

ESTIMATED ENTRAINMENT OF
STRIPED BASS EGGS AND LARVAE AT
STATE WATER PROJECT AND CENTRAL VALLEY PROJECT FACILITIES
IN THE SACRAMENTO-SAN JOAQUIN DELTA
1985 AND 1986

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Technical Report 13
August 1987

Interagency Ecological Study Program
for the Sacramento-San Joaquin Estuary

A cooperative study by the:

California Department of Water Resources
California Department of Fish and Game
State Water Resources Control Board
U.S. Bureau of Reclamation
U.S. Fish and Wildlife Service
U.S. Geological Survey

ABSTRACT

A striped bass egg and larval sampling program was conducted in the southern Delta near the intakes of the State Water Project (SWP) and Central Valley Project (CVP) during spring 1985 and 1986. The information is being used to estimate entrainment of striped bass eggs and larvae by these diversions and will allow comparison of this method to Baracco's (1983) method.

Striped bass eggs and larvae entrained by the SWP were estimated to be 441.1 million in 1985 and 51.9 million in 1986. Baracco's method estimated 2.573 billion for 1985 and 727.6 million for 1986. Striped bass eggs and larvae entrained by the CVP were estimated to be 352.5 million in 1985 and 47.8 million in 1986. Baracco's method estimated 1.795 billion in 1985 and 95.1 million in 1986. Entrainment estimates based on densities taken near the points of diversion should provide more accurate estimates than those calculated by Baracco.



INTRODUCTION

Striped bass are entrained with water diverted by State Water Project (SWP) and Central Valley Project (CVP) pumping plant facilities in the southern Delta. To define SWP and CVP impacts on striped bass, numbers of striped bass eggs and larvae lost to these diversions were estimated based on densities of eggs and larvae available to be entrained and the amount of water being exported. Density estimates were obtained by sampling with an egg and larval net in

the channels immediately adjacent to each point of diversion. Additional stations were also sampled in the vicinity of the diversions to obtain information on the source of the eggs and larvae, but those samples are not dealt with in this report.

Losses of eggs and larvae were also calculated using the procedure described by Baracco (1983) to compare the two methods.

MATERIALS AND METHODS

An egg and larval survey was conducted from mid-April to mid-July in 1985 and 1986 at five locations in the southern Delta (Figure 1). A sixth location was added in 1986.

- * Station 91 (ROLD 38) is about 1/2 mile upstream of the Highway 4 bridge on Old River.
- * Station 92 (DHWST 0) is on West Canal about 650 feet downstream of the intake to Clifton Court Forebay.
- * Station 95 (CHNRT 0) is on North Canal about 300 feet downstream of the confluence of North Canal and Old River (where the canal becomes straight).
- * Station 96 (ROLD 47) is on Old River about 1,300 feet downstream of the intake to the CVP.
- * Station 97 (CHGRL 0) is on Grant Line Canal about 1,650 feet upstream of the confluence of Grant Line Canal and Old River (where the canal becomes straight).
- * Station 98 (CHGRL 11) (1986 addition) is on Grant Line Canal near the mouth of Salmon Slough.

In 1985, samples were taken at each station every other day from April 16 to May 22 and every fourth day from May 16 to July 13. In 1986, samples were taken at each station every other day from April 16 to July 11. Samples were taken by making a single 10-minute oblique tow, regardless of tidal stage, at each station with an egg and larval net mounted on a ski frame. When heavy blooms of filamentous algae occurred, 5-minute tows, and sometimes 2.5-minute tows, were made because of net clogging. Boat speed was adjusted to

maintain a towing cable angle declination of about 71 degrees. A cone-shaped net 30 inches in diameter at the opening and 10 feet long, made of 505-micron mesh Nitex netting was used. A 32-ounce plastic collecting jar, screened with 470-micron mesh bolting cloth, was attached at the cod end to collect samples. At the end of each tow, contents of the net were rinsed into the collecting jar, and the sample was preserved in a 5 percent formalin and rose bengal dye solution. The rose bengal dye makes eggs and larvae more visible and easy to distinguish from detritus. The sampling methods are essentially identical to those by Fish and Game in its Delta striped bass egg and larval sampling program.

A digital flowmeter (Oceanics Model 2030) was used to measure water flow through the net and subsequently compute the cubic meters of water sampled. The flowmeter was calibrated by the Hydraulic Laboratory at the University of California, Davis.

Surface water temperature, water transparency (secchi disc), and surface electrical conductivity were measured at each sampling site.

In the lab, samples were rinsed thoroughly with water through a No. 50 sieve (300-micron mesh) to remove formalin, excess dye, and algae. Samples were then placed in plexiglass trays, and fish eggs and larvae were sorted under a lighted magnifying lens. Samples with heavy detritus or large numbers of eggs and/or larvae were subsampled (either 1/2, 1/4, or 1/16 of the total sample was sorted). Eggs were identified to species, where possible, and counted; striped bass eggs were further classified as dead,

0-8 hours old, or 9-36 hours old. Fish larvae were classified to family and in some cases to species. Striped bass larvae were measured to the nearest millimeter standard length. Eggs and larvae in about 2.5 percent of the samples were identified and measured a second time as a quality control measure.

Daily amount of Clifton Court Forebay inflow (acre-feet) for the SWP (DWR 1985) and daily exports (acre-feet) for the CVP (DFG, Bay-Delta Project, unpublished data) for April through July were obtained from daily operation summaries for each facility (Appendixes A and B).

To estimate density of striped bass eggs and larvae entrained by the SWP and CVP facilities, densities at sample stations immediately in line with the intake of each facility (Stations 96 and 92, respectively) were used. Data were broken down into size groups (eggs and 3-6mm, 7-10mm, 11-14mm, 15-18mm, and 19-20mm larvae). Densities (eggs

or larvae per cubic meter) for each size group were calculated for each sample station by day. Daily inflow to Clifton Court Forebay for the SWP and daily export by the CVP were then multiplied by the appropriate density of eggs and larvae. For days when no samples were taken, the previous day's densities were used to calculate entrainment.

Baracco (1983) estimated entrainment by averaging densities at sample stations about one tidal excursion above and below the mouth of Old River, DFG stations 49, 51, 53, 55, 57, 59, and 60 (Figure 1). Data from these stations were broken down by the same size groups as for the 1985-1986 method. Mean densities for each size group were calculated by 10-day periods (encompassing 5 survey days) throughout the survey period.

Methods for estimating losses at the SWP and CVP facilities were compared for the 1985 and 1986 data.

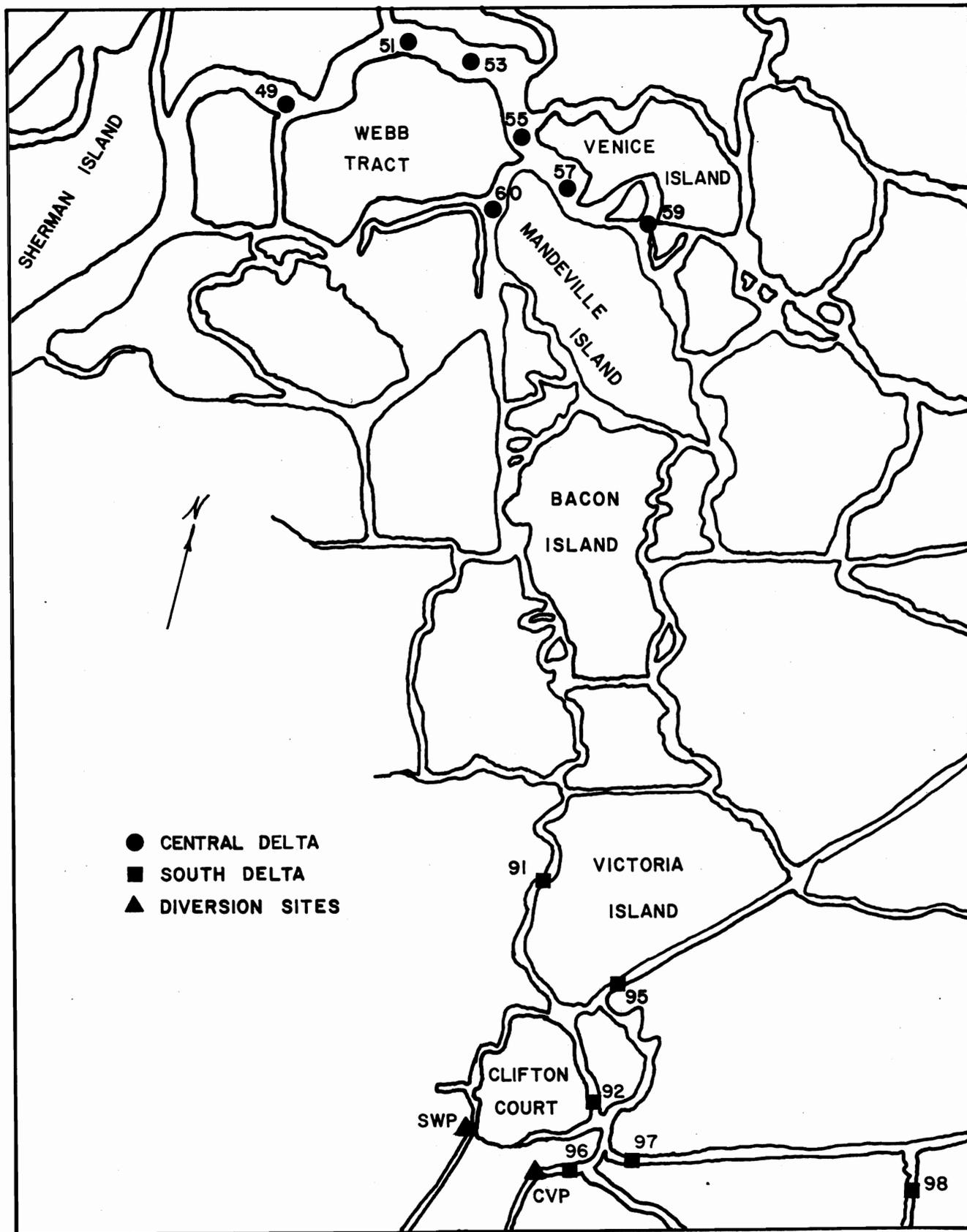


Figure 1. Central and south Delta egg and larval sampling stations and State Water Project and Central Valley Project Diversion sites.



RESULTS

Total estimated entrainment by the SWP and CVP of striped bass eggs and larvae less than 21mm in length as measured by an egg and larval survey near the intakes (our method) were 793.6 million in 1985 and 99.7 million in 1986. Combined exports during this time totaled 1.22 million acre-feet for 1985 and 1.1 million acre-feet for 1986.

State Water Project

In both 1985 and 1986, bimonthly average densities of striped bass eggs near the intake to the SWP were highest during the period May 1-15 (0.6064 eggs/m³ in 1985 and 0.027 eggs/m³ in 1986) (Table 1). Egg and larval densities in 1985 were considerably higher than those in 1986 for all size groups. No eggs were observed after June 6th. Bimonthly average densities of striped bass larvae were highest during May 16-31 of both years. Average densities of all larvae per cubic meter during this period were 0.3530 in 1985 and 0.0710 in 1986.

Striped bass eggs and larvae entrained by the SWP were estimated to be 441.1 million in 1985 and 51.9 million in 1986 (Table 2). In 1985, an estimated 85.9 million eggs were entrained; only 3.8 million were entrained in 1986. Entrainment was greatest for larvae in the 3-6mm size group in both years: 307.4 million in 1985 and 27.1 million in 1986.

Surface water temperature, water transparency (secchi disc), and surface electrical conductivity at the sampling

station near the intake to the SWP for both years were averaged on a bimonthly basis (Table 3).

Central Valley Project

Bimonthly average densities of striped bass eggs near the intake to the CVP were highest during May 1-15, 1985 (0.4832 eggs/m³), while in 1986 the high was during the May 16-31 period (0.0628 eggs/m³) (Table 4). Bimonthly average densities of striped bass larvae were highest during May 16-31 in both years. Average densities of all larvae per cubic meter during this period were 0.4477 in 1985 and 0.0511 in 1986. Egg and larval densities in 1985 were considerably higher than those in 1986 for larvae 10mm and less; densities for larvae greater than 10mm were higher in 1986.

Striped bass eggs and larvae entrained by the CVP were estimated to be 352.5 million in 1985 and 47.8 million in 1986 (Table 5). In 1985, an estimated 84.9 million eggs were entrained, while only 9.3 million eggs were entrained in 1986. Entrainment was greatest for larvae in the 3-6mm size group (237.2 million) in 1985; in 1986 the 7-10mm size group had the greatest entrainment (29.1 million).

Surface water temperature, water transparency (secchi disc), and surface electrical conductivity at the sampling station near the intake to the CVP for both years were averaged on a bimonthly basis (Table 6).

TABLE 1. STRIPED BASS EGG AND LARVAL 1985 AND 1986 AVERAGE DENSITY (FISH PER CUBIC METER) ESTIMATES NEAR THE INTAKE TO THE SWP.

	SIZE GROUPS					
	EGGS	3-6 mm	7-10 mm	11-14 mm	15-18 mm	19-20 mm
1985 DENSITY						
APR 16-30	0.0231	0.3285	0.0345	0	0	0
MAY 1-15	0.6064	0.6052	0.1232	0	0	0
MAY 16-31	0.0722	1.0399	0.0169	0.0023	0	0
JUN 1-15	0.0085	0.4093	0.0799	0	0	0
JUN 16-30	0	0.1569	0.1039	0.0120	0	0
JUL 1-13	0	0.0030	0.0074	0.0059	0	0
1986 DENSITY						
APR 16-30	0.0025	0	0	0	0	0
MAY 1-15	0.0277	0.0458	0.0167	0	0	0
MAY 16-31	0.0045	0.1561	0.0513	0.0054	0	0
JUN 1-15	0.0006	0.0118	0.3591	0.0301	0.0061	0
JUN 16-30	0	0	0	0.0008	0	0
JUL 1-11	0	0.0063	0.0025	0.0084	0.0016	0.0030

TABLE 2. STRIPED BASS EGG AND LARVAL 1985 AND 1986 ENTRAINMENT ESTIMATES FOR THE SWP INTAKE.

	SIZE GROUPS					
	EGGS	3-6 mm	7-10 mm	11-14 mm	15-18 mm	19-20 mm
1985 ENTRAINMENT						
APR 16-30	3161003	38461069	4289227	0	0	0
MAY 1-15	72754238	69328241	13288904	0	0	0
MAY 16-31	9186982	133014715	2281900	337231	0	0
JUN 1-15	776332	42792309	8809719	0	0	0
JUN 16-30	0	23174110	15141675	1919412	0	0
JUL 1-13	0	455787	1090896	879193	0	0
TOTAL	85878556	307226231	44902321	3135835	0	0
GRAND TOTAL						441,142,942
1986 ENTRAINMENT						
APR 16-30	232344	0	0	0	0	0
MAY 1-15	2925636	4700959	1701729	0	0	0
MAY 16-31	535473	20319317	6024493	622261	0	0
JUN 1-15	78070	1278781	6191257	3839482	695104	0
JUN 16-30	0	0	0	131636	0	0
JUL 1-11	0	771049	296738	1022474	188306	353651
TOTAL	3772123	27070106	14214217	5615853	883410	353651
GRAND TOTAL						51,909,361

TABLE 3. BIMONTHLY ENVIRONMENTAL PARAMETERS AND EXPORT RATES NEAR THE INTAKE TO THE SWP, APRIL 16 THROUGH JULY 15, 1985 AND 1986.

	EC (uMHOS)	SECCHI (cm)	TEMP (°F)	EXPORT (ac-ft)
1985				
APR 16-30	336	61	63	6758
MAY 1-15	291	40	54	6280
MAY 16-31	353	35	69	6002
JUN 1-15	263	38	72	5744
JUN 16-30	342	36	75	7750
JUL 1-15	337	49	75	9218
1986				
APR 16-30	232	37	62	5631
MAY 1-15	288	41	62	5982
MAY 16-31	315	38	67	6621
JUN 1-15	303	34	71	6779
JUN 16-30	287	30	73	5364
JUL 1-15	246	31	75	8652

TABLE 4. STRIPED BASS EGG AND LARVAL 1985 AND 1986 AVERAGE DENSITY (FISH PER CUBIC METER ESTIMATES NEAR THE INTAKE TO THE CVP).

	EGGS	SIZE GROUPS				
		3-6 mm	7-10 mm	11-14 mm	15-18 mm	19-20 mm
1985 DENSITY						
APR 16-30	0.0095	0.2491	0.0368	0	0	0
MAY 1-15	0.4833	0.4933	0.0595	0	0	0
MAY 16-31	0.2457	0.8754	0.0200	0	0	0
JUN 1-15	0	0.3707	0.0132	0	0	0
JUN 16-30	0	0.0645	0.0596	0	0	0
JUL 1-13	0	0	0.0070	0.0062	0	0
1986 DENSITY						
APR 16-30	0.0074	0	0	0	0	0
MAY 1-15	0.0070	0.0026	0.0006	0.0006	0	0
MAY 16-31	0.0628	0.0998	0.0712	0.0282	0.0052	0
JUN 1-15	0.0019	0.0087	0.0393	0.0215	0.0041	0
JUN 16-30	0	0.0031	0.0129	0.0116	0.0042	0.0043
JUL 1-11	0	0.0028	0.0121	0	0.0013	0.0018

TABLE 5. STRIPED BASS EGG AND LARVAL 1985 AND 1986 ENTRAINMENT ESTIMATES FOR THE CVP INTAKE.

	EGGS	SIZE GROUPS				
		3-6 mm	7-10 mm	11-14 mm	15-18 mm	19-20 mm
1985 ENTRAINMENT						
APR 16-30	1441386	36453707	5358129	0	0	0
MAY 1-15	53133878	50714312	5878537	0	0	0
MAY 16-31	30287795	107676719	2467556	0	0	0
JUN 1-15	0	42307228	1475222	0	0	0
JUN 16-30	0	6977666	6392579	0	0	0
JUL 1-13	0	0	1008369	887339	0	0
TOTAL	84863059	244129632	22580392	887339	0	0
GRAND TOTAL						352,460,422
1986 ENTRAINMENT						
APR 16-30	887433	0	0	0	0	0
MAY 1-15	781887	307790	73543	73543	0	0
MAY 16-31	7368537	11917849	8468814	3389458	631474	0
JUN 1-15	234260	937747	4031236	2458346	372145	0
JUN 16-30	0	347403	1452850	1272731	397805	527523
JUL 1-11	0	283243	1245136	0	135265	217030
TOTAL	9272117	13794033	15271579	7194078	1536689	744553
GRAND TOTAL						47,813,048

TABLE 6. BIMONTHLY ENVIRONMENTAL PARAMETERS AND EXPORT RATES NEAR THE INTAKE TO THE CVP, APRIL 16 THROUGH JULY 15, 1985 AND 1986.

	EC (uMHOS)	SECCHI (cm)	TEMP (°F)	EXPORT (ac-ft)
1985				
APR 16-30	318	55	63	8196
MAY 1-15	343	38	65	5607
MAY 16-31	442	28	68	6237
JUN 1-15	318	36	72	6108
JUN 16-30	341	32	75	5792
JUL 1-15	409	36	75	9032
1986				
APR 16-30	238	38	61	6191
MAY 1-15	293	36	62	6272
MAY 16-31	320	33	67	5643
JUN 1-15	303	31	71	5891
JUN 16-30	284	23	73	5980
JUL 1-15	315	29	75	6865

**Central Delta Densities
and Entrainment Estimates**

Mean striped bass egg densities for 1985 at the central Delta stations (Baracco's method) were highest during the period May 11-20 (2.02692 eggs/m³) (Table 7). Highest larval densities were in the 3-6mm size group (3.71548 fish/m³). Mean densities for 1985 at the central Delta stations were considerably higher than those measured at the SWP and CVP intakes (Table 7 and Figures 2-5). Mean striped bass egg densities for 1986 at the central Delta stations were highest during the period May 11-20 (0.21772 eggs/m³) (Table 8). Highest larval densities were in the 3-6mm size group (1.18947 fish/m³) during the period May 21-30. Mean densities for 1986 at the central Delta stations were lower than those at the SWP and CVP intakes (Table 8 and Figures 6-9).

Mean densities of eggs and larvae for the central Delta stations were considerably higher in 1985 than in 1986.

Entrainment estimates of striped bass eggs and larvae for 1985 using Baracco's (1983) method were 2.573 billion for the SWP and 1.795 billion for the CVP (Table 9). Entrainment losses of eggs were estimated to be 789.6 million for the SWP and 503.3 million for the CVP. Entrainment losses of larvae were highest in the 3-6mm size group: 1.659 billion for SWP and 1.208 billion for CVP.

Entrainment estimates of striped bass eggs and larvae for 1986 using Baracco's method were 727.6 million for SWP and 95.1 million for CVP (Table 10). Entrainment losses of eggs were estimated to be 101.6 million for SWP and 5.5 million for CVP.

In both years, entrainment estimates using Baracco's method were higher than those calculated from densities near the SWP and CVP intakes (our method). Using either method, entrainment estimates for 1985 were considerably higher than those for 1986.

Yearling Equivalent Losses

Entrainment losses for striped bass eggs and larvae during 1985 and 1986 were converted to an equivalent number of one-year-old fish using Baracco's (1983) survival rates (Tables 11 and 12). Striped bass yearling equivalent losses based on central Delta densities (Baracco's method) were:

	<u>SWP</u>	<u>CVP</u>
1985	293,559	207,413
1986	148,916	32,874

Yearling equivalent losses based on densities taken near the SWP and CVP intakes (our method) were:

	<u>SWP</u>	<u>CVP</u>
1985	65,177	42,861
1986	35,315	50,415

TABLE 7. STRIPED BASS EGG AND LARVAL 1985 AVERAGE DENSITY (FISH PER CUBIC METER) ESTIMATES IN THE CENTRAL DELTA, AND ADJACENT TO THE SWP AND CVP INTAKES.

DENSITIES IN THE CENTRAL DELTA

TIME PERIOD	EGGS	3-6 mm	7-10 mm	11-14 mm	15-18 mm	19-20 mm
4/11-20	0.3281	0.5398	0.0160	0	0	0
4/21-30	0.6113	0.7868	0.1148	0	0	0
5/ 1-10	1.4474	1.4510	0.1072	0.0004	0	0
5/11-20	2.0269	2.9408	0.1468	0	0	0
5/21-30	0.3908	3.7155	0.1022	0	0	0
5/31-6/9	0.0436	0.9839	0.0456	0.0007	0	0
6/10-19	0.0156	0.5949	0.1124	0.0008	0	0.0002
6/20-29	0.0023	0.1256	0.1061	0.0011	0	0.0002
6/30-7/9	0	0.0068	0.0106	0.0002	0	0
7/10-19	0	0.0006	0.0017	0	0	0

DENSITIES NEAR THE SWP INTAKE

4/11-20	0.0338	0.0695	0.0082	0	0	0
4/21-30	0.0160	0.4631	0.0473	0	0	0
5/ 1-10	0.6573	0.6391	0.1402	0	0	0
5/11-20	0.2102	1.1375	0.0232	0.0046	0	0
5/21-30	0.0381	0.6878	0.0134	0	0	0
5/31-6/9	0.0106	0.4997	0.0918	0	0	0
6/10-19	0	0.1973	0.0827	0	0	0
6/20-29	0	0.0572	0.0730	0.0182	0	0
6/30-7/9	0	0.0032	0.0080	0.0064	0	0
7/10-19	0	0	0	0	0	0

DENSITIES NEAR THE CVP INTAKE

4/11-20	0.0058	0.0559	0.0080	0	0	0
4/21-30	0.0108	0.2637	0.0385	0	0	0
5/ 1-10	0.4586	0.5590	0.0818	0	0	0
5/11-20	0.4314	0.6761	0.0232	0	0	0
5/21-30	0.0612	0.7199	0.0112	0	0	0
5/31-6/9	0	0.4450	0.0135	0	0	0
6/10-19	0	0.1029	0.0383	0	0	0
6/20-29	0	0.0357	0.0655	0	0	0
6/30-7/9	0	0	0.0067	0.0067	0	0
7/10-19	0	0	0.0054	0	0	0

STRIPED BASS EGGS

1985 DENSITIES

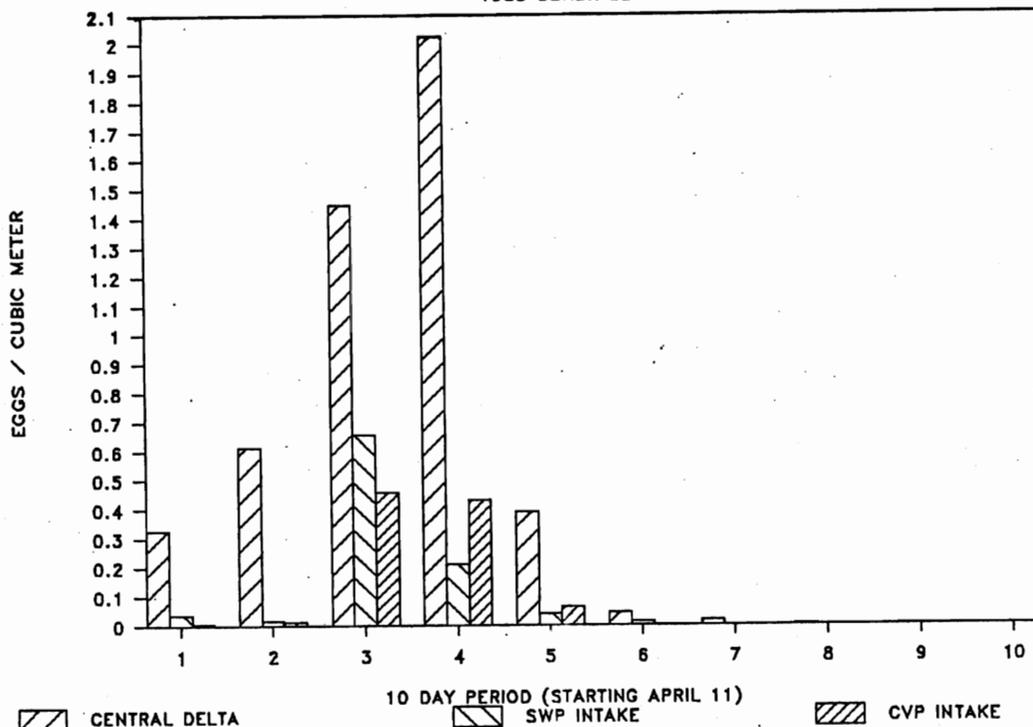


Figure 2. Average densities of striped bass eggs in 1985 in the Central Delta and adjacent to the SWP and CVP intakes.

STRIPED BASS <7MM

1985 DENSITIES

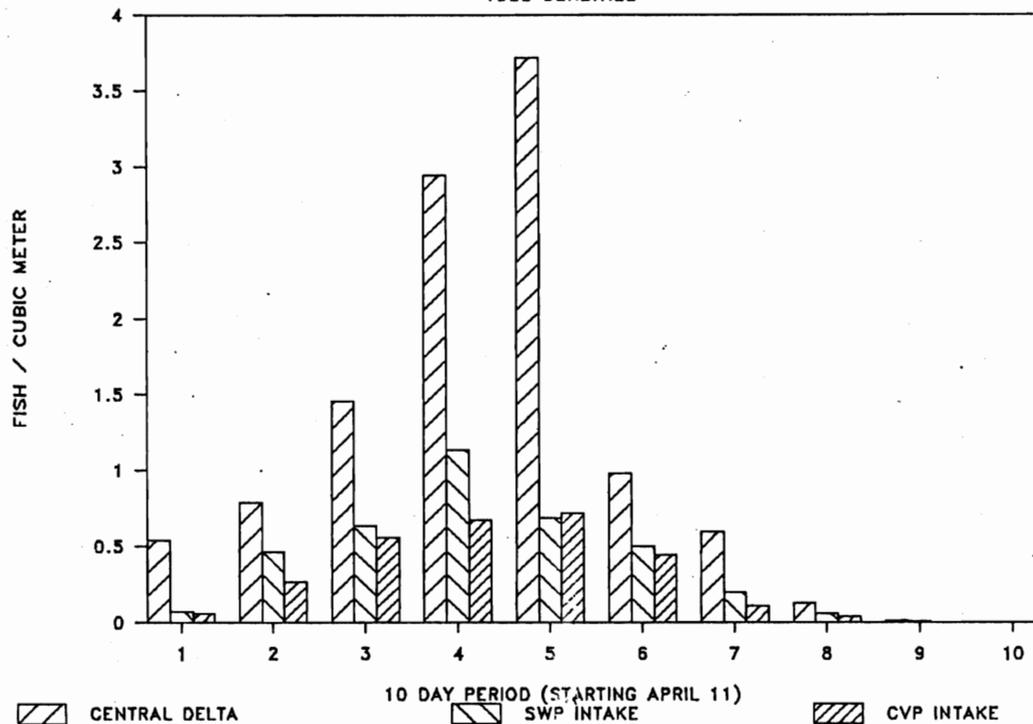


Figure 3. Average densities of striped bass larvae less than 7 mm in length in 1985 in the Central Delta, and adjacent to the SWP and CVP intakes.

STRIPED BASS 7-10MM

1985 DENSITIES

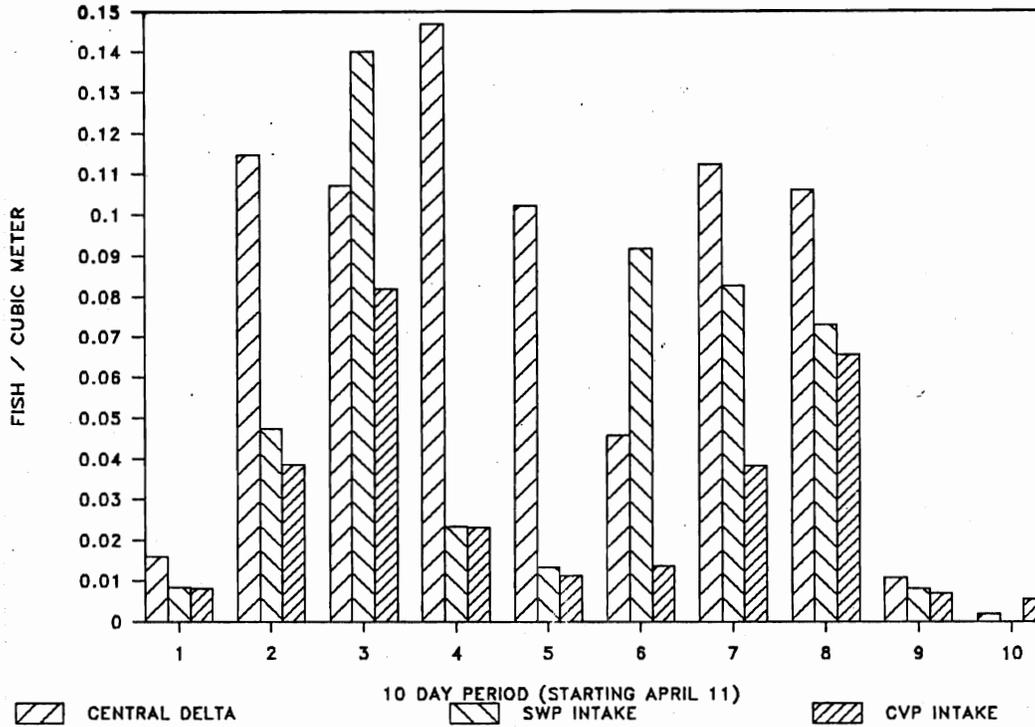


Figure 4. Average densities of striped bass larvae 7 to 10 mm in length in 1985 in the Central Delta, and adjacent to the SWP and CVP intakes.

STRIPED BASS 11-14MM

1985 DENSITIES

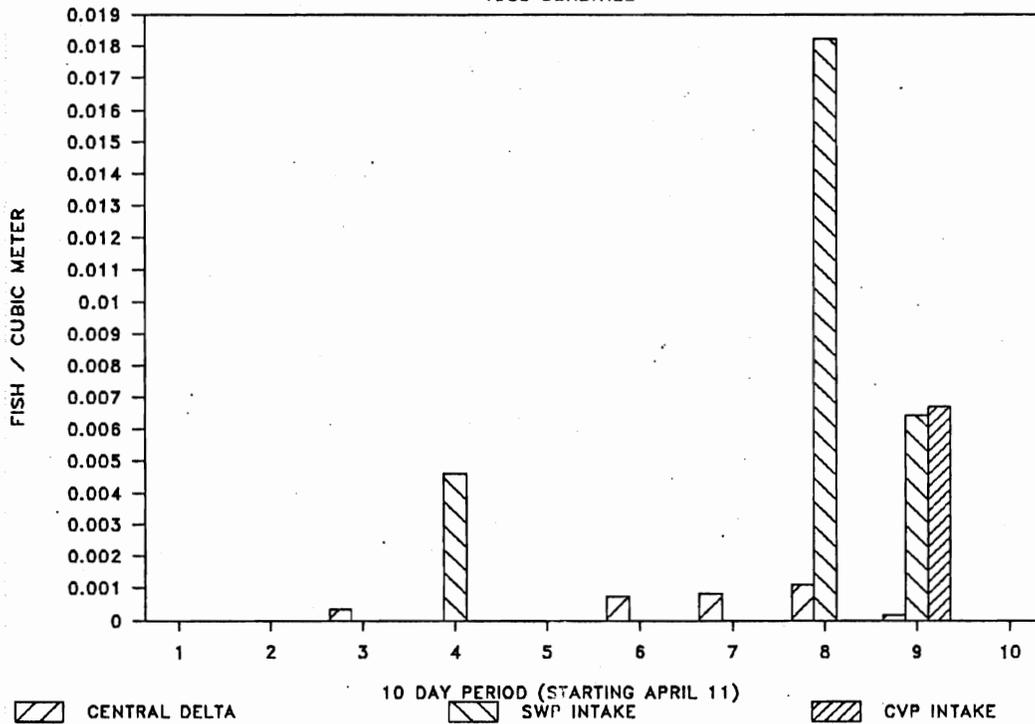


Figure 5. Average densities of striped bass larvae 11 to 14 mm in length in 1985 in the Central Delta, and adjacent to the SWP and CVP intakes.

TABLE 8. STRIPED BASS EGG AND LARVAL 1986 AVERAGE DENSITY (FISH PER CUBIC METER) ESTIMATES IN THE CENTRAL DELTA, AND ADJACENT TO THE SWP AND CVP INTAKES.

TIME PERIOD	DENSITIES IN THE CENTRAL DELTA					
	EGGS	3-6 mm	7-10 mm	11-14 mm	15-18 mm	19-20 mm
4/11-20	0.0010	0.0105	0	0	0	0
4/21-30	0.0666	0.1911	0.0084	0	0	0
5/ 1-10	0.1417	0.1817	0.0169	0.0001	0	0
5/11-20	0.2177	0.5481	0.0341	0.0005	0.0001	0
5/21-30	0.1779	1.1895	0.3734	0.0033	0.0001	0
5/31-6/9	0.0180	0.7891	0.3416	0.0100	0.0005	0.0002
6/10-19	0.0119	0.0811	0.0911	0.0127	0.0005	0.0002
6/20-29	0	0.1078	0.0714	0.0110	0	0
6/30-7/9	0.0018	0.0157	0.0228	0.0046	0.0016	0.0035
7/10-19	0	0.0031	0.0007	0	0	0

TIME PERIOD	DENSITIES NEAR THE SWP INTAKE					
	EGGS	3-6 mm	7-10 mm	11-14 mm	15-18 mm	19-20 mm
4/11-20	0.0044	0	0	0	0	0
4/21-30	0.0328	0	0	0	0	0
5/ 1-10	0.2542	0.1338	0.0663	0	0	0
5/11-20	0.2229	0.5939	0.2672	0	0	0
5/21-30	0.0097	2.4565	0.7338	0.0869	0	0
5/31-6/9	0.0089	0.1707	0.8150	0.1743	0.0551	0
6/10-19	0	0.0057	0.0760	0.2898	0.0359	0
6/20-29	0	0	0	0	0	0
6/30-7/9	0	0.0638	0.0279	0.0922	0.0135	0.0279
7/10-19	0	0.0055	0	0	0.0042	0.0055

TIME PERIOD	DENSITIES NEAR THE CVP INTAKE					
	EGGS	3-6 mm	7-10 mm	11-14 mm	15-18 mm	19-20 mm
4/11-20	0	0	0	0	0	0
4/21-30	0.1109	0	0	0	0	0
5/ 1-10	0.0840	0.0045	0.0045	0.0045	0	0
5/11-20	0.0204	0.0546	0.0045	0.0045	0	0
5/21-30	0.9960	1.5663	1.1397	0.4461	0.0787	0
5/31-6/9	0.0383	0.1402	0.4685	0.2772	0.0660	0
6/10-19	0	0.0232	0.2507	0.1828	0	0.0649
6/20-29	0	0.0232	0.0634	0.0866	0.0634	0
6/30-7/9	0	0.0306	0.1275	0	0.0095	0.0196
7/10-19	0	0	0.0053	0	0.0053	0

STRIPED BASS EGGS

1986 DENSITIES

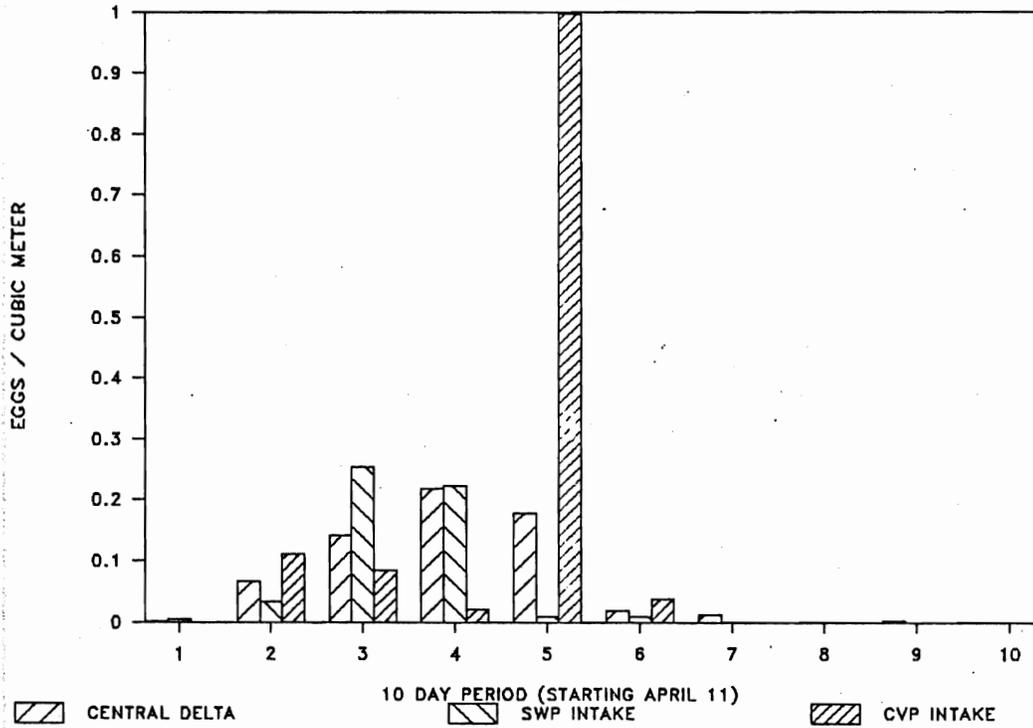


Figure 6. Average densities of striped bass eggs in 1986 in the Central Delta and adjacent to the SWP and CVP intakes.

STRIPED BASS <7MM

1986 DENSITIES

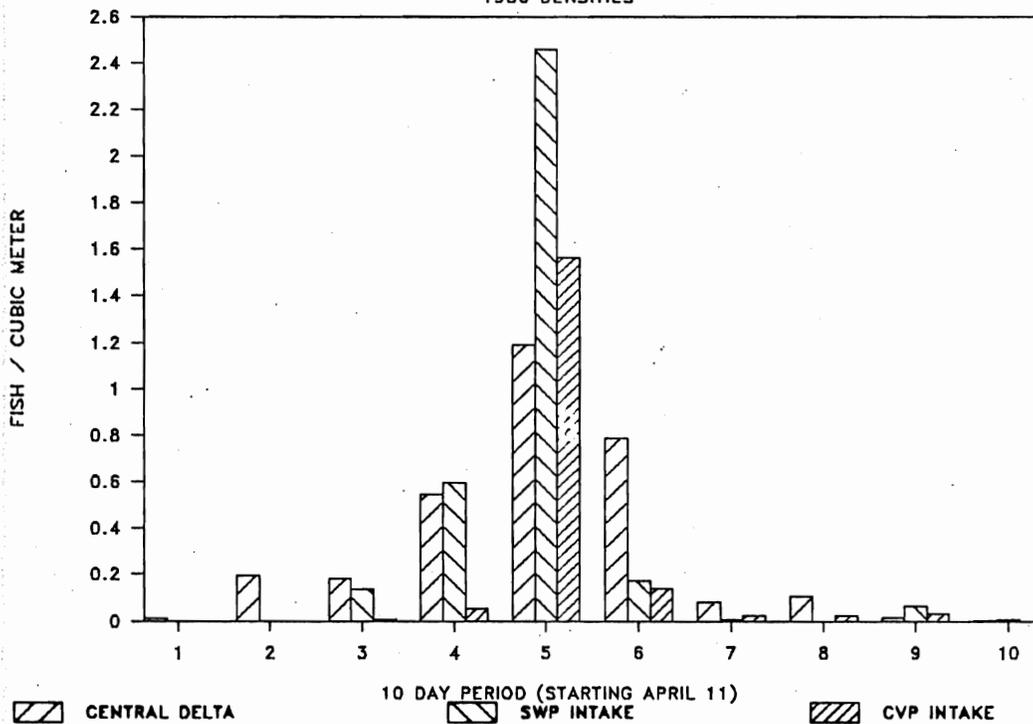


Figure 7. Average densities of striped bass larvae less than 7 mm in length in 1986 in the Central Delta, and adjacent to the SWP and CVP intakes.

STRIPED BASS 7-10MM

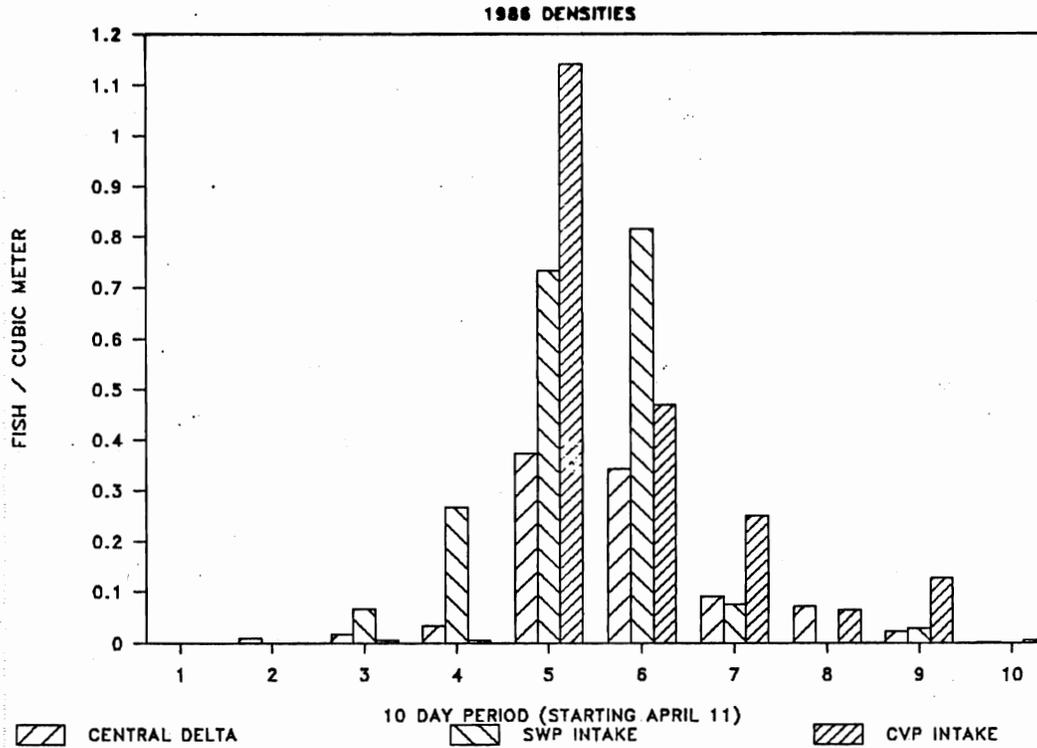


Figure 8. Average densities of striped bass larvae 7 to 10 mm in length in 1986 in the Central Delta, and adjacent to the SWP and CVP intakes.

STRIPED BASS 11-14MM

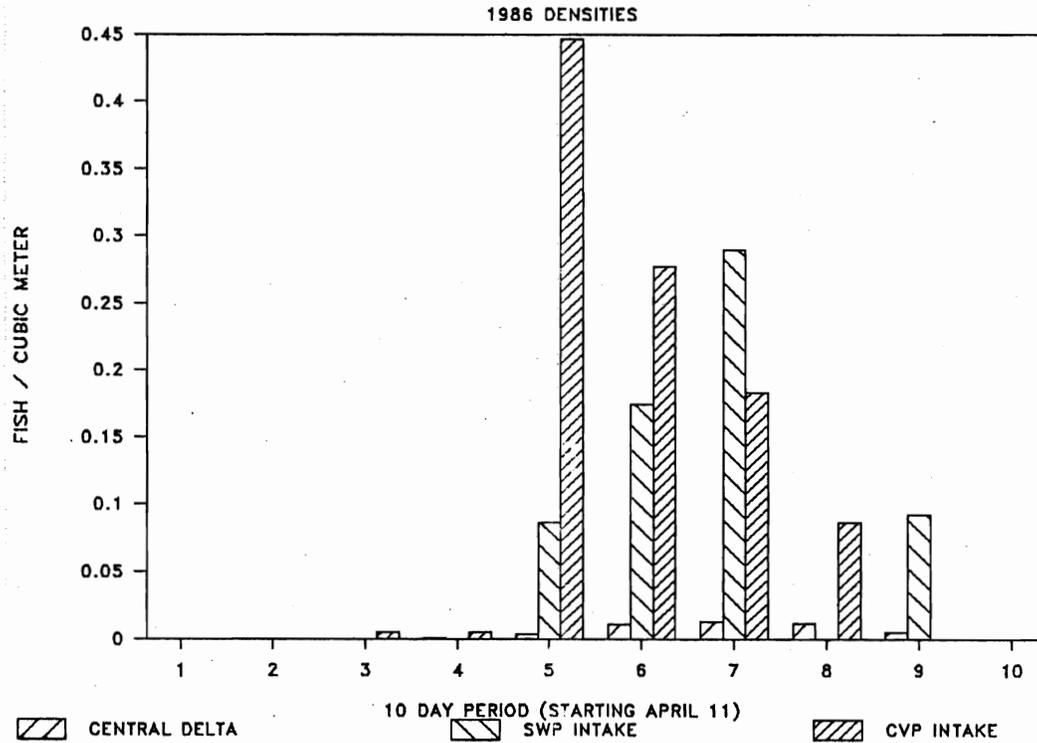


Figure 9. Average densities of striped bass larvae 11 to 14 mm in length in 1985 in the Central Delta, and adjacent to the SWP and CVP intakes.

TABLE 9. COMPARISON OF ENTRAINMENT LOSSES OF STRIPED BASS EGGS AND LARVAE LESS THAN 21 MM AT THE SWP AND CVP EXPORT FACILITIES BASED ON DENSITIES IN THE CENTRAL DELTA AND NEAR THE INTAKES, APRIL 16 THROUGH JULY 13, 1985.

SIZE GROUP	CENTRAL DELTA		NEAR INTAKES	
	SWP	CVP	SWP	CVP
EGGS	789,577,296	503,274,911	85,878,556	84,863,059
3-6 mm	1,659,081,764	1,208,012,470	307,226,231	244,129,632
7-10 mm	123,261,237	83,449,454	44,902,321	22,580,392
11-14 mm	543,186	344,540	3,135,835	887,339
15-18 mm	0	0	0	0
19-20 mm	75,282	45,917	0	0
TOTAL	2,572,538,765	1,795,127,292	441,142,943	352,460,422

TABLE 10. COMPARISON OF ENTRAINMENT LOSSES OF STRIPED BASS EGGS AND LARVAE LESS THAN 21 MM AT THE SWP AND CVP EXPORT FACILITIES BASED ON DENSITIES IN THE CENTRAL DELTA AND NEAR THE INTAKES, APRIL 16 THROUGH JULY 11, 1986.

SIZE GROUP	CENTRAL DELTA		NEAR INTAKES	
	SWP	CVP	SWP	CVP
EGGS	101,559,822	5,474,795	3,772,123	9,272,117
3-6 mm	474,525,846	59,149,497	27,070,106	13,794,033
7-10 mm	143,709,919	27,685,758	14,214,217	15,271,579
11-14 mm	6,448,309	2,079,894	5,615,853	7,194,078
15-18 mm	540,802	229,996	883,410	1,536,689
19-20 mm	836,640	452,148	353,651	744,553
TOTAL	727,621,338	95,072,088	51,909,360	47,813,049

TABLE 11. STRIPED BASS YEARLING EQUIVALENT LOSS AT THE SWP AND CVP EXPORT FACILITIES BASED ON CENTRAL DELTA DENSITIES AND DENSITIES NEAR THE INTAKES AND WATER EXPORTS DURING APRIL 16 THROUGH JULY 13, 1985.

SIZE GROUP	SURVIVAL RATE TO AGE 1 *	CENTRAL DELTA		NEAR INTAKES	
		SWP	CVP	SWP	CVP
EGGS	0.000047	37,109	23,437	4,036	3,989
3-6 mm	0.000124	205,726	149,794	38,096	30,272
7-10 mm	0.000338	47,826	32,378	15,177	7,632
11-14 mm	0.002509	1,362	866	7,868	2,226
15-18 mm	0.006415	0	0	0	0
19-20 mm	0.020414	1,536	938	0	0
TOTAL		293,559	207,413	65,177	44,119

* SURVIVAL RATES TO AGE 1 FOR DIFFERENT SIZE GROUPS WERE CALCULATED BY ECOLOGICAL ANALYSTS 1981. EGG SURVIVAL RATE WAS ESTIMATED BY CALCULATING THE POTENTIAL NUMBER OF EGGS SPAWNED COMPARED TO THE ESTIMATED NUMBER OF AGE 1 FISH IN THE ESTUARY.

TABLE 12. STRIPED BASS YEARLING EQUIVALENT LOSS AT THE SWP AND CVP EXPORT FACILITIES BASED ON CENTRAL DELTA DENSITIES AND DENSITIES NEAR THE INTAKES AND WATER EXPORTS DURING APRIL 16 THROUGH JULY 11, 1986.

SIZE GROUP	SURVIVAL RATE TO AGE 1 *	CENTRAL DELTA		NEAR INTAKES	
		SWP	CVP	SWP	CVP
EGGS	0.000047	4,773	257	177	436
3-6 mm	0.000124	58,841	7,335	3,357	1,710
7-10 mm	0.000338	48,574	9,358	4,804	5,162
11-14 mm	0.002509	16,179	5,218	14,090	18,050
15-18 mm	0.006415	3,469	1,475	5,667	9,858
19-20 mm	0.020414	17,079	9,230	7,219	15,199
TOTAL		148,916	32,874	35,315	50,415

* SURVIVAL RATES TO AGE 1 FOR DIFFERENT SIZE GROUPS WERE CALCULATED BY ECOLOGICAL ANALYSTS 1981. EGG SURVIVAL RATE WAS ESTIMATED BY CALCULATING THE POTENTIAL NUMBER OF EGGS SPAWNED COMPARED TO THE ESTIMATED NUMBER OF AGE 1 FISH IN THE ESTUARY.



DISCUSSION

In spring 1985 and 1986, the loss of striped bass eggs and larvae was estimated based on direct measurement of densities of eggs and larvae at points near the diversions and the volume of water being exported during the survey. To date, this method appears to represent the most accurate means of estimating the magnitude of entrainment. However, several potential biases may result in underestimates:

- * Nets may not be totally efficient, especially for larger size larvae.
- * Spatial distribution of larvae within the channel may be different than at midchannel where sampling was done using an oblique tow.
- * Towing during daylight hours may decrease efficiency due to increased net avoidance.
- * Net efficiency may be greatly reduced during algal blooms.

The estimated entrainment based on densities taken near the intakes was slightly more than 10 times greater in 1985 than in 1986. This is most likely because high flow rates in Old River during early spring 1986 forced eggs and larvae farther downstream, out of the influence of the two pumping facilities. (Mean mid-April through mid-July flow was 2,280 cfs for 1985 and 5,952 cfs for 1986.)

Entrainment estimates were higher for the SWP than for the CVP in both years. This difference is probably because water from West Canal passes in front of the SWP first or because of dilution by San Joaquin River water. Estimates of combined SWP/CVP entrainment losses compared as follows:

	<u>Baracco's Method</u>	<u>Our Method</u>
1985	4.368 billion	793.6 million
1986	822.7 million	99.7 million

The difference is probably due to the higher central Delta densities.

Combined SWP/CVP entrainment losses for striped bass yearling equivalents compared as follows:

	<u>Baracco's Method</u>	<u>Our Method</u>
1985	500,972	109,296
1986	181,790	85,730

Baracco estimated a combined SWP/CVP average annual entrainment loss for 1968 through 1977 of 227,000 striped bass yearling equivalents.

It is not surprising that there is a large difference in our estimates and Baracco's estimates, since they are a direct function of the densities used. Entrainment estimates based on densities taken nearer the points of diversion should provide more accurate estimates than those calculated by Baracco.



REFERENCES

Baracco, A. 1983. Estimated entrainment of striped bass eggs and larvae less than 19mm in length at State Water Project and Central Valley Project facilities in the Sacramento-San Joaquin Delta, California, 1968-1977. Memorandum dated July 12, 1983.

Department of Water Resources. 1985. Dayflow Summary, April 1 - July 31, 1985. Central District.



APPENDIX A. DAILY INFLOW (arce-feet) INTO CLIFTON COURT FOREBAY
 APRIL THROUGH JULY, 1985 AND 1986.

DAY	1985				1986			
	APRIL	MAY	JUNE	JULY	APRIL	MAY	JUNE	JULY
1	4969	5318	5060	6942	0	10089	6627	8718
2	6874	4955	4921	8925	0	5746	7550	9718
3	5209	5919	4950	9917	0	5527	4686	8786
4	6216	6561	4958	9917	2028	5219	5775	7907
5	6942	8119	4958	10909	1031	6269	5906	10552
6	6744	7899	4959	9917	3435	5141	5922	7863
7	6744	6567	5951	8661	4202	5526	4978	8739
8	6744	5972	5950	8926	413	6431	9558	9997
9	7708	5943	5950	8857	3045	6279	6687	8921
10	6819	4959	5355	8926	0	5155	7205	8925
11	6425	4959	6348	8925	1407	5925	7427	8319
12	5713	4959	6942	8918	0	4938	6167	6942
13	5740	6002	5951	8923	2030	5423	8027	7537
14	7226	8926	6942	9684	5013	5650	6357	8132
15	7000	7140	6964	9916	3757	6412	8806	8727
16	5645	7532	6920	9520	251	5851	8928	7339
17	6910	7347	6942	9322	6514	7929	7961	6149
18	9698	8882	6671	10271	1570	10502	5300	5087
19	9189	8919	7934	10895	7583	10050	5651	5508
20	9124	8884	7924	10909	5967	8950	5144	5554
21	8952	5919	8524	10909	4780	6929	4760	5663
22	8799	4939	7932	8638	5669	7748	2294	4959
23	8920	3894	7920	9242	5022	8089	1981	5762
24	6946	3967	8923	8279	4208	9927	4748	7621
25	3993	4457	7207	9038	4268	10607	4557	9718
26	6742	4959	10494	8900	8307	10507	4953	9316
27	4958	4959	8837	8864	8778	4061	5548	6774
28	3967	5541	6940	8896	6921	119	4958	9539
29	3954	4959	6541	8924	6906	1443	5950	8909
30	3572	4959	6545	10305	7728	2591	7725	9505
31		5917		9918		639		9917



APPENDIX B. DAILY EXPORT RATES (acre-feet) BY THE CVP APRIL THROUGH JULY, 1985 AND 1986.

DAY	1985				1986			
	APRIL	MAY	JUNE	JULY	APRIL	MAY	JUNE	JULY
1	8361	6150	6207	9147	4080	5895	6632	9146
2	7048	6111	6247	8891	3440	6039	6610	8931
3	6955	5260	6176	8882	4544	6031	6580	8899
4	6533	4955	6230	8860	6021	6019	6623	8905
5	6247	4955	6241	8929	6455	6019	5145	9036
6	6016	4744	6237	8950	6422	6330	4845	9096
7	5999	4965	5781	8925	5636	6539	4859	8820
8	5965	4927	6250	9050	4864	6541	4867	4501
9	5976	4987	6212	9072	4112	6544	4869	4478
10	6013	5905	6214	9081	3527	6567	4854	4481
11	8558	6241	6219	9069	4277	6559	6115	4443
12	9192	6233	6048	9135	4736	6546	6597	4465
13	8867	6237	5848	9159	4696	6289	6604	4455
14	9062	6212	5859	9159	4847	6078	6589	4434
15	9047	6228	5846	9166	5062	6087	6582	8884
16	8893	6307	5637	9161	5979	5344	6572	8714
17	8929	6292	5901	9186	6566	5031	6601	8887
18	8951	6281	5906	9169	5613	5027	6587	8932
19	8992	6212	5899	9142	5015	5051	6591	8944
20	8951	6210	5923	9130	5046	5042	5532	8924
21	8956	6209	5883	9094	5054	4819	5075	8683
22	7925	6220	5835	9188	5980	5062	5105	8029
23	7965	6214	5924	9046	6565	5075	5118	8393
24	7929	6244	5835	9233	6551	5780	5078	8343
25	7952	6254	5623	9258	6540	6102	5107	8485
26	7940	6245	5706	9247	6558	6070	6295	8555
27	7886	6268	5735	8793	6263	6101	6722	8540
28	7625	6232	5631	9232	6535	6370	6512	8723
29	7137	6222	5995	9060	6678	6394	6414	
30	6910	6194	5446	8902	7924	6633	6395	
31		6188		8871		6386		

