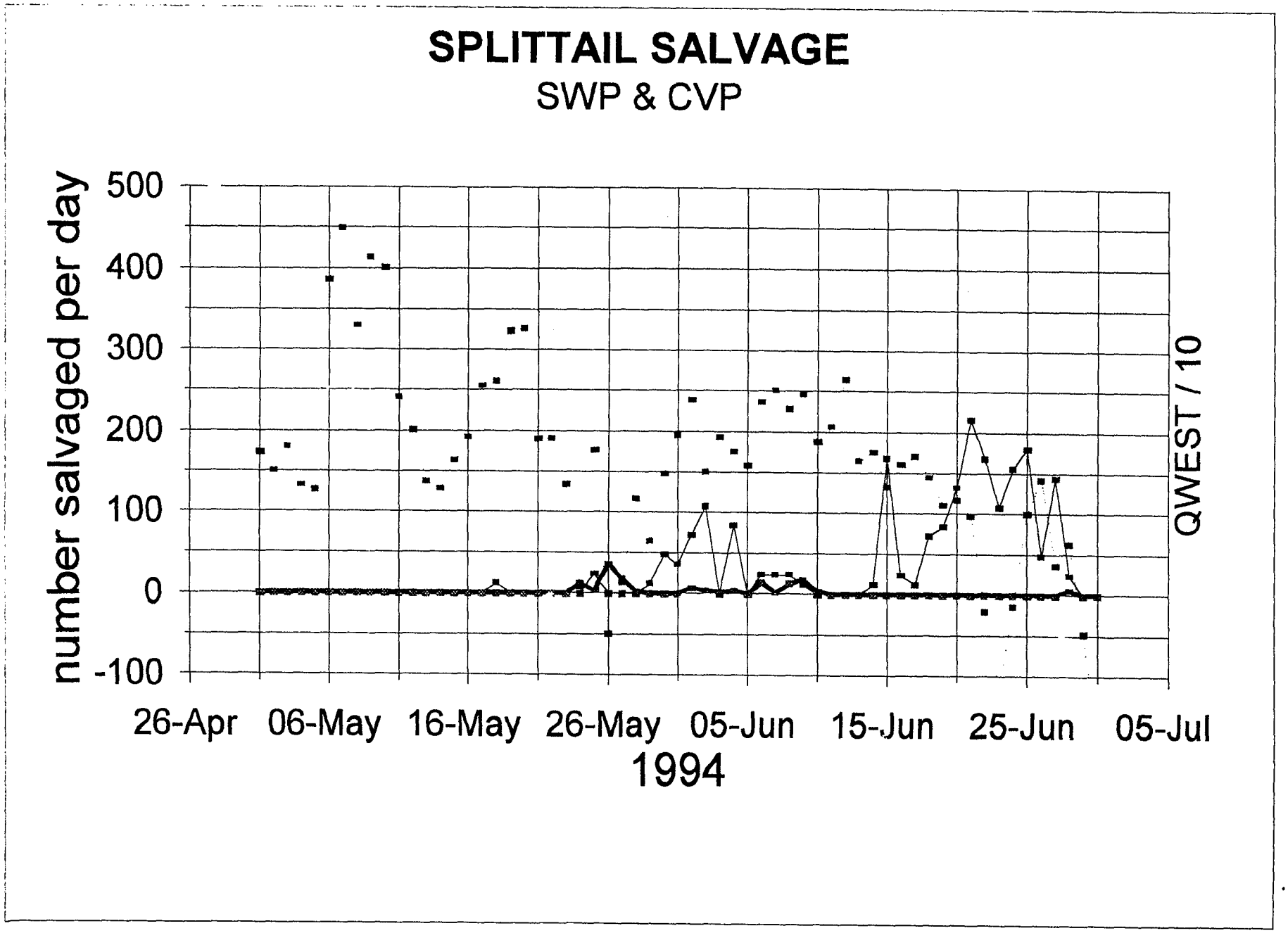

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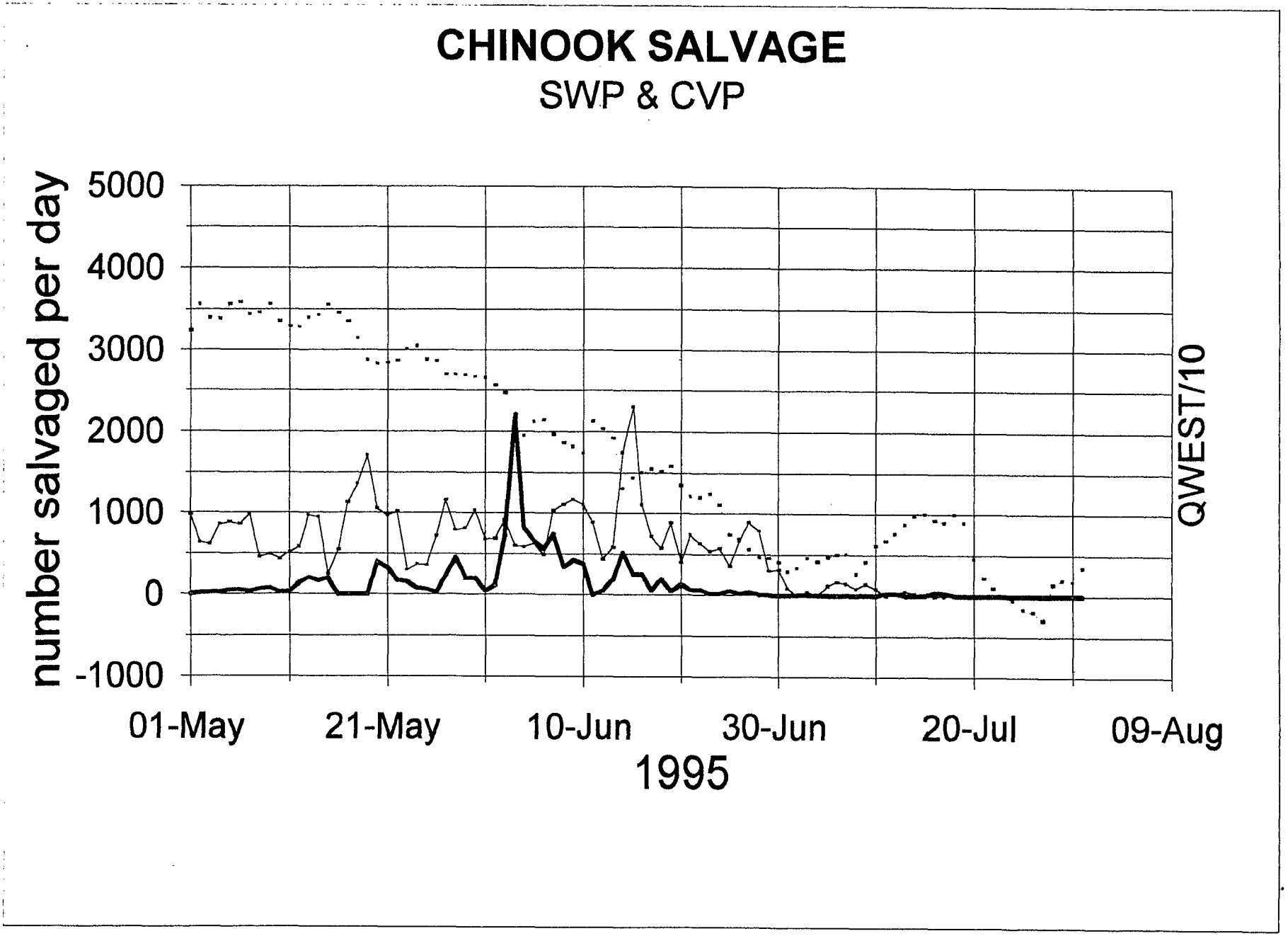

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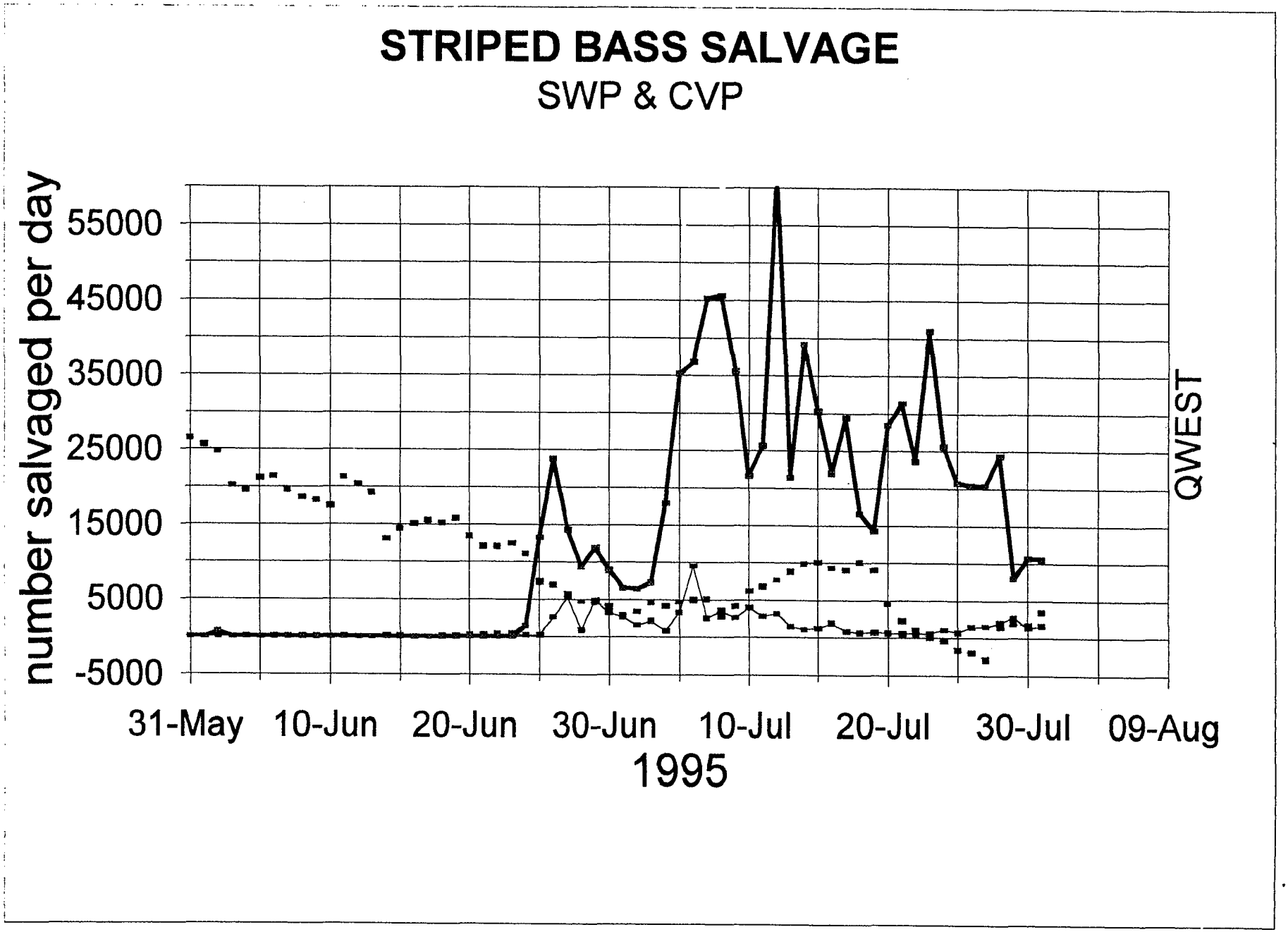

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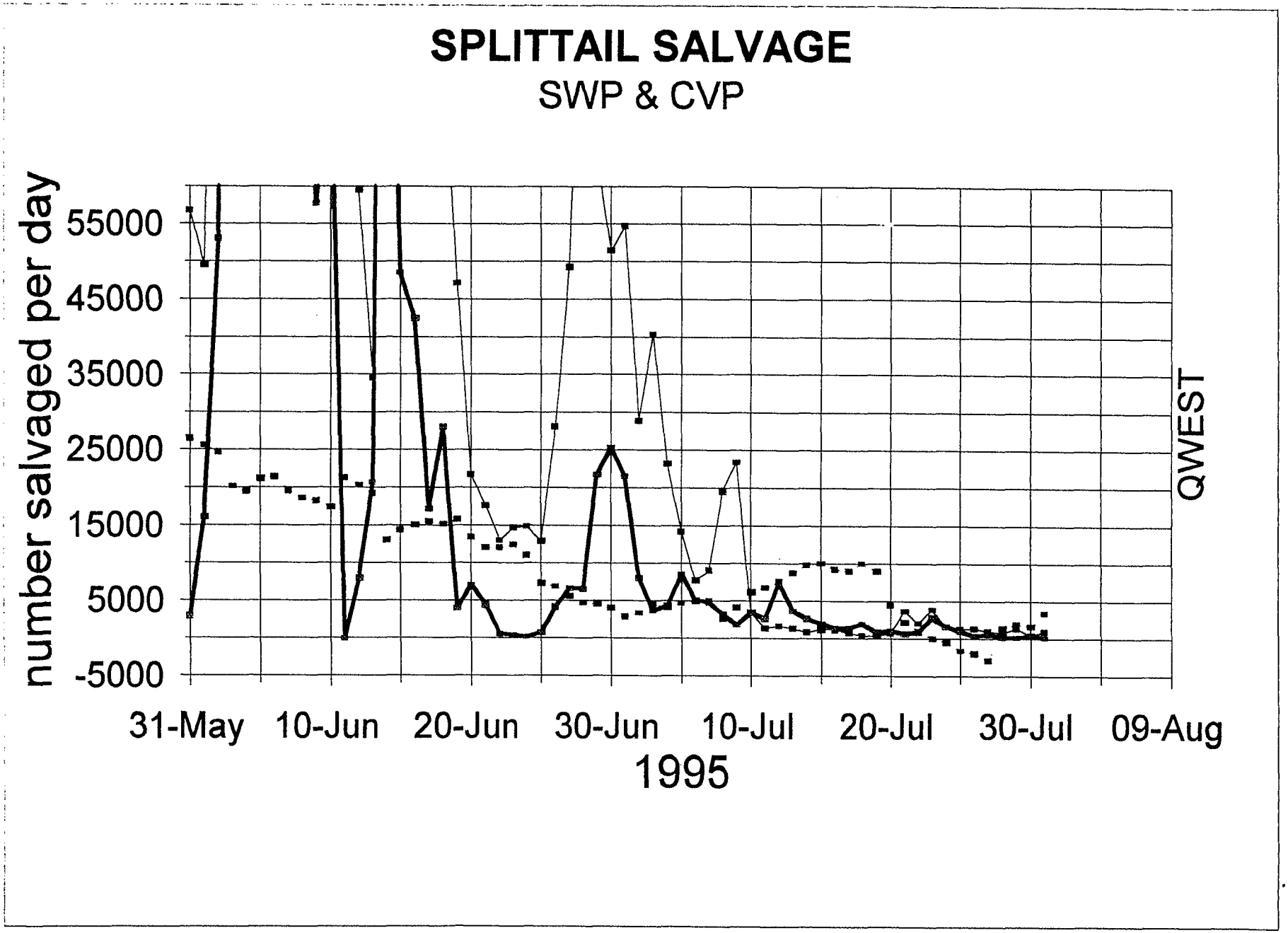

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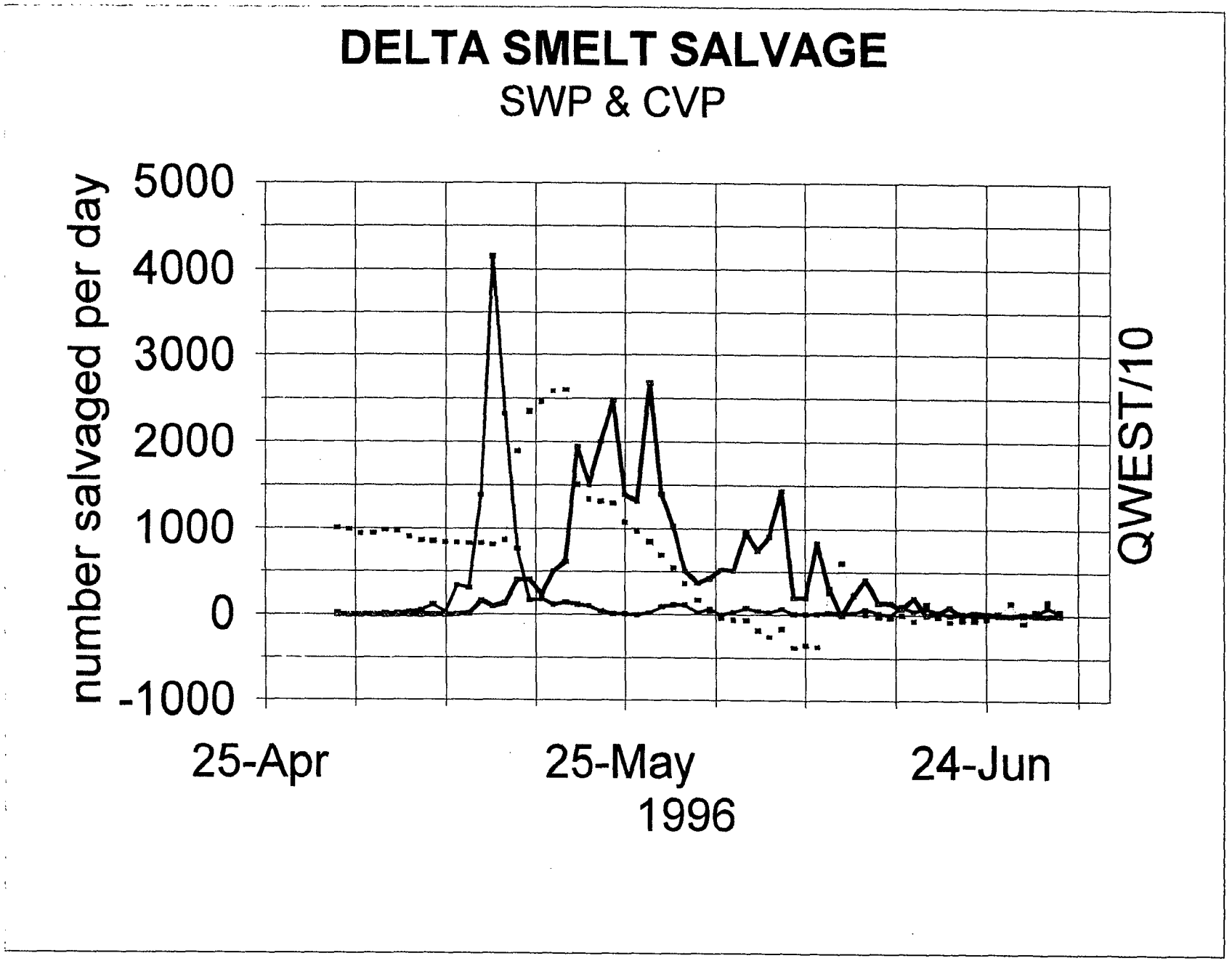

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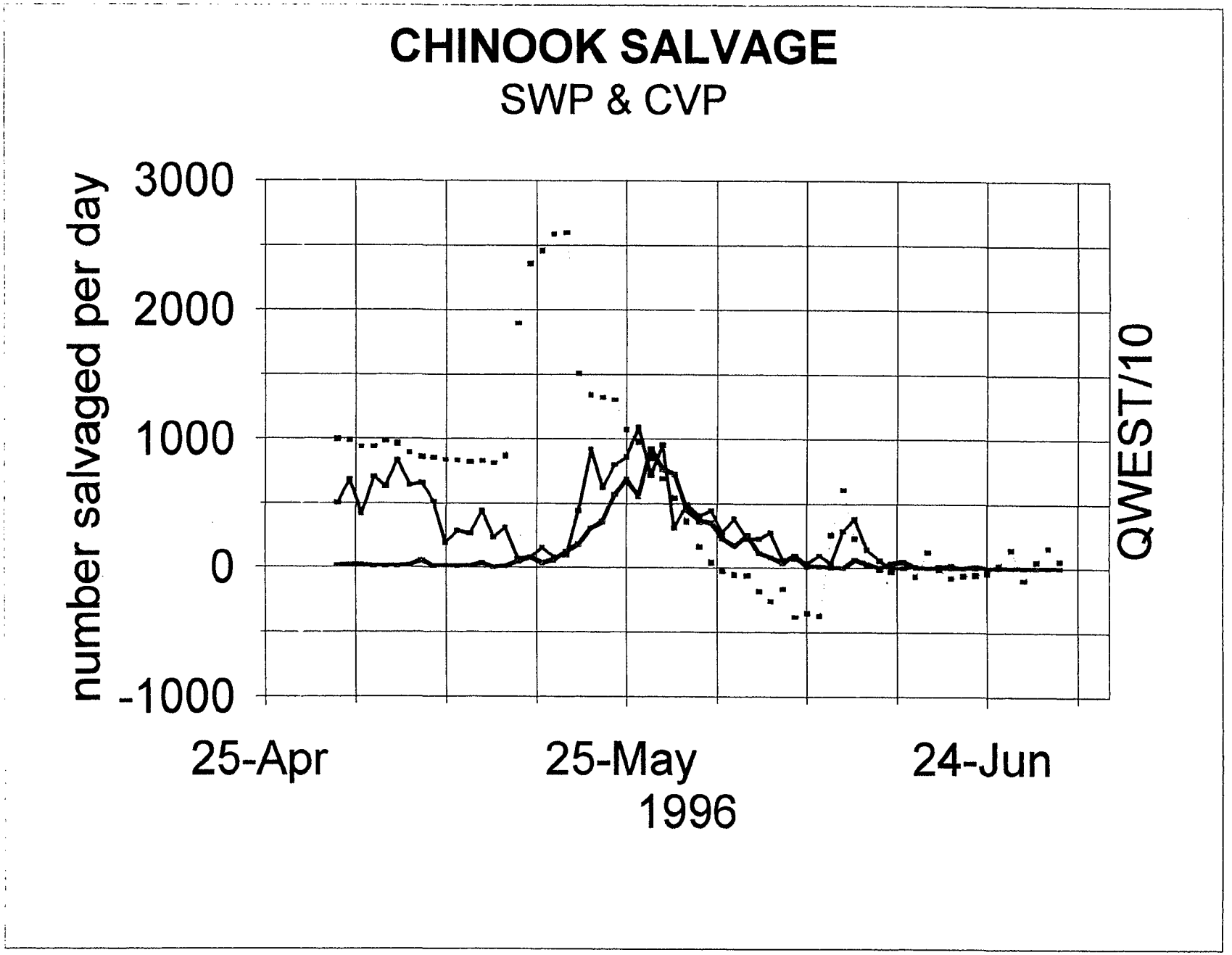

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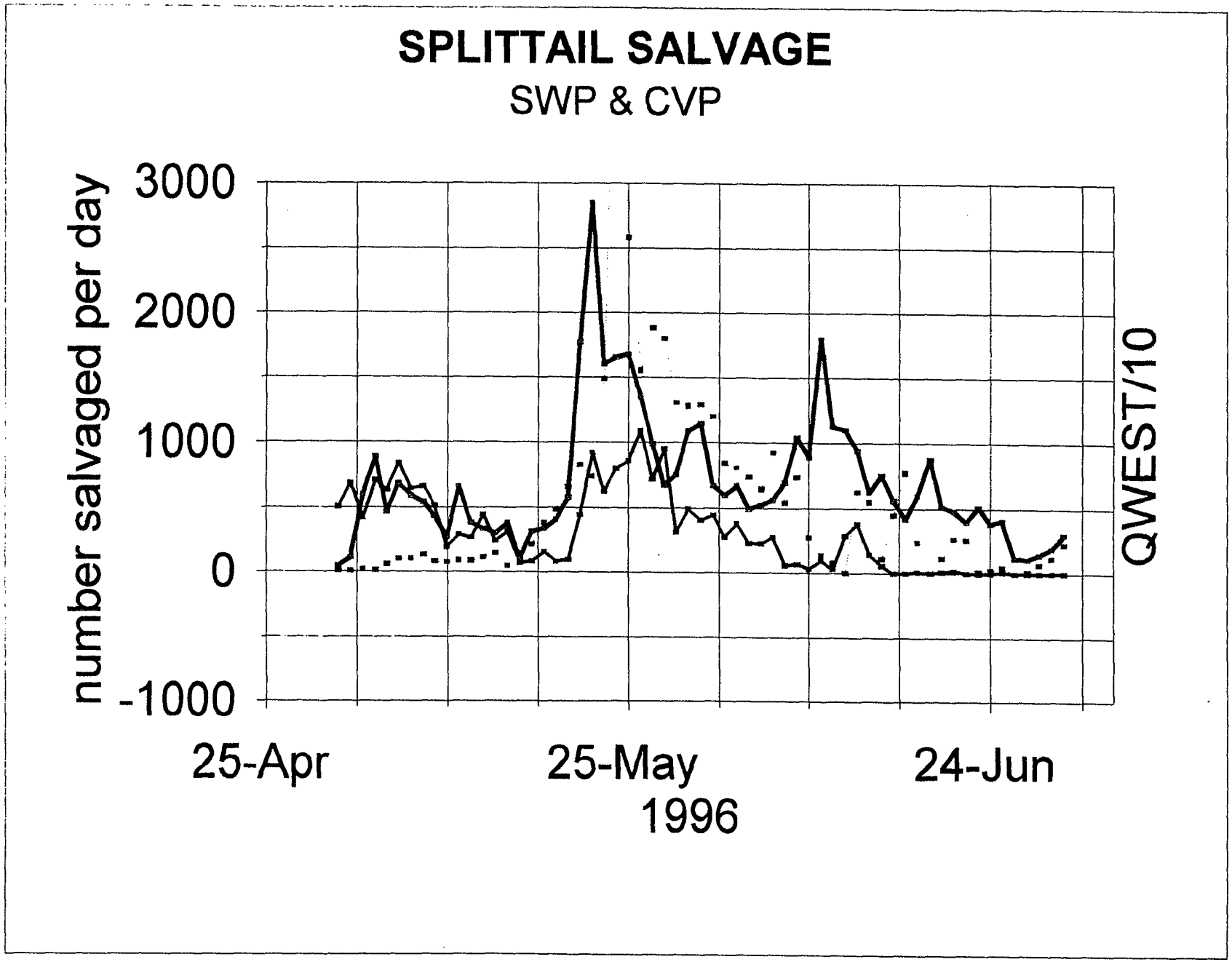

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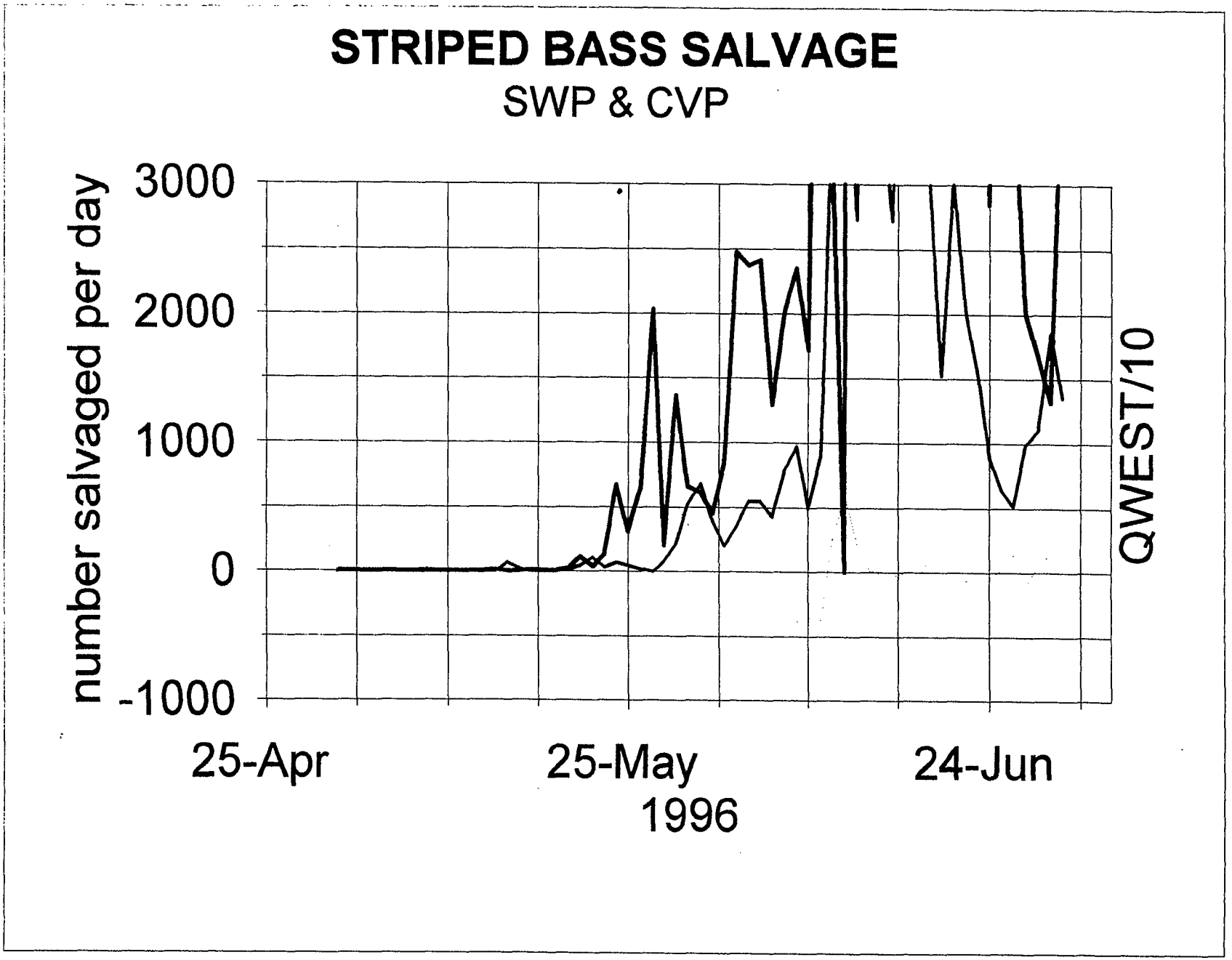

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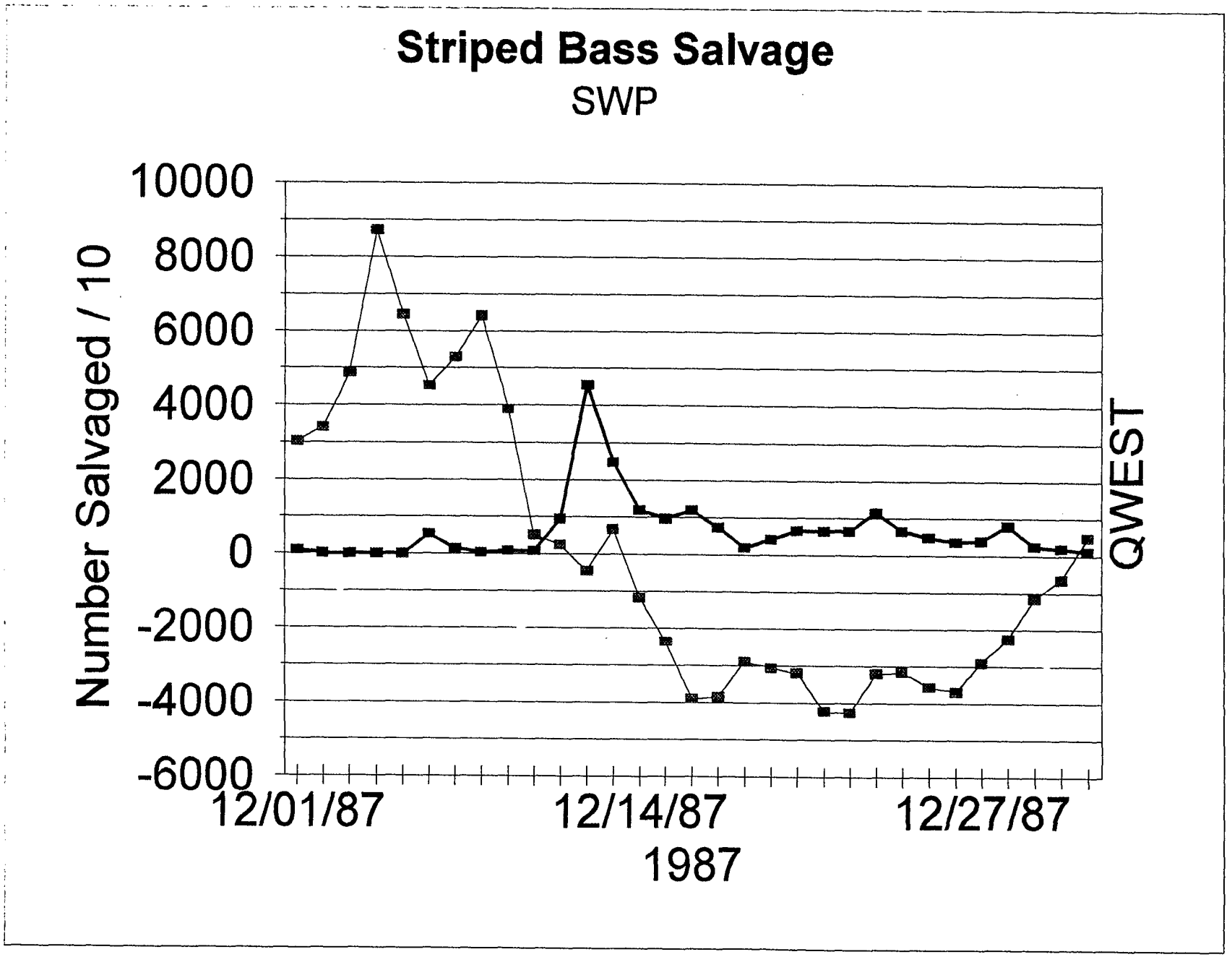

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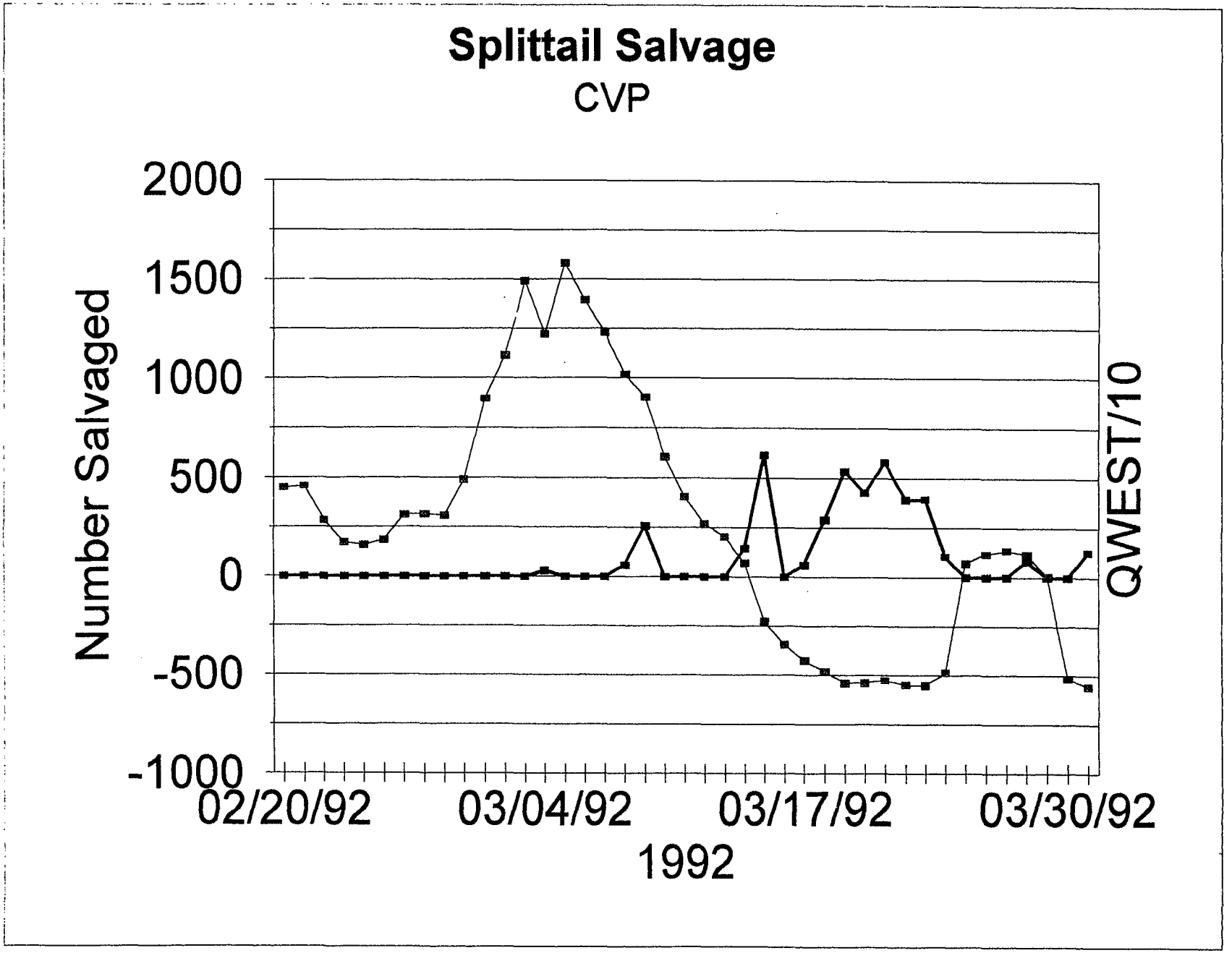

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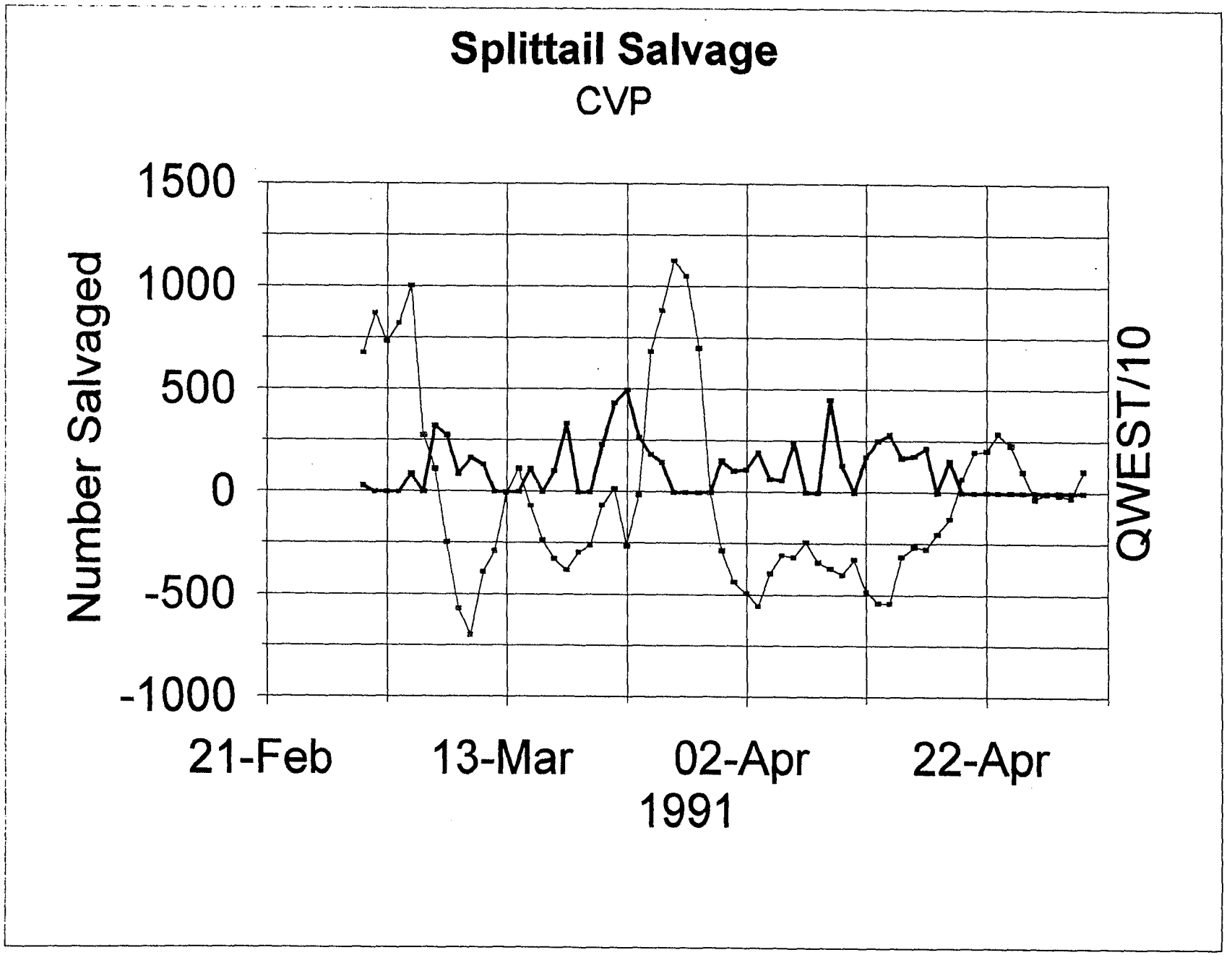

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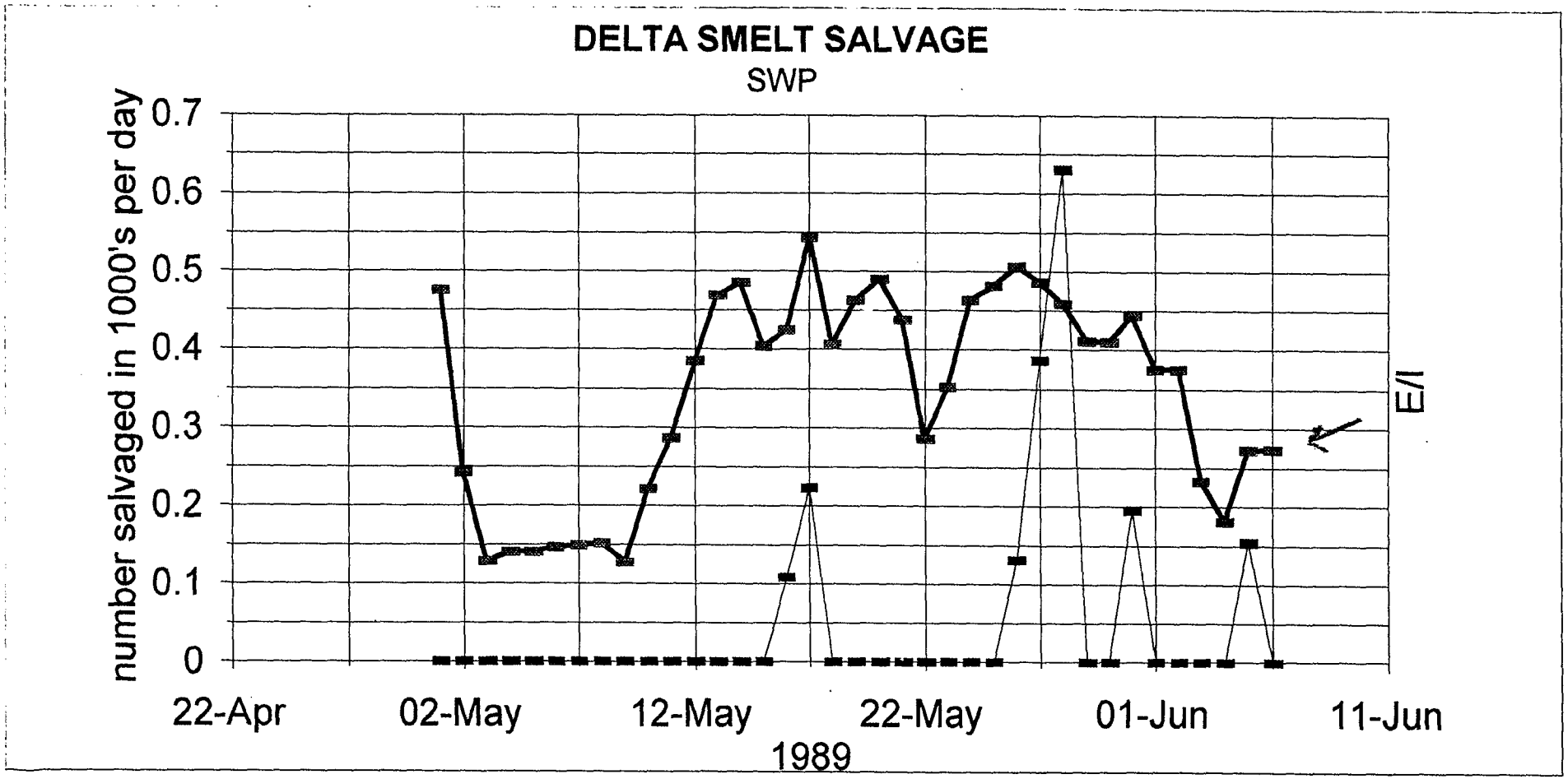

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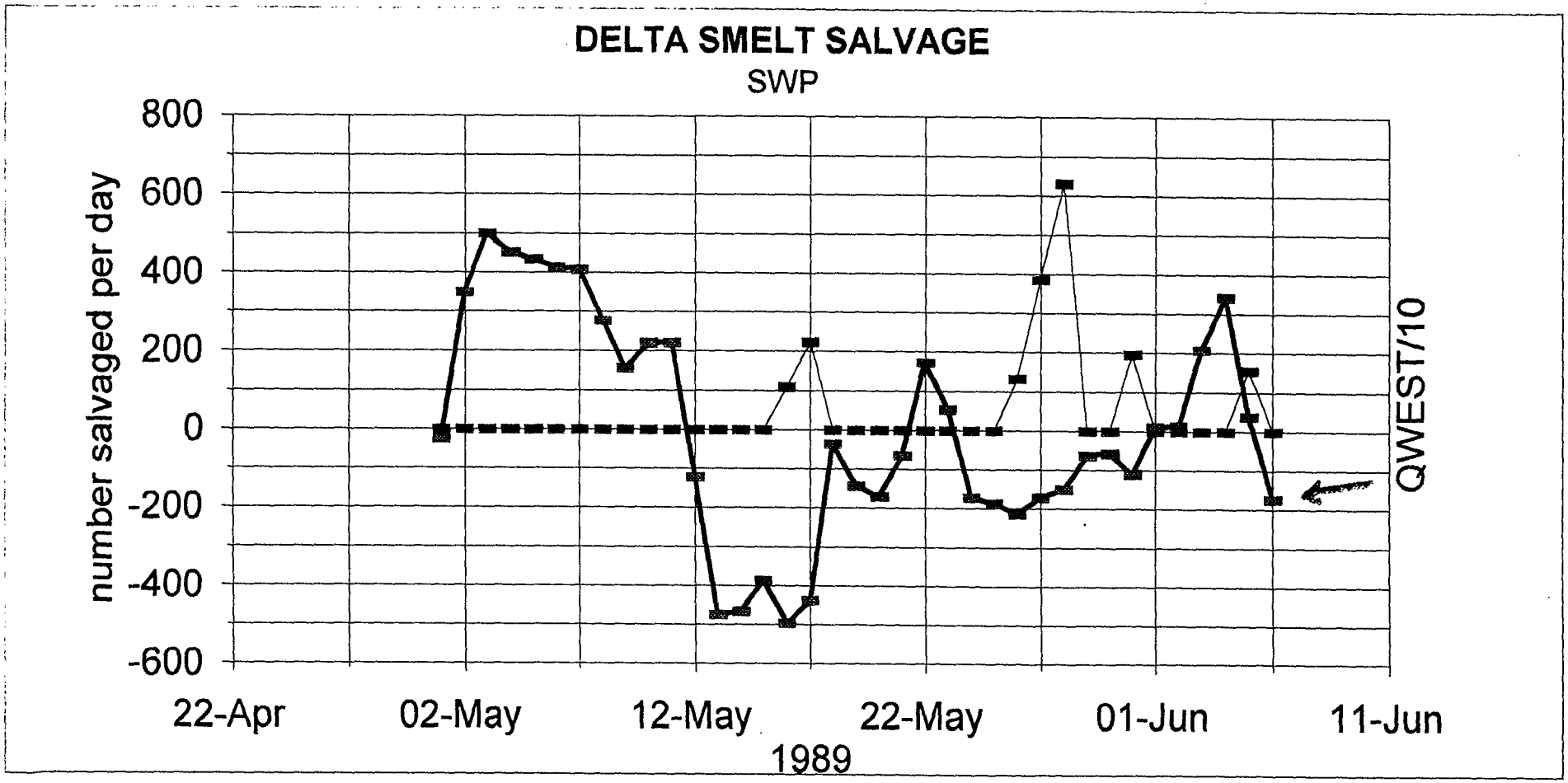

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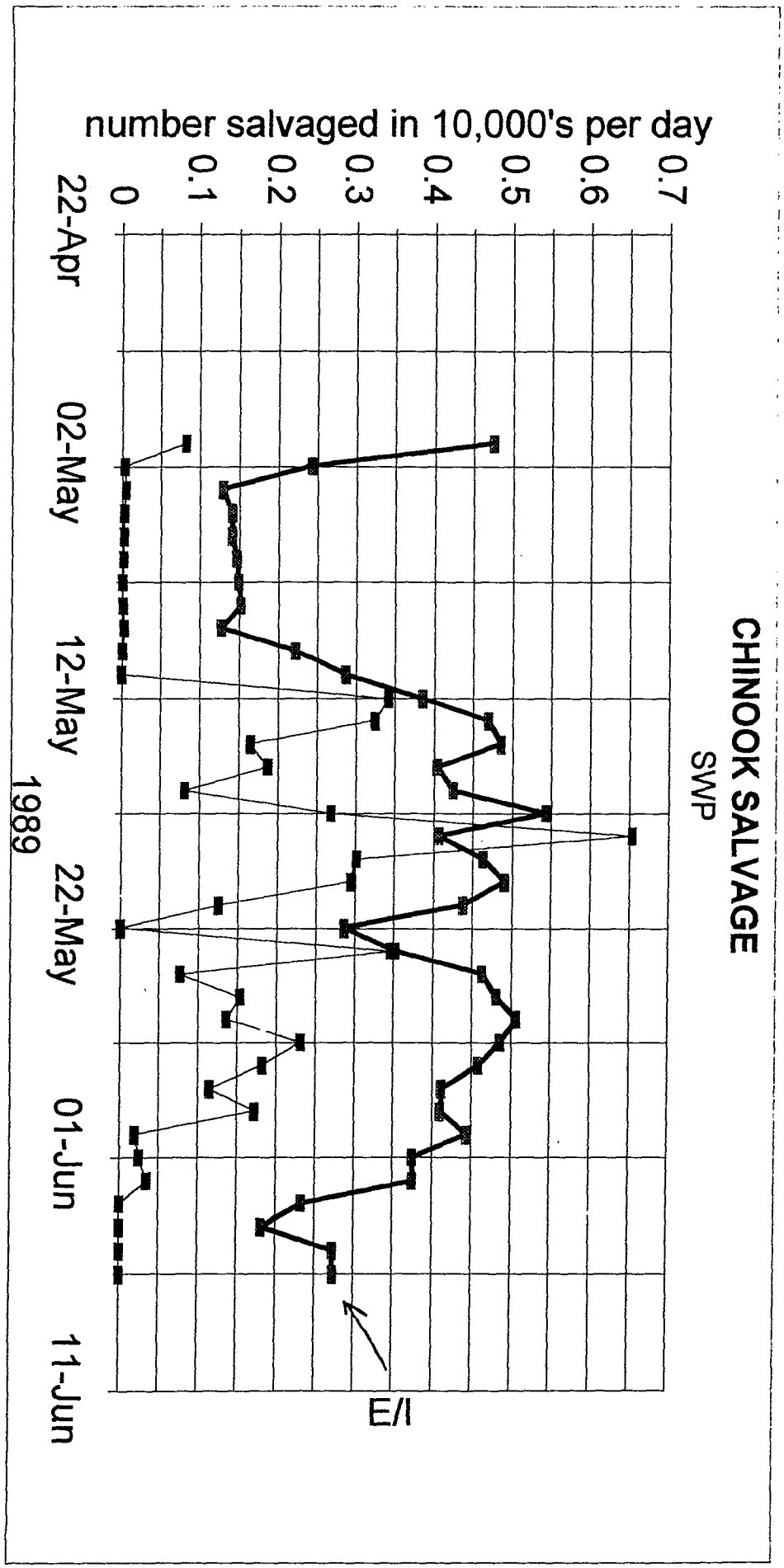
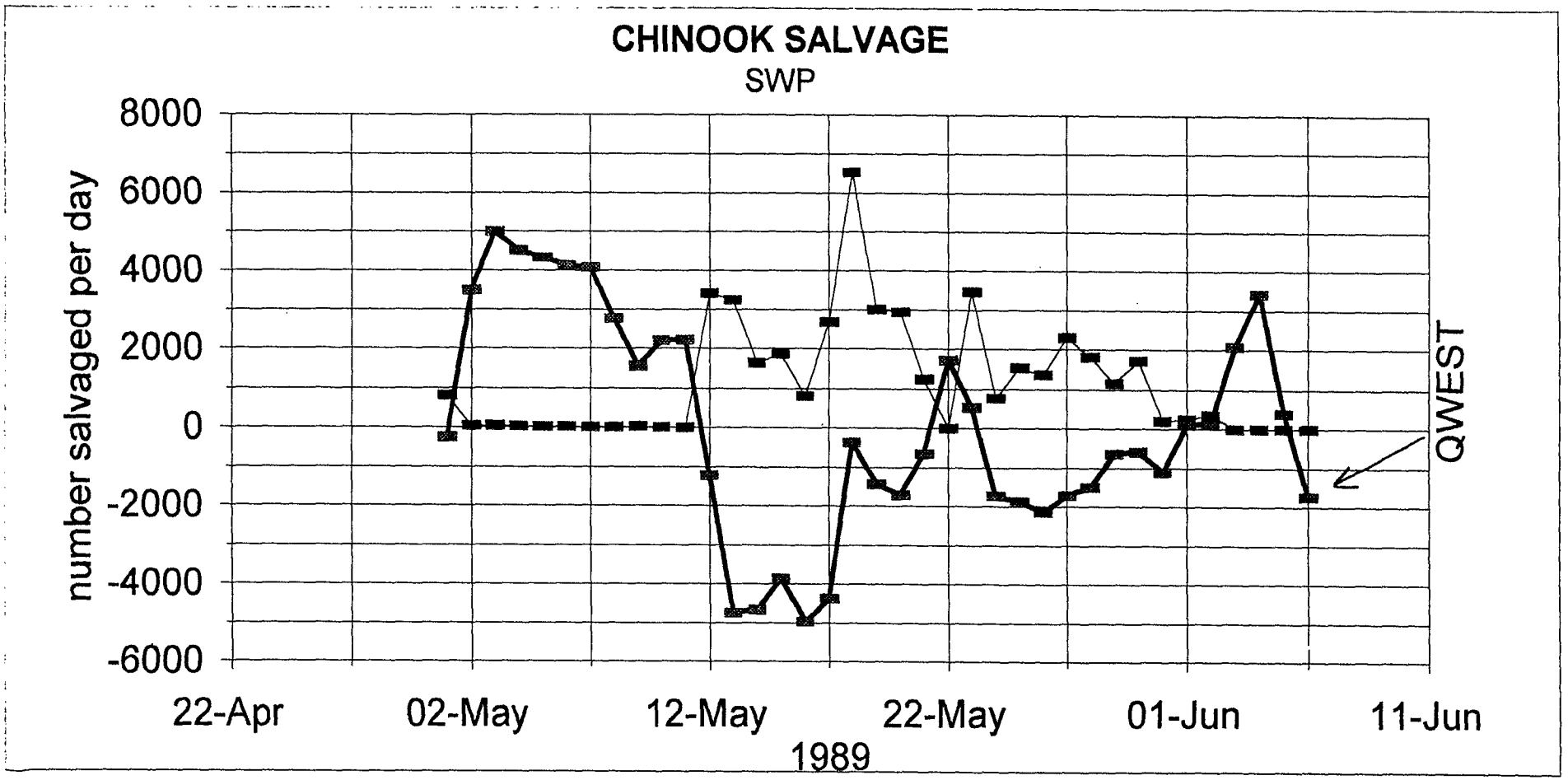

CHINOOK SALVAGE
SWP
number salvaged in 10,000's per day
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
22-Apr
02-May
12-May
22-May
01-Jun
11-Jun
1989
E/I



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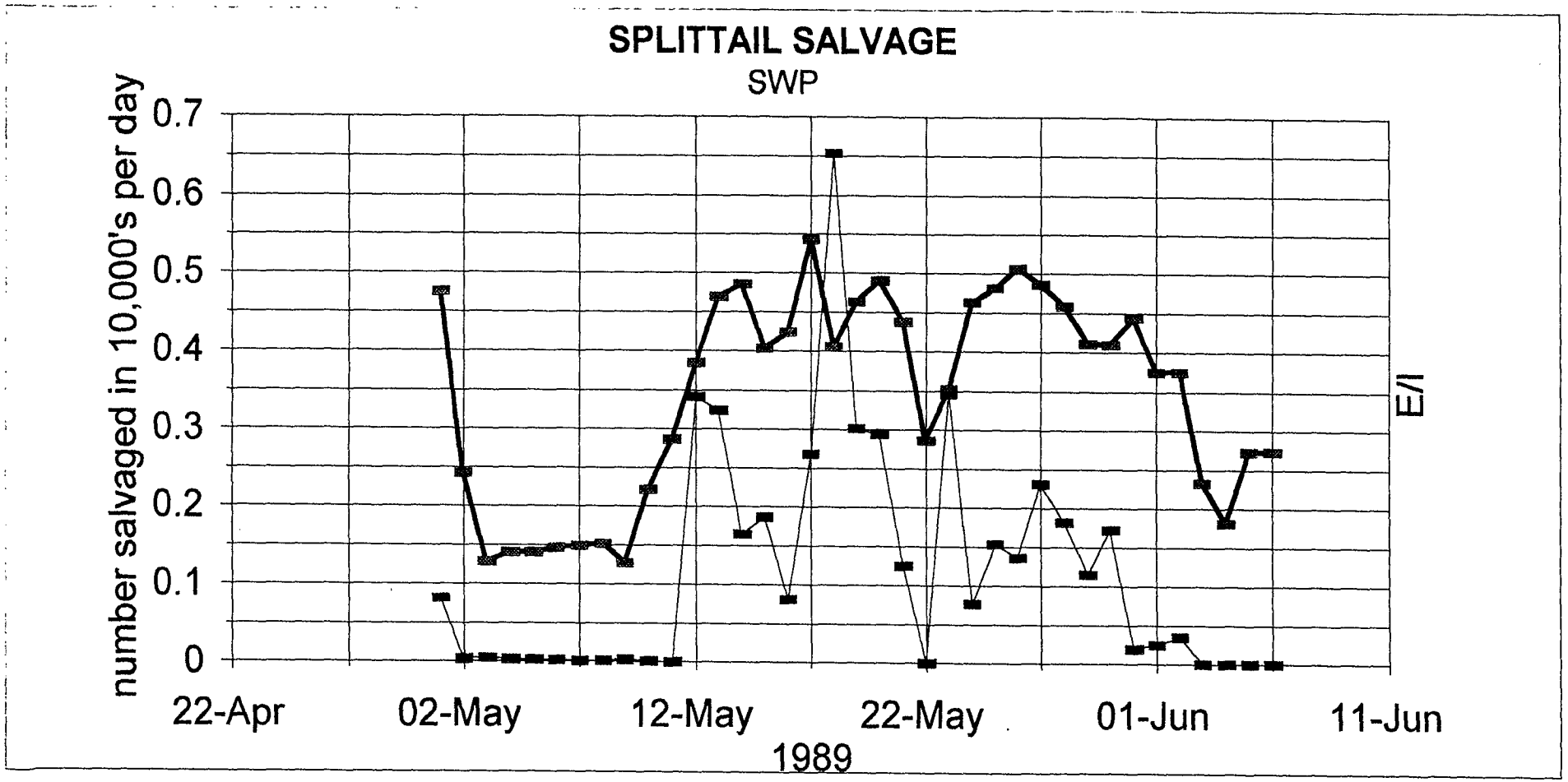

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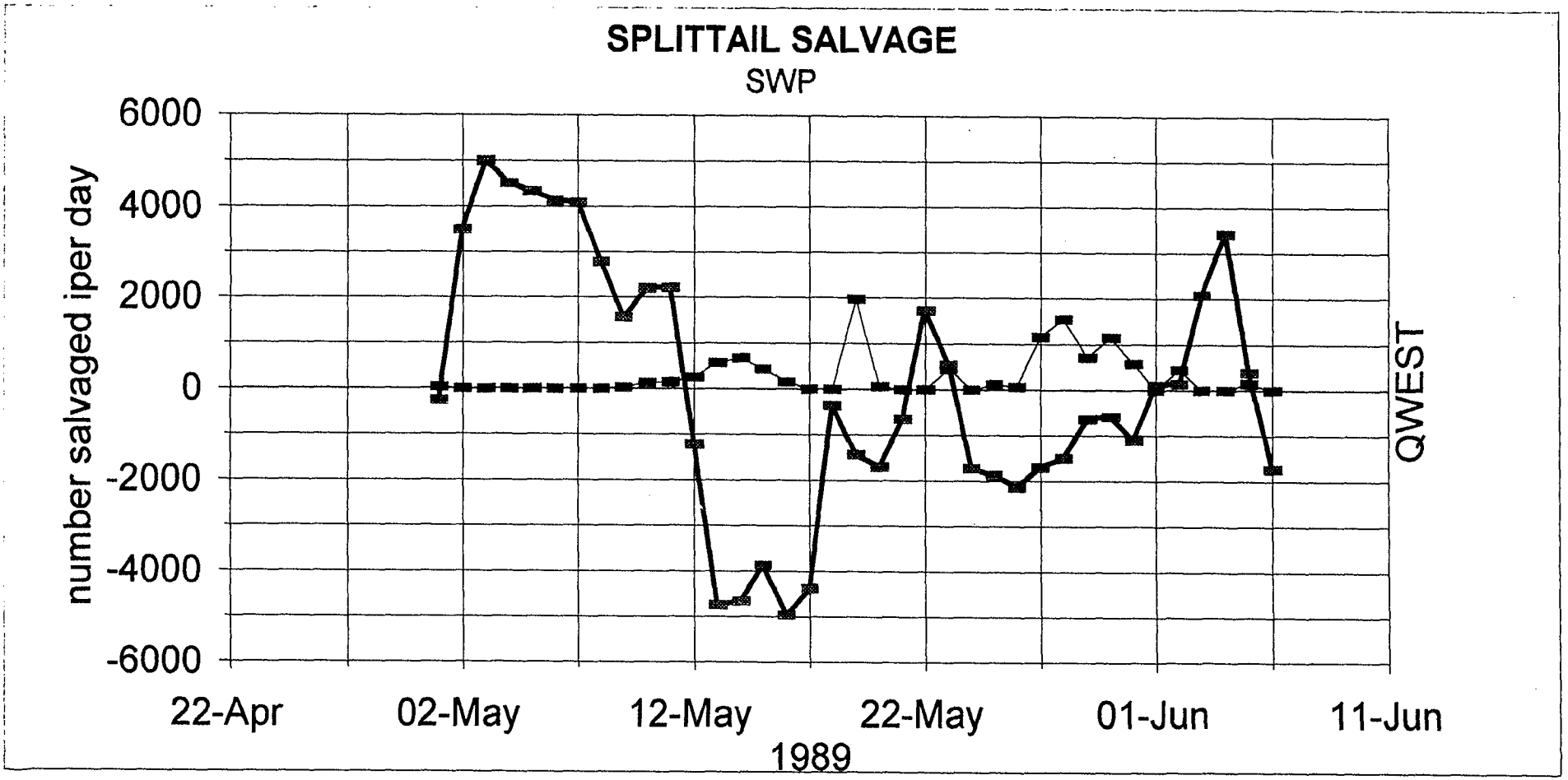

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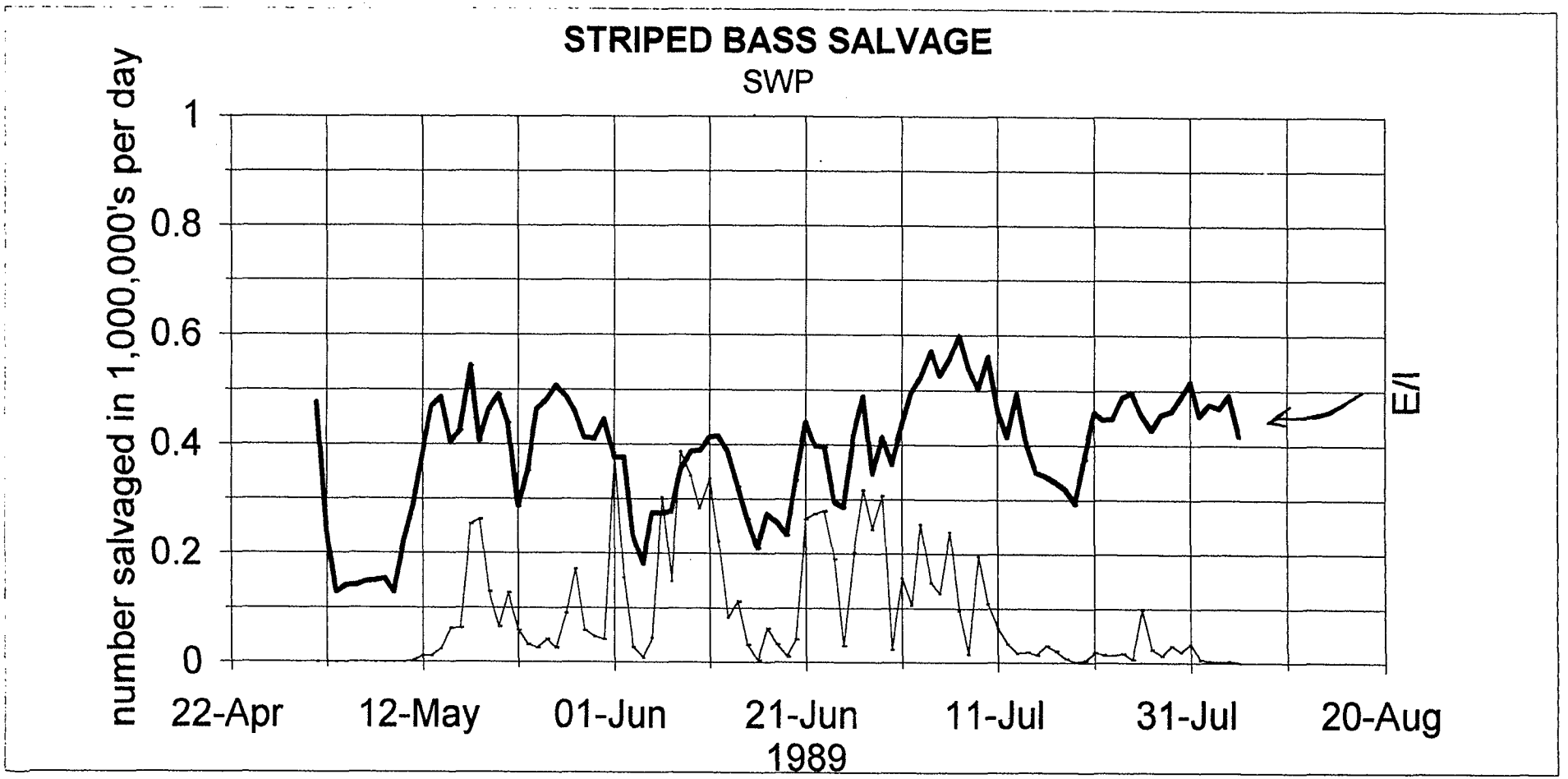

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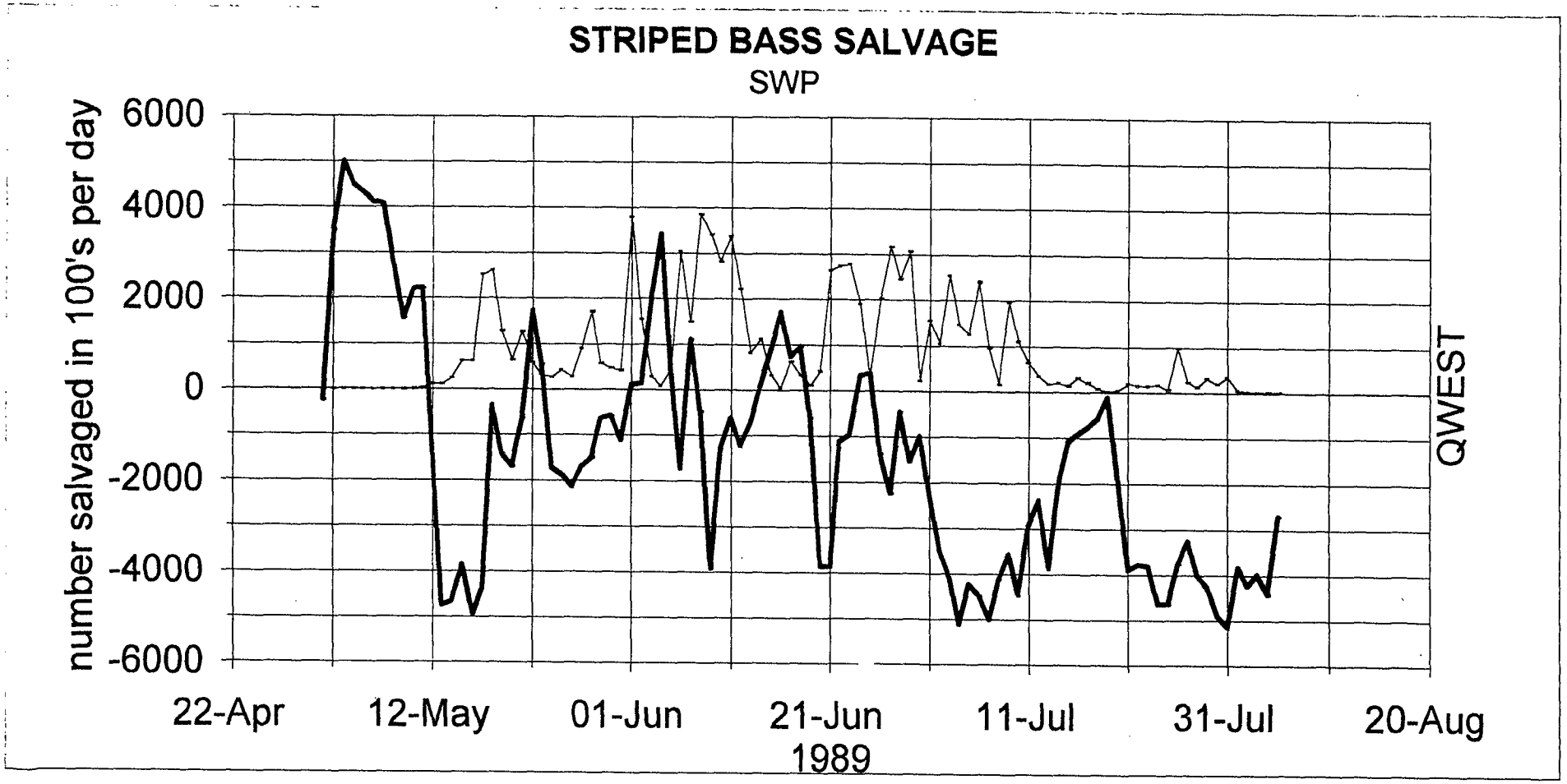

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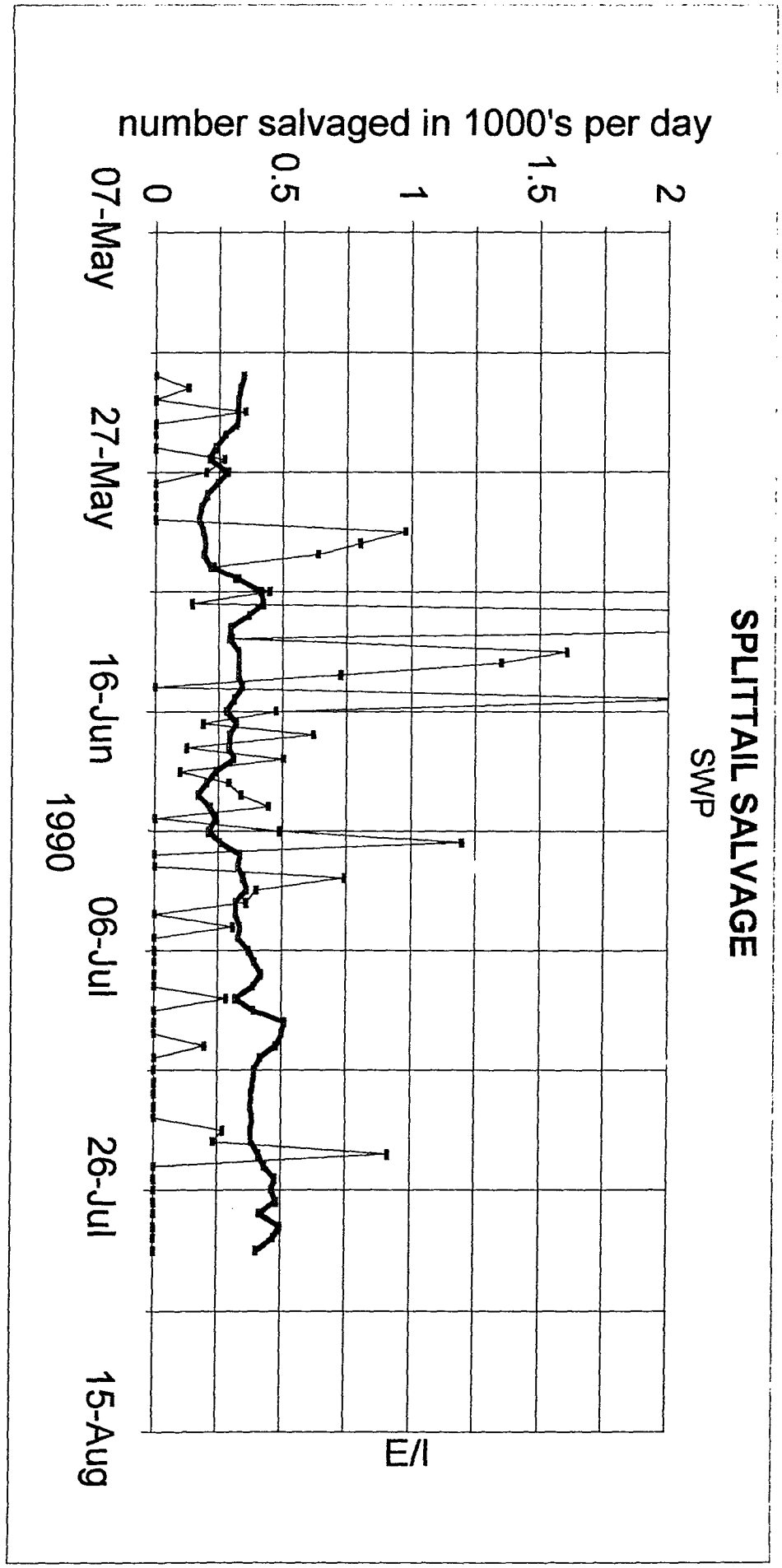
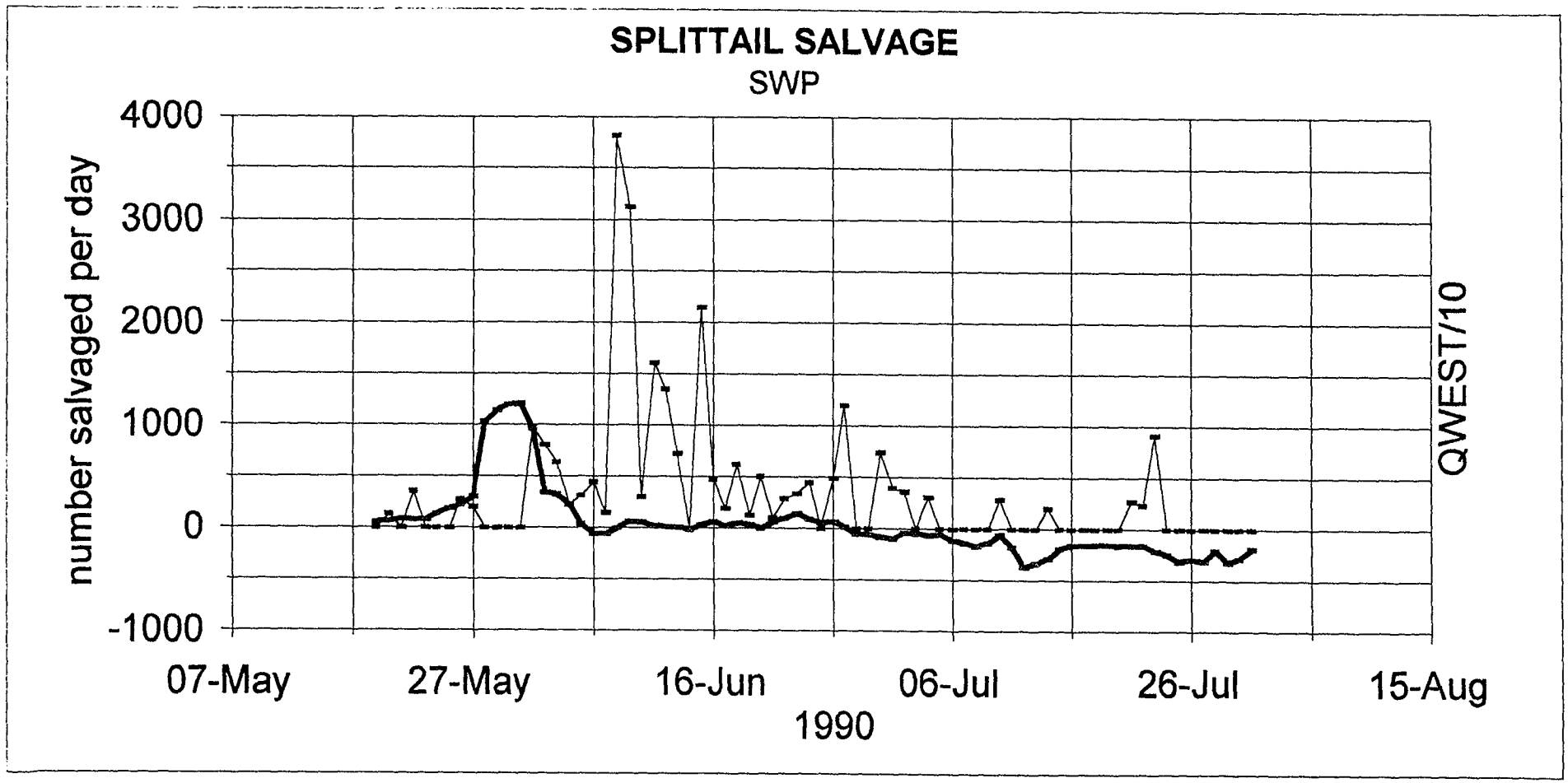

SPLITTAIL SALVAGE
SWP
number salvaged in 1000's per day
2
1.5
1
0.5
0
07-May
27-May
16-Jun
06-Jul
26-Jul
15-Aug
1990
E/I



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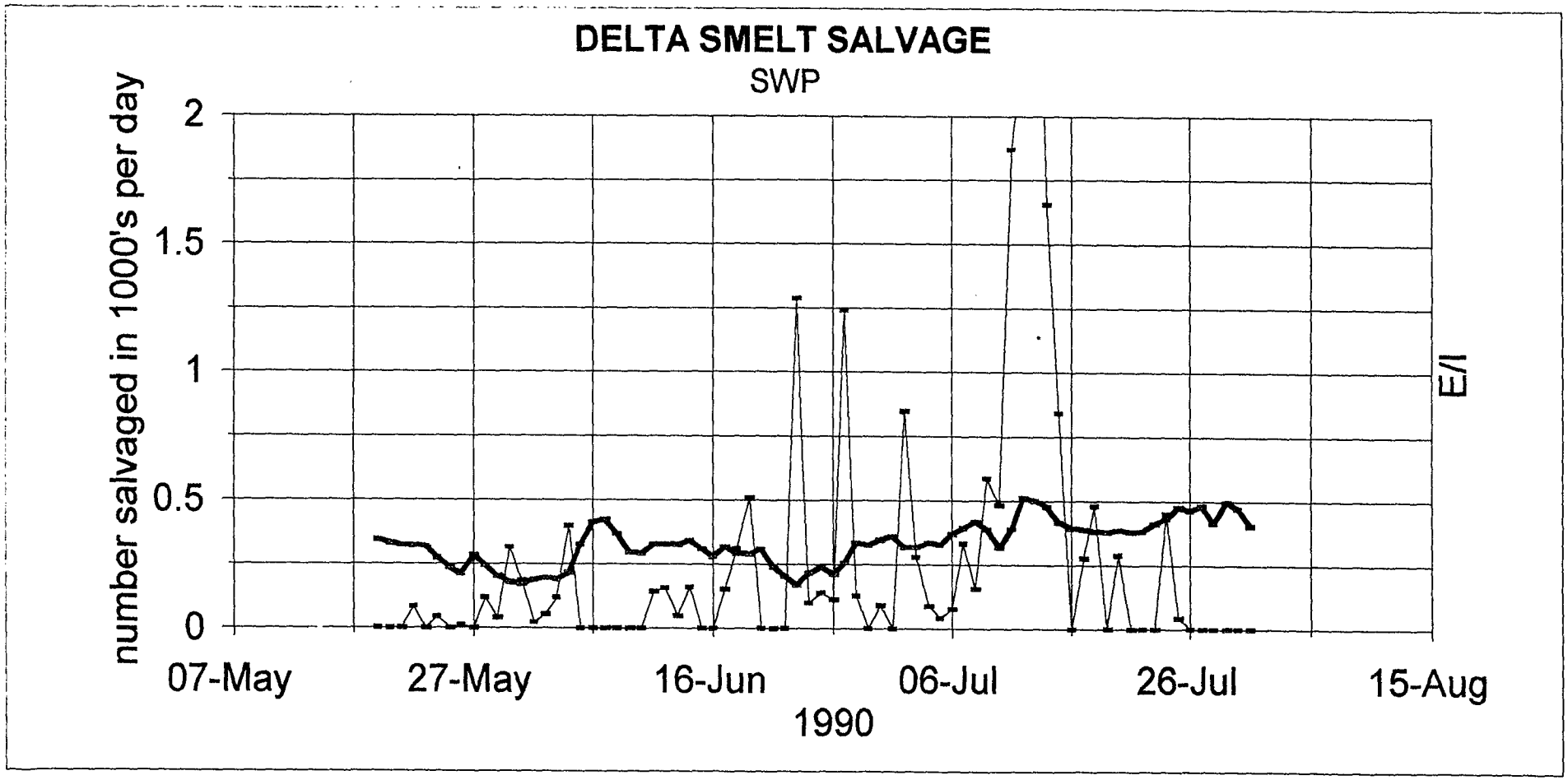

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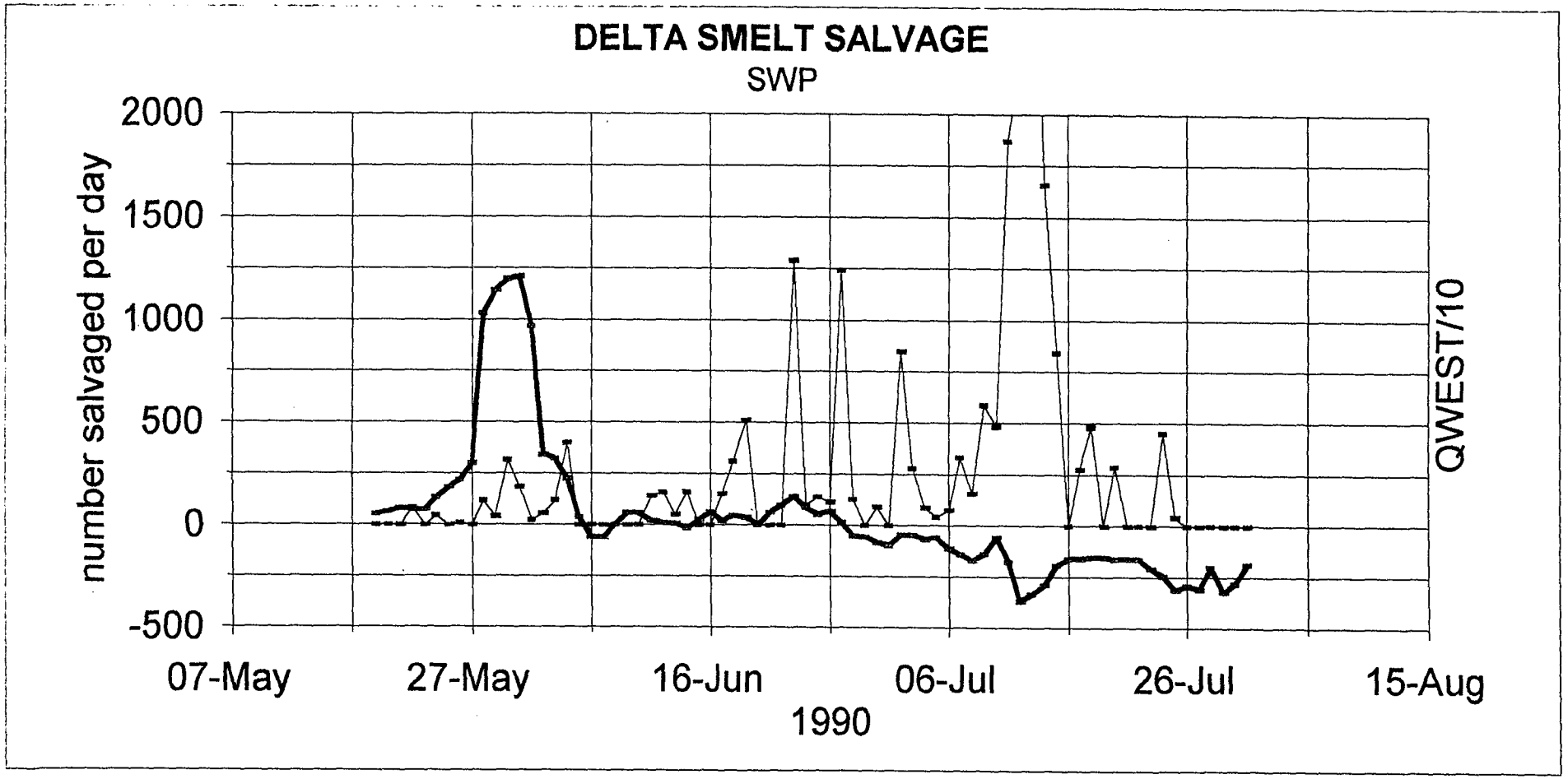

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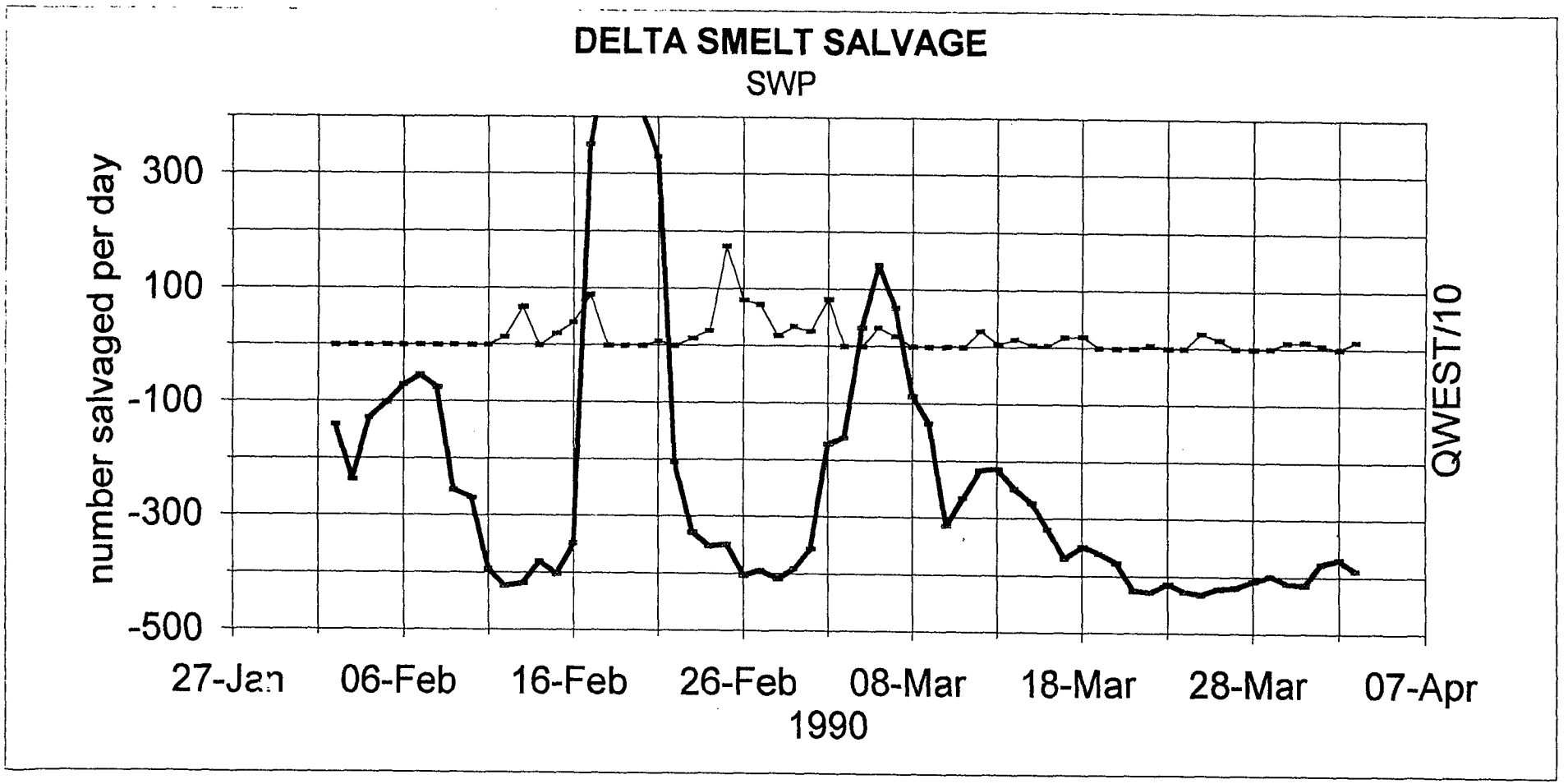

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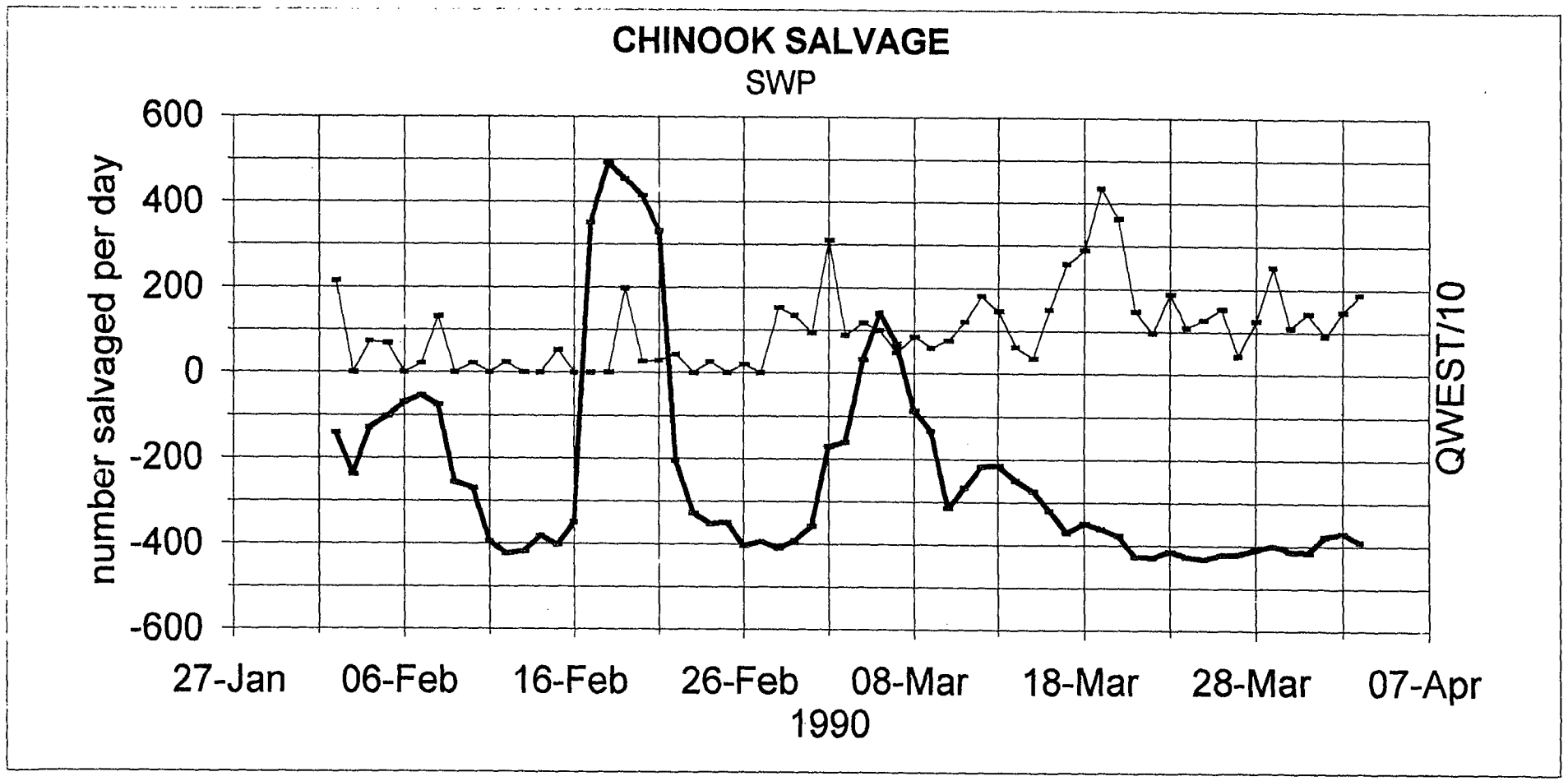

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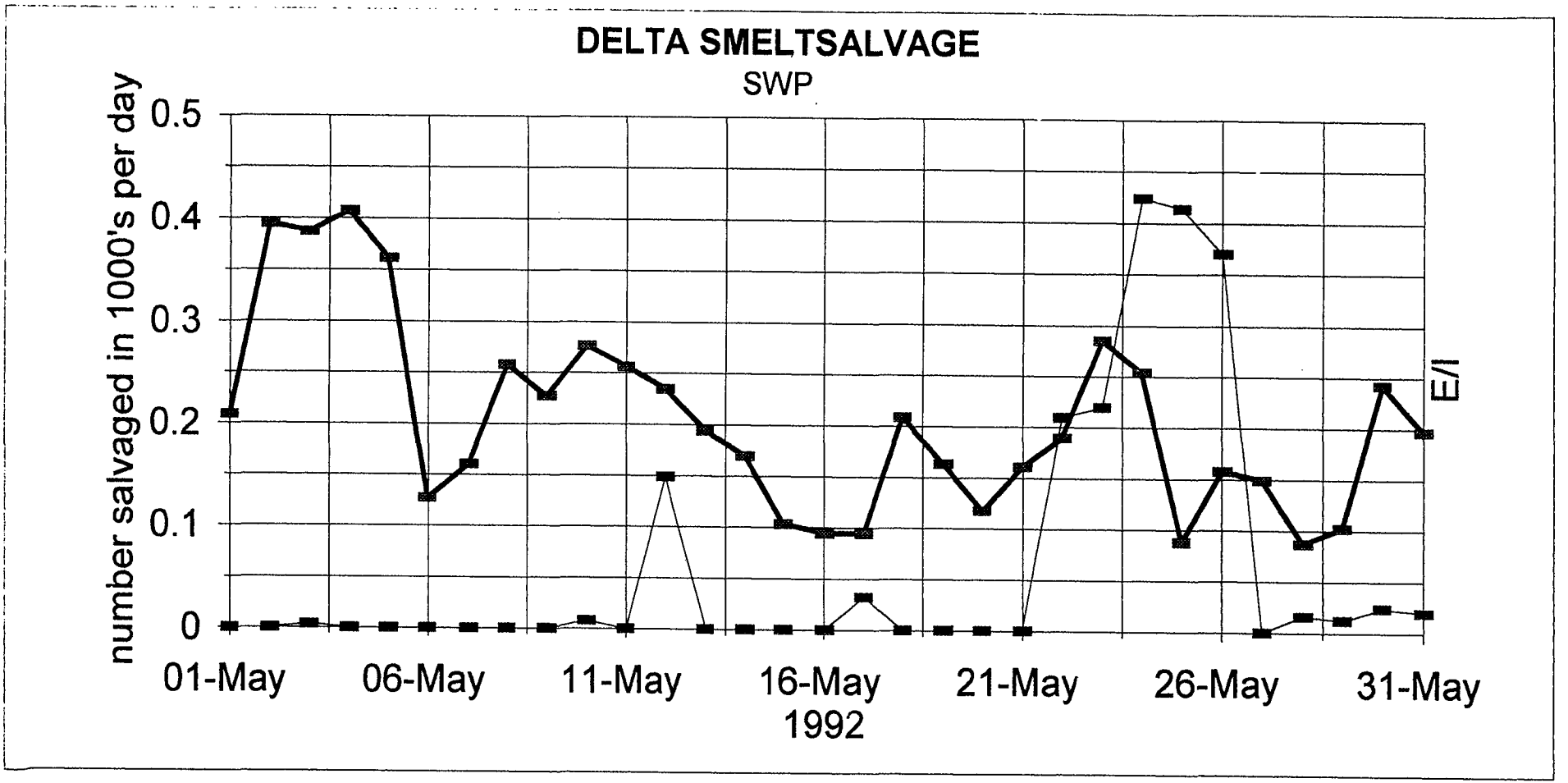

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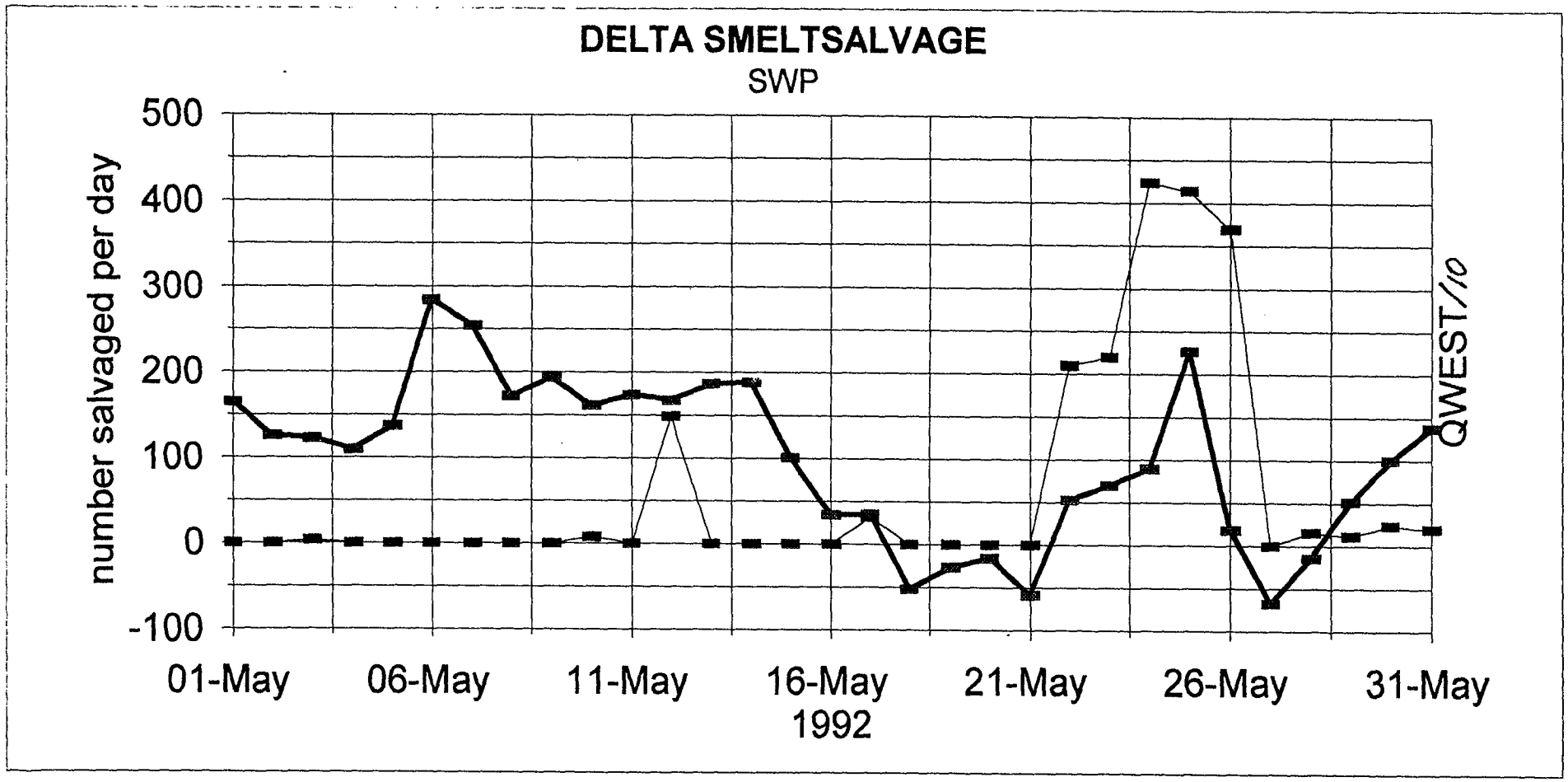

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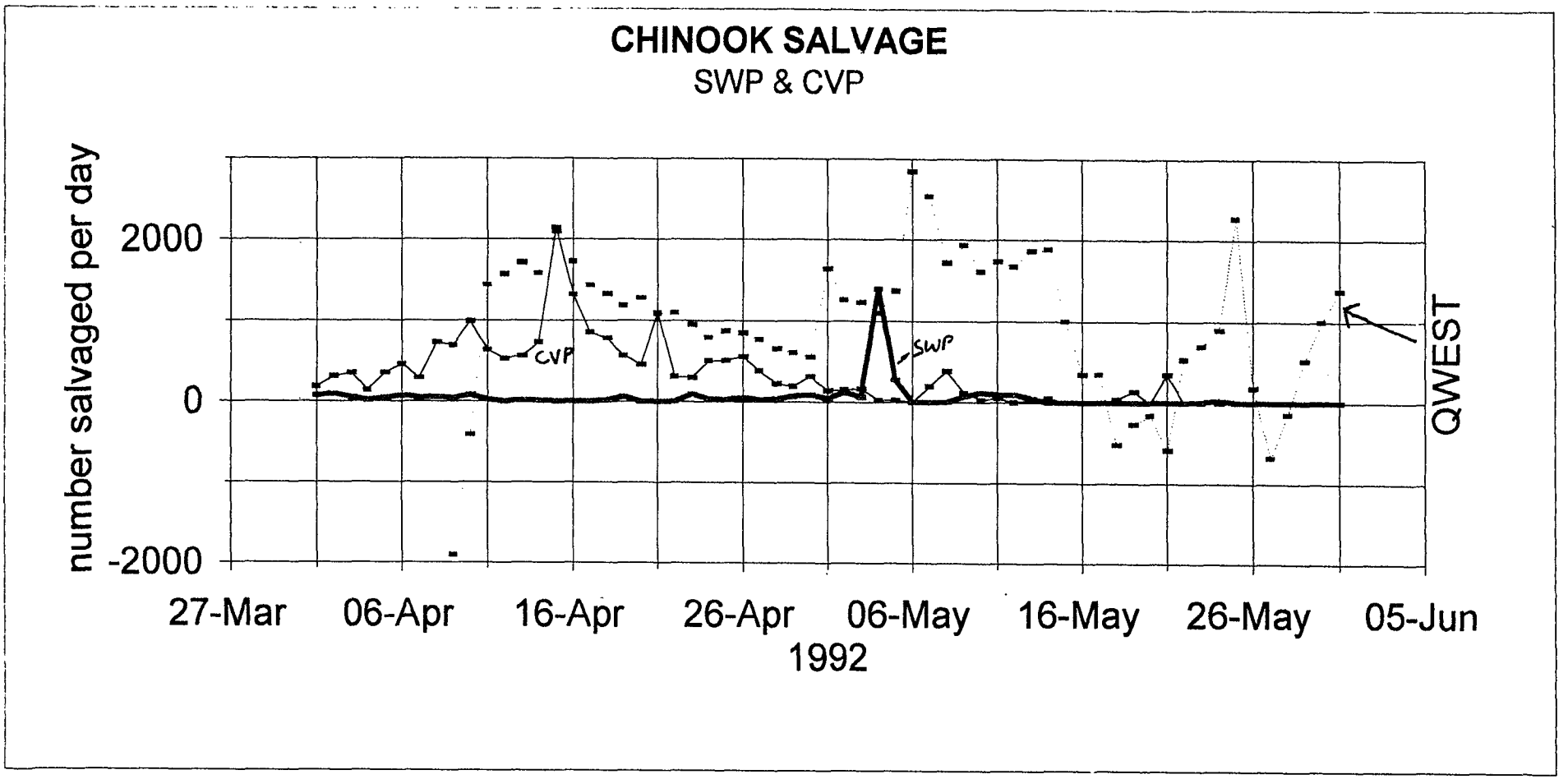

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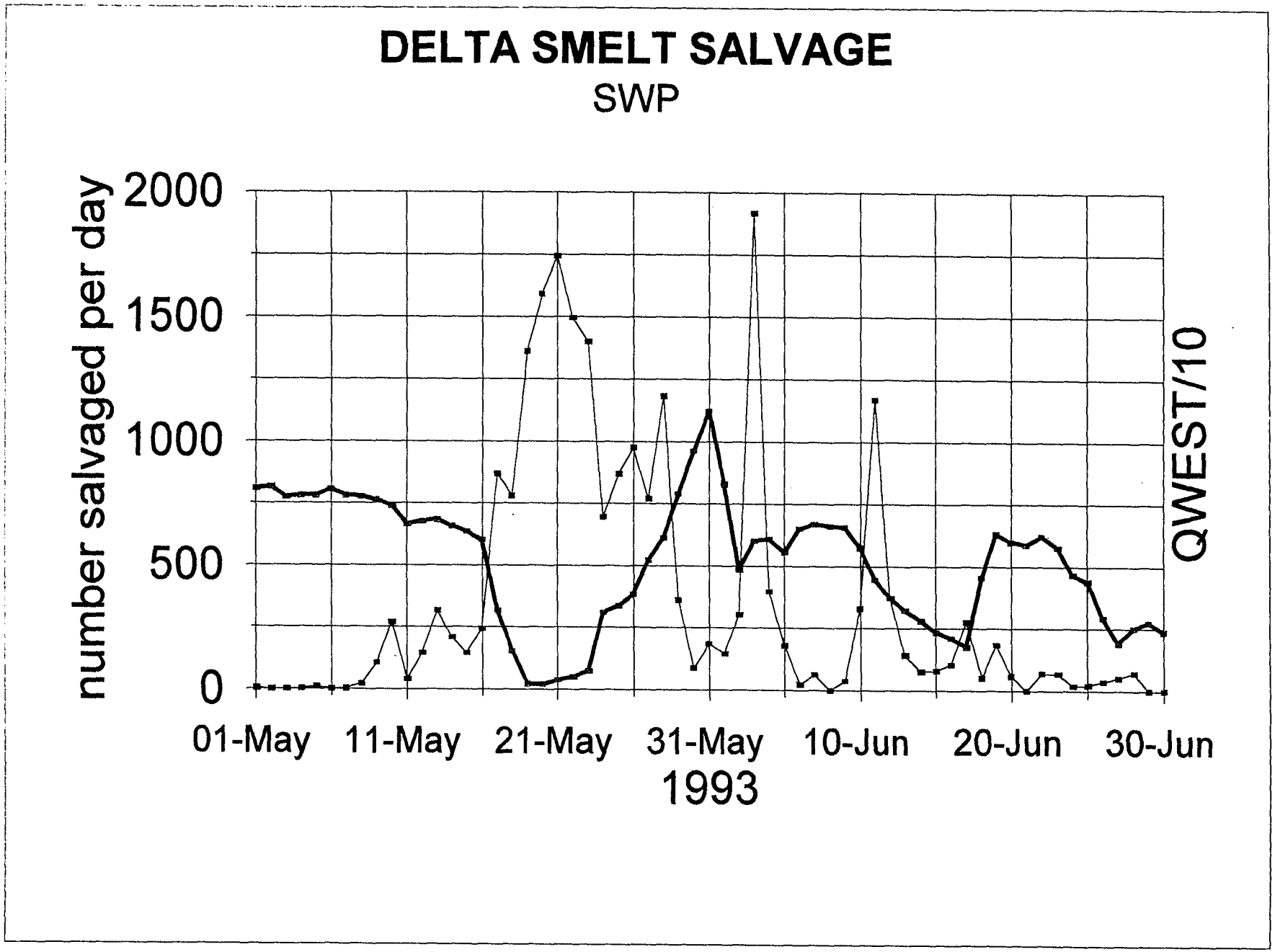

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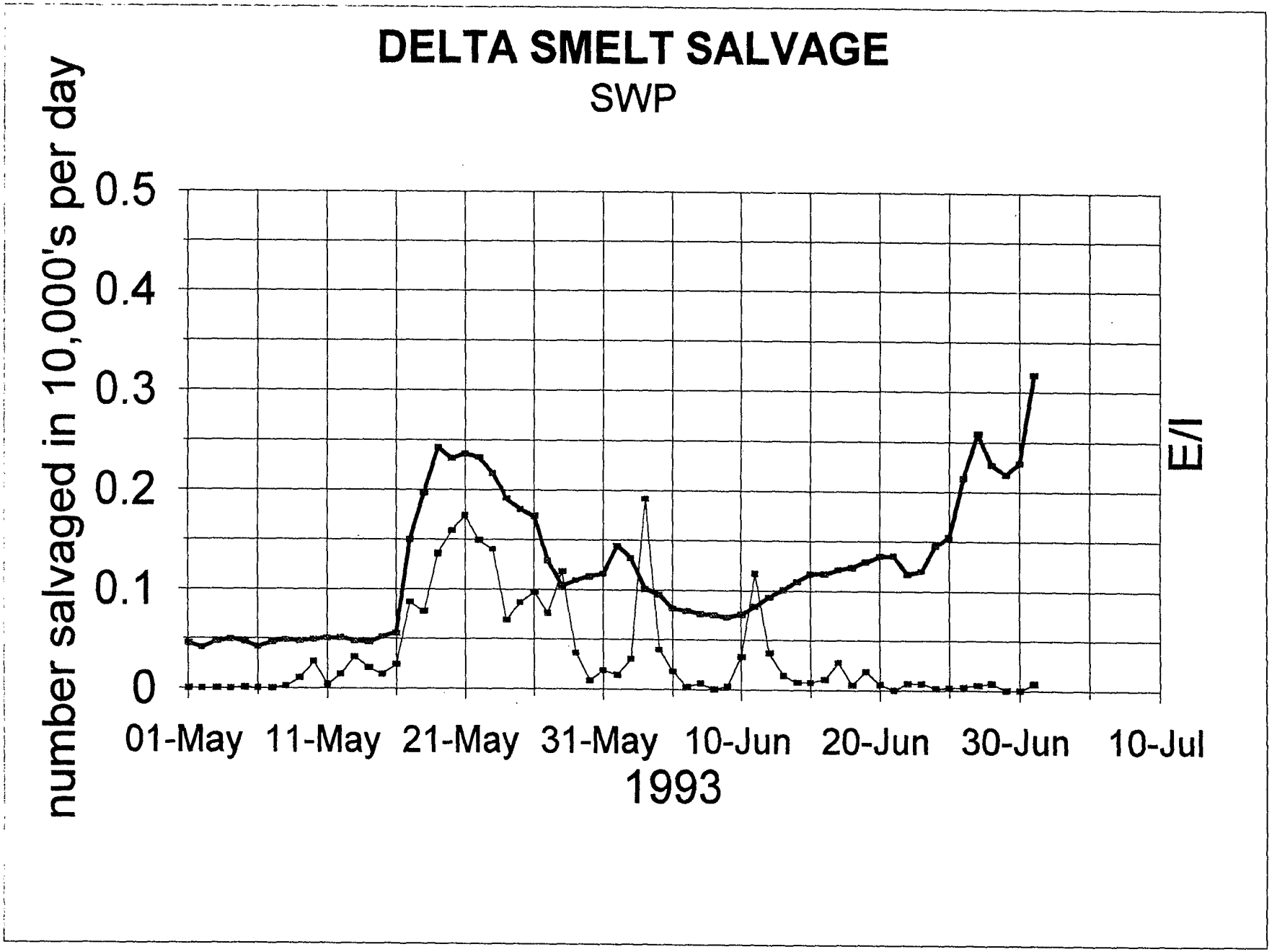

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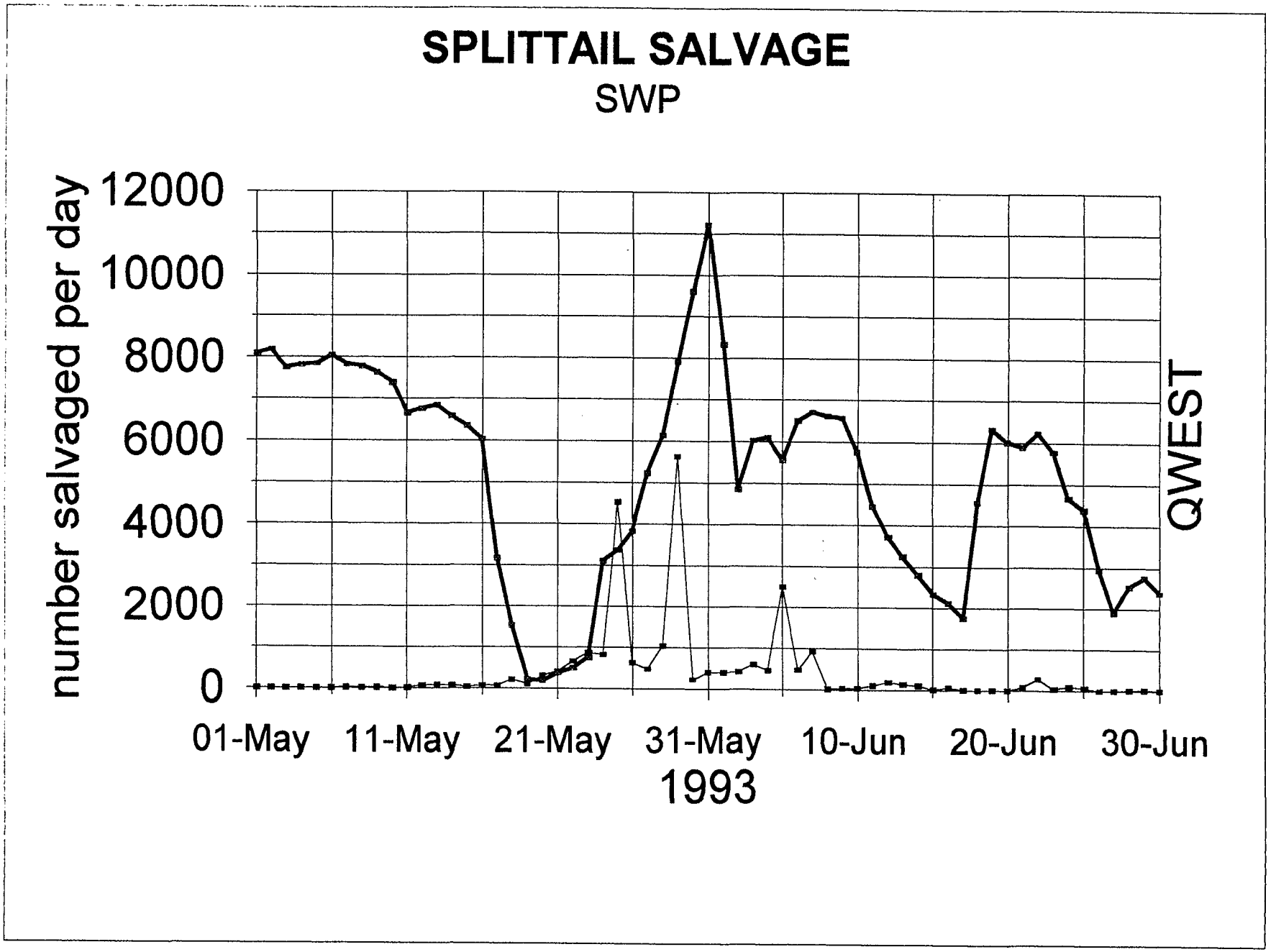

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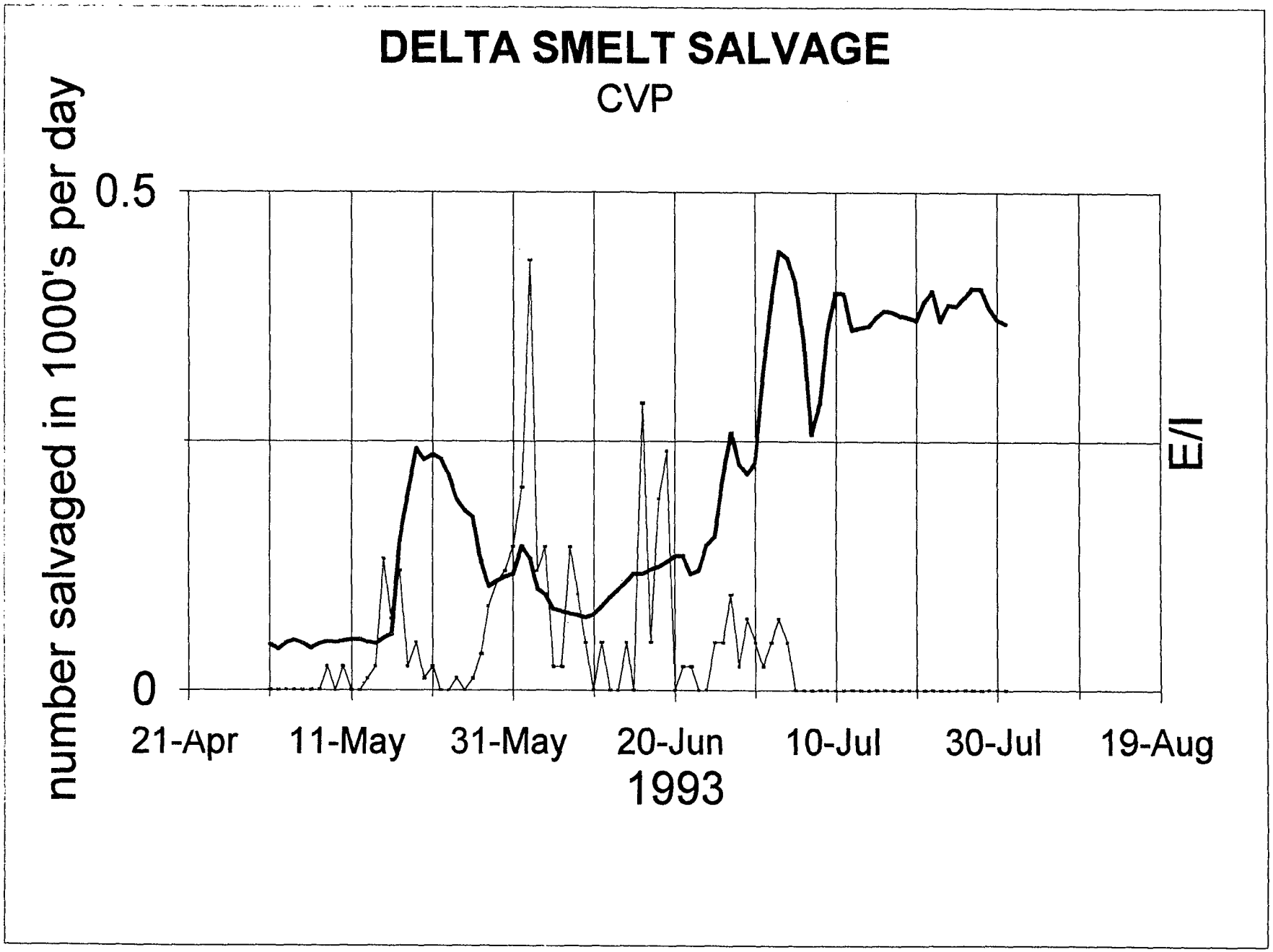

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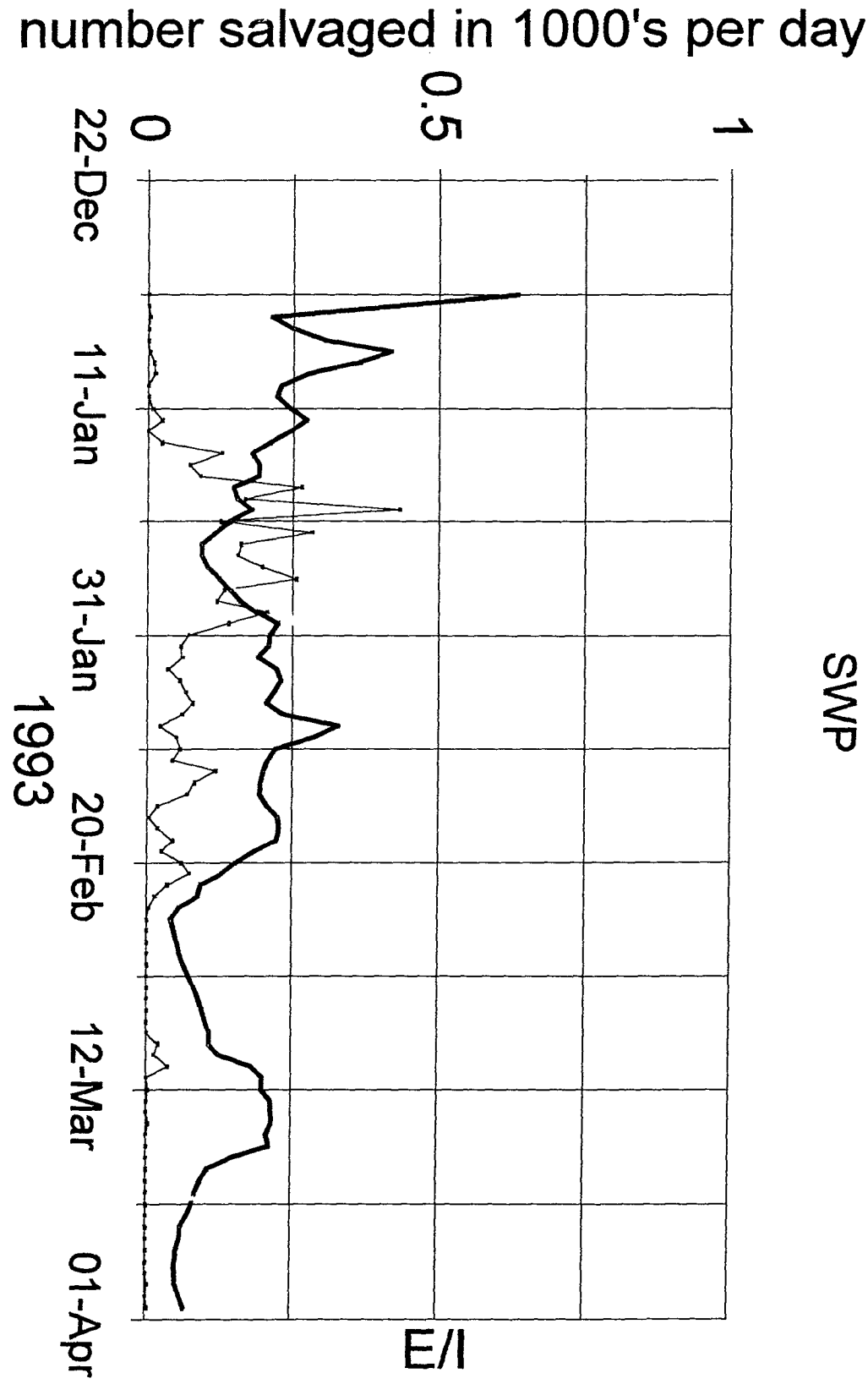
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SWP
number salvaged in 1000's per day
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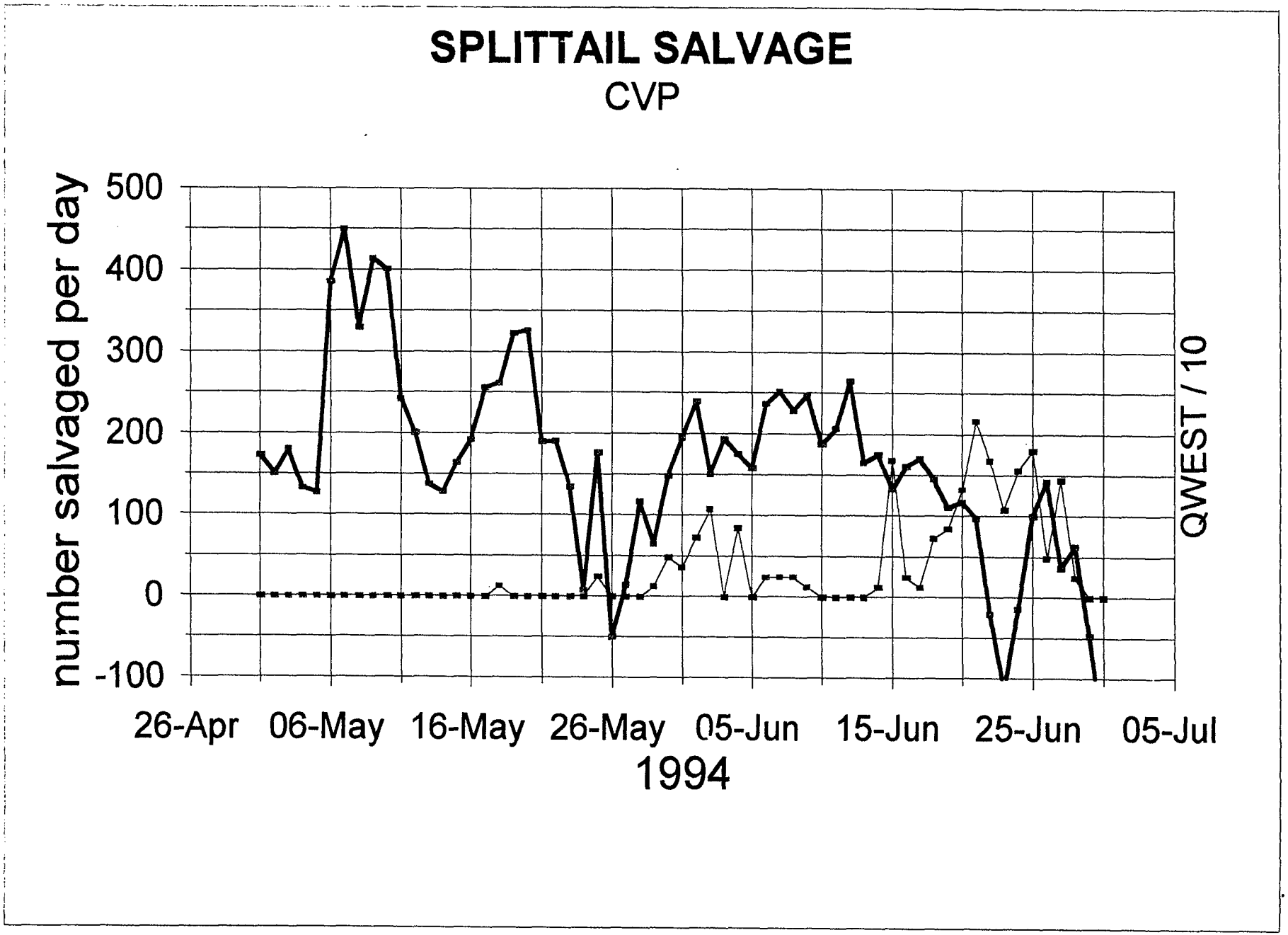
0.5
0
22-Dec
11-Jan
31-Jan
20-Feb
12-Mar
01-Apr
1993
E/I

D-016264



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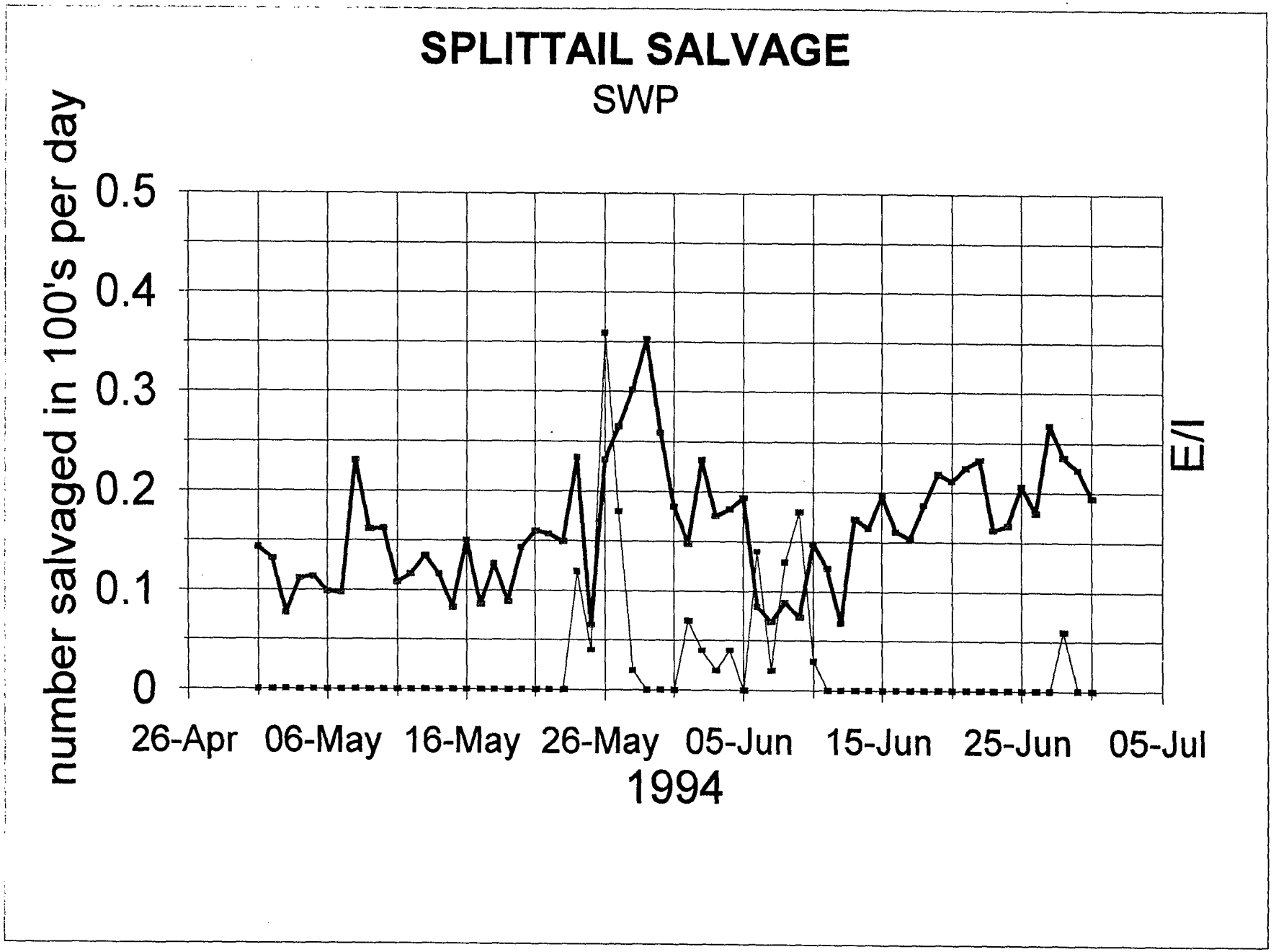

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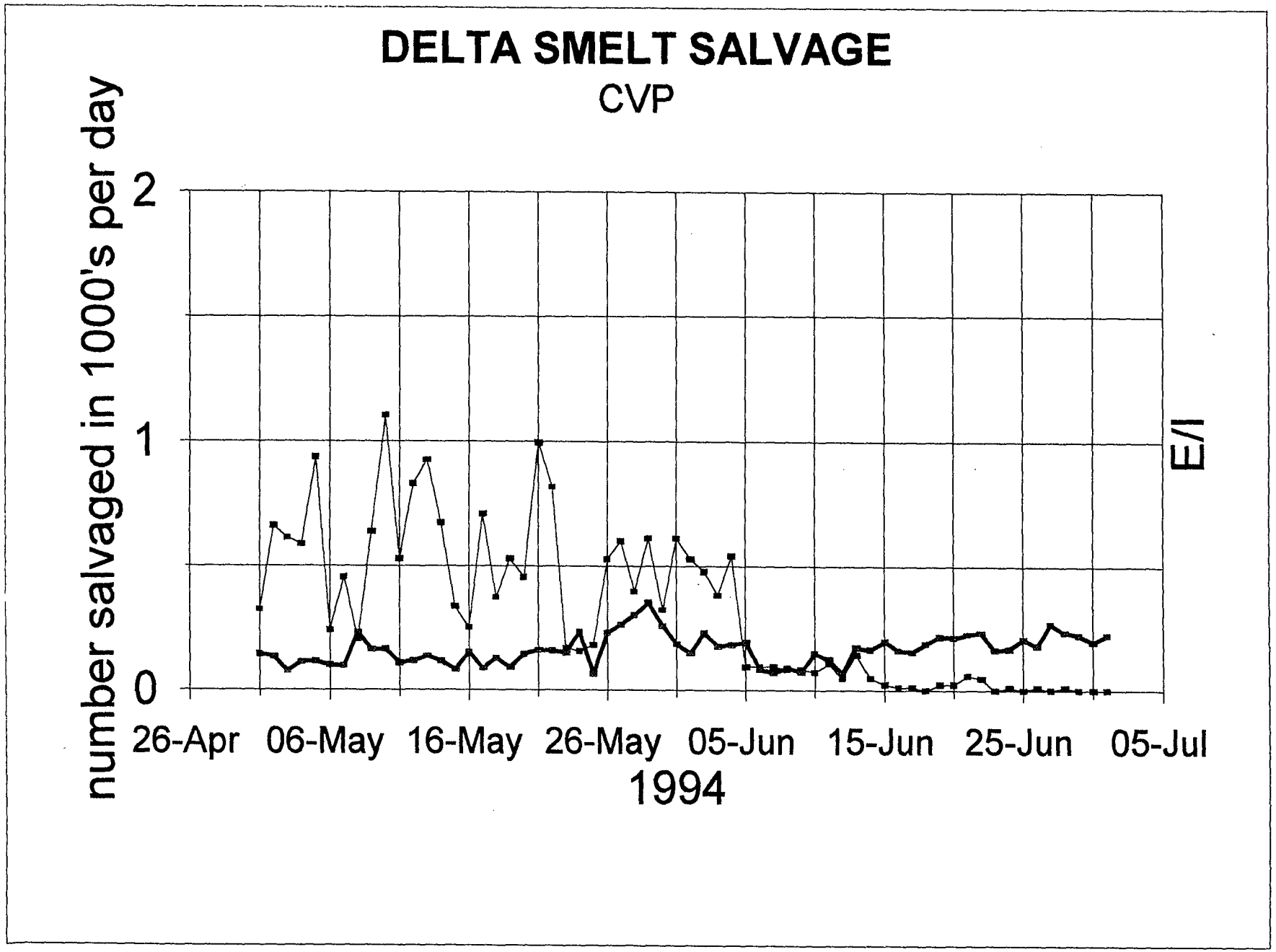

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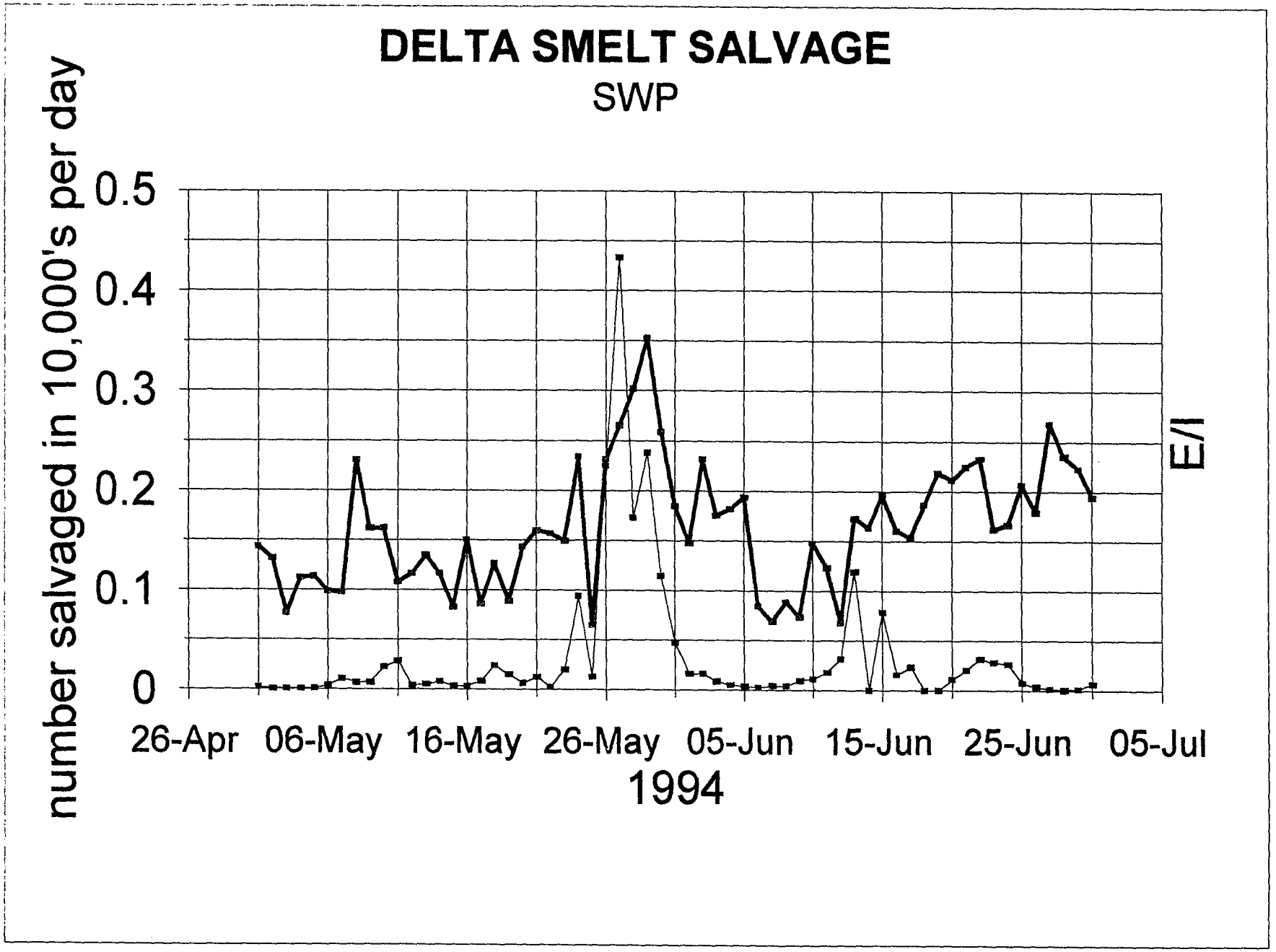

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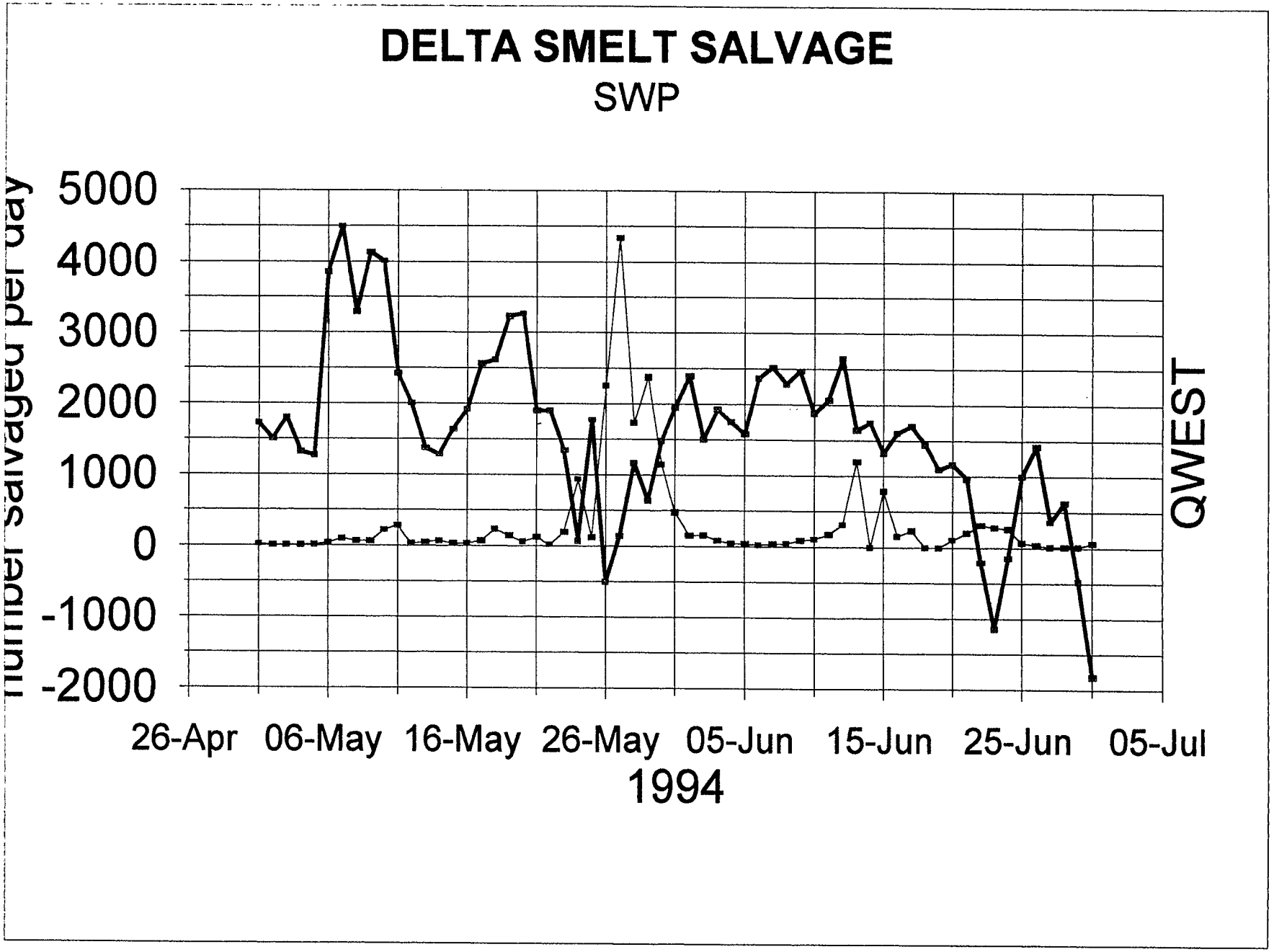

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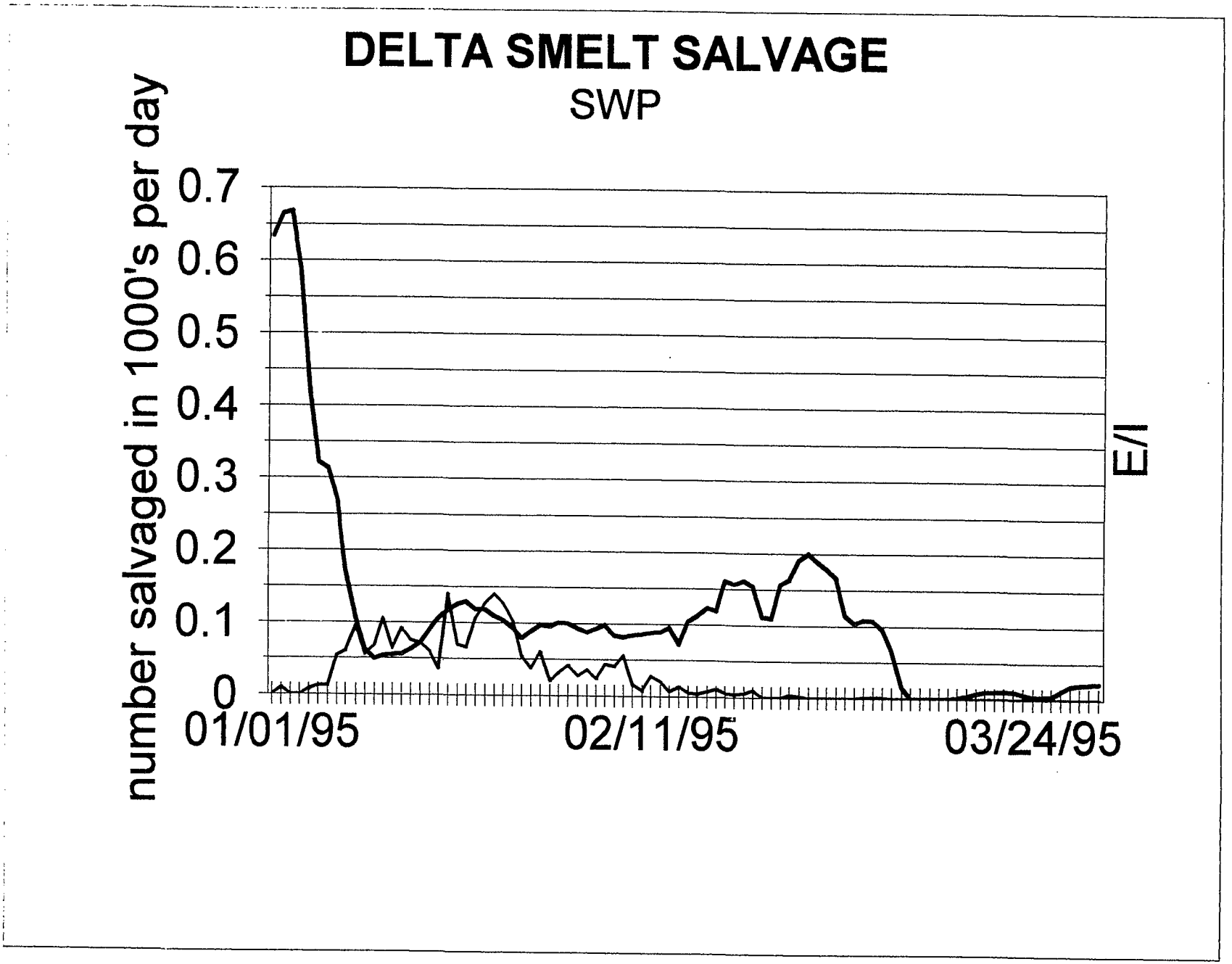

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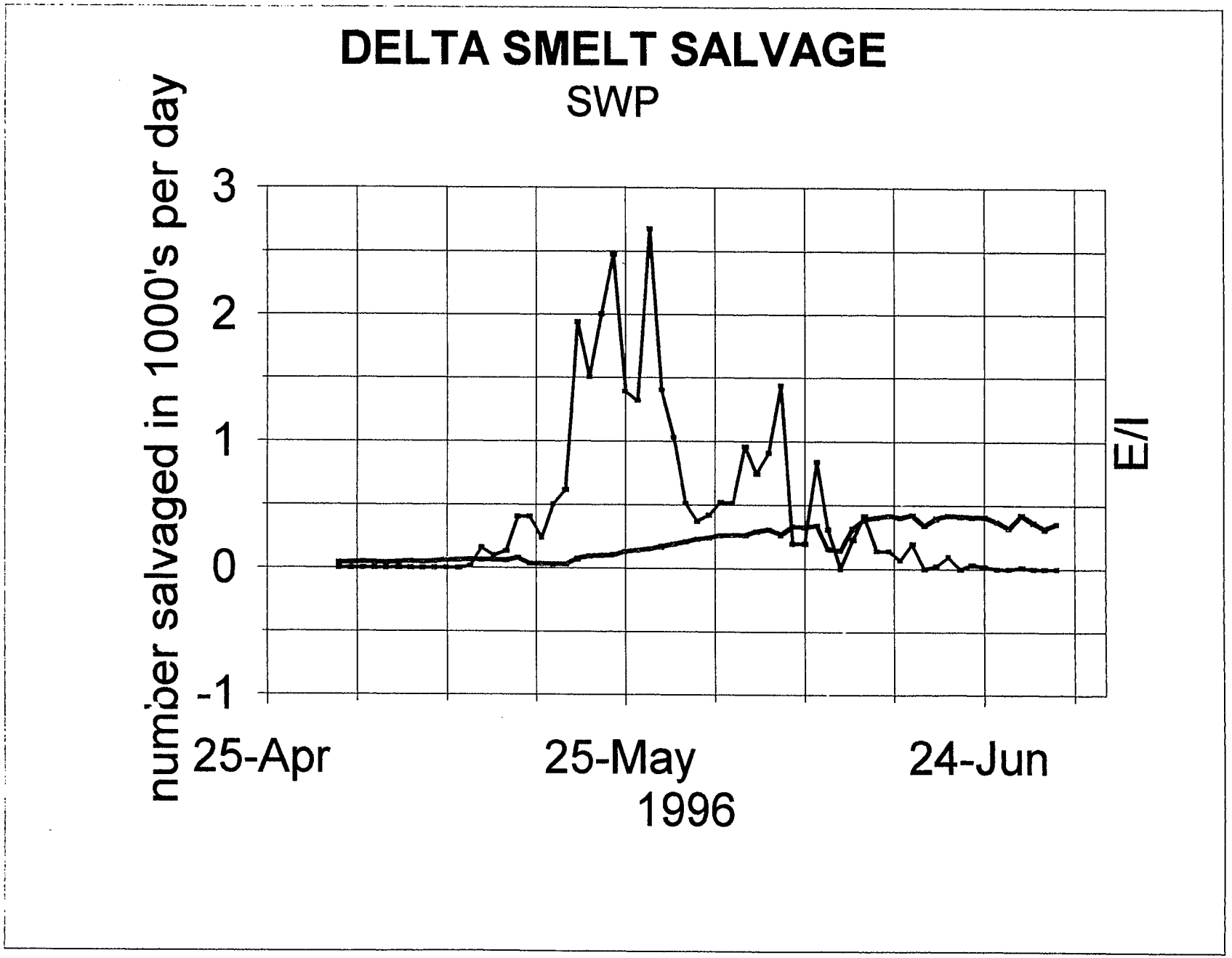

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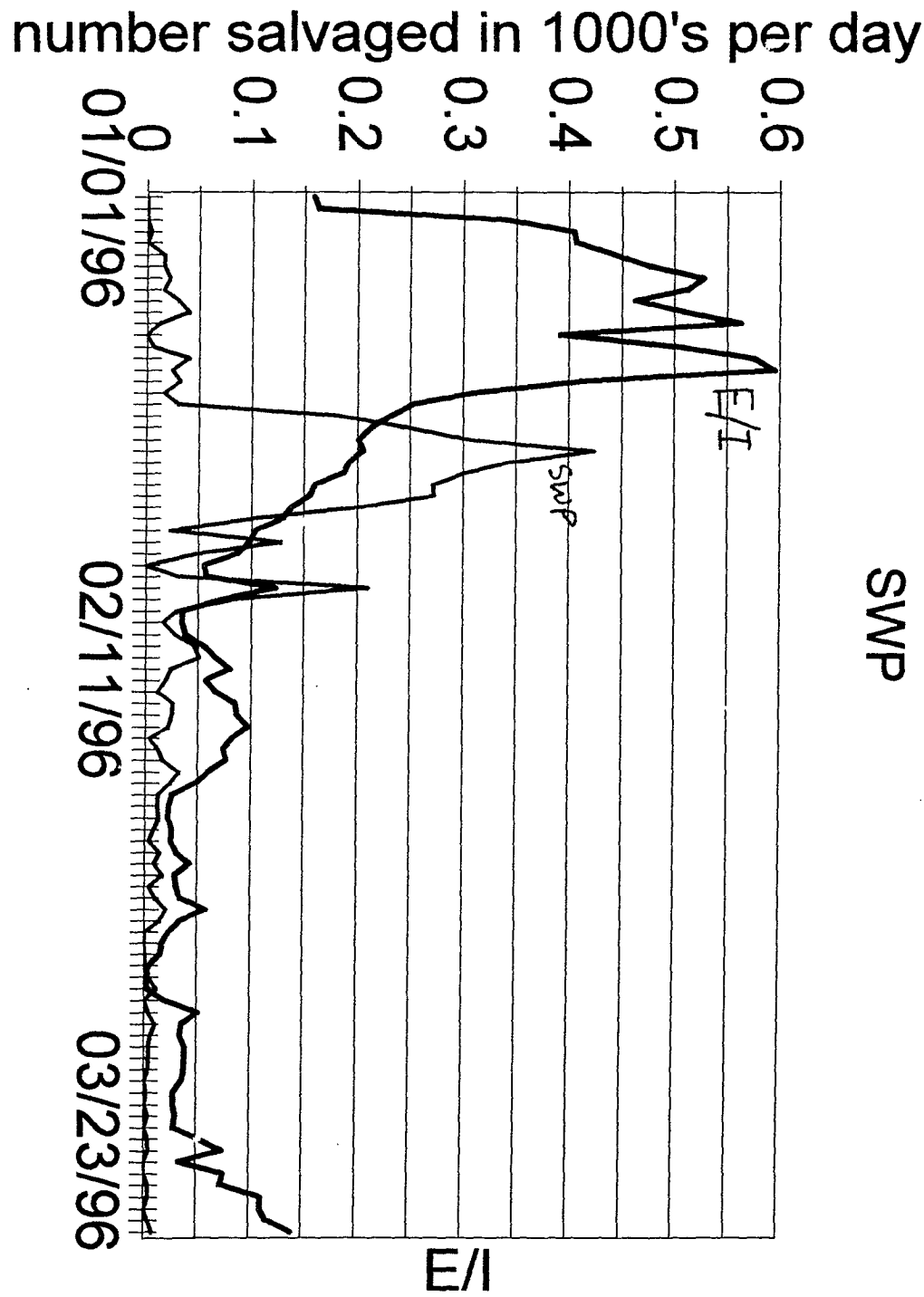
DELTA SMELT SALVAGE
SWP
number salvaged in 1000's per day
0.6
0.5
0.4
0.3
0.2
0.1
0
E/I
SWP
01/01/96
02/11/96
03/23/96
E/I