Appendix E – Entrainment and Impingement Estimates (Steinbeck, July 2008)

Compilation of California Coastal Power Plant Entrainment and Impingement Estimates for California State Water Resources Control Board Staff Draft Issue Paper on Once-through Cooling

July 18, 2008

Prepared for:

Dr. Michael Foster
Coastal Solutions Group
911 Elkhorn Rd.
Watsonville, CA 95076

Prepared by:

John Steinbeck
356 Miramar Ln.
Pismo Beach, CA 93449
jsteinbeck@charter.net

Introduction

The purpose of this report is to compile the most complete and most recent information on the biological effects of entrainment and impingement by coastal power plants in California that use once-through cooling (OTC). The information will be used by the California State Water Resources Control Board (SWRCB) in developing policy for regulating the use of OTC by power plants in the state. The sources for much of the information presented in this report are 316(b) studies that have been completed at many of the coastal power plants in California in the past five to ten years.

To put the results into context it was necessary to compile accurate information on the actual volume of cooling water used by the plants. The design flows for the systems (i.e., maximum pumping capacity) were compiled from information already provided in the March draft of the SWRCB Scoping Document. These values were checked against information published in the recent 316(b) studies and 316(b) Proposals for Information Collection (PIC). Some of the reported design flow values that differed between sources were also checked with plant staff. It is important to point out that the design flows may not reflect the maximum possible intake volumes for some of the plants, since the values typically include the volumes for the main circulating water pumps, and not the smaller service water pumps in the systems. The total volumes for these smaller pumps are generally less than 5 percent of the main circulating pump capacities. Actual cooling water flows reported to the RWQCBs under the NPDES permits for the plants were used to calculate average daily flows for the six-year period from 2000–2005. The sources used in compiling the flow information are provided in **Appendix A**.

The methods used for compiling the entrainment and impingement estimates presented in **Tables 1** and **2** and are described in the following sections.

Entrainment Estimates

The entrainment data presented in **Table 1** were mostly compiled from recent 316(b) studies of cooling water systems at power plants in California. Entrainment estimates are only presented for larval fishes because this is the only taxonomic group and life stage that was sampled consistently across all of the facilities. Entrainment of the larval stages of some commercially important macroinvertebrates was assessed at some of the plants, but limited to later stage larvae of crabs and lobster, and recently-hatched immature squid. Earlier larval stages of these and other macroinvertebrates are not effectively collected by the mesh of the nets used in the sampling and would have required additional sampling efforts. Many macroinvertebrates have multiple larval stages that have varying periods of development further complicating the planning of an appropriate sampling program and further complicating the assessment. The entrainment assessment method used for most of the studies was the Empirical Transport Model which can be used in assessing the potential entrainment impacts on other macroinvertebrates using assumptions regarding the distribution of the larvae in the source water and the extent and volume of the source water for the populations relative to the cooling water volume. The focus on fish larvae in these studies is appropriate since larval fishes are much more limited in number in the water column and the adults for many species are limited in distribution, increasing the potential for population-level effects.

The table presents two sets of entrainment estimates. The first set is simply calculated using annual average larval concentrations multiplied by annual design and average actual 2000–2005 flows. The other set of entrainment estimates is from the published studies, which takes into account month-by-month differences in larval concentrations and therefore provide more accurate estimates of actual entrainment for the periods of study (**Appendix B**). Some of these studies did not include estimates for both design and actual flows (shown as 'nc' in **Table 1**). The only plants where recent representative entrainment data were not available were the Contra Costa and Pittsburg power plants located in the Sacramento-San Joaquin Delta (Delta) system. The table does present annual entrainment estimates for those two plants from studies completed thirty years ago in 1978–1979. No estimates were calculated from the larval concentrations measured during those studies because there have been so many long-term changes in flows and species composition within the Delta system that the historical estimates are unlikely to be representative of current conditions.

The entrainment estimates calculated using the average annual larval concentrations are very similar to the published entrainment estimates for the two nuclear plants (SONGS and DCPP) and units at other plants that operate at high capacity factors. There are greater differences between the two sets of estimates for plants and units that operate at low capacity factors. This is due to seasonal changes in larval concentrations that can significantly affect estimates of annual entrainment, especially when peak pumping capacity is occurring during periods with high concentrations of larvae. The seasonality in larval abundances varies between central and southern California, and also between open coast and protected bays and harbors (**Figures 1** and **2**).

Impingement Estimates

Similar to entrainment, the impingement data presented in **Tables 2a** and **2b** were mostly obtained from recent studies (**Appendix B**) at power plants in California using the same flow data used in **Table 1** and documented in **Appendix A**. Impingement estimates are only presented for fishes because this is the only taxonomic group that was sampled consistently across all of the facilities. Data on macroinvertebrate impingement were collected at all the facilities, but the data collected varied among plants. At some facilities all invertebrate groups were counted, and at others only invertebrates that could be characterized as shellfish (e.g., crabs, shrimp, squid, and octopus) were counted, while the other invertebrate categories were only recorded as 'present' when they were collected. At some facilities only shellfish were collected and quantified. Besides the inconsistencies in the sampling among plants, it is sometimes difficult to distinguish the invertebrates that are collected after they are dislodged from the intake conduit walls from organisms that are impinged from the source water. Even crabs, shrimp, and other invertebrates that could be characterized as 'shellfish' that are collected during impingement sampling probably settled in the biofouling community inside the cooling water intake system as larvae. As a result of these issues, only data on fish impingement is summarized in **Tables 2a** and **2b**.

The information in **Tables 2a** and **2b** presents two sets of impingement estimates for both numbers and biomass of fishes. The first set is calculated using the annual average impingement rates during normal operations calculated from the recent studies. The total annual normal operations impingement estimates were calculated by multiplying the impingement rates by the total annual design and average 2000–2005 flows. These impingement estimates for normal operations would be added to the average annual impingement during heat treatments for the plants where heat treatments are used for controlling biofouling inside the cooling system. The other set of impingement estimates is from published studies, which did not in all cases present estimates for both design and actual flows (shown as 'nc' in **Table 2b**). These estimates include both normal operations and heat treatment impingement. As with the entrainment studies, the only plants where recent representative data were not available were the Contra Costa and Pittsburg power plants located in the Delta system. The table does present annual impingement estimates for those two plants from studies completed thirty years ago in 1978–1979.

Intake Structure

Information on the intake structures at the California power plants is presented in **Table 3**. The various fish protection measures in use at each plant are listed and details are provided on the dimensions of screening used at the openings to the cooling water systems. This information could be used in evaluating the potential for entrapment of marine mammals and sea turtles into the systems. Note that the only plants with variable speed drives that allow flow to be adjusted to meet load capacity are installed at the Contra Costa and Pittsburg power plants in the Delta. San Onofre is the only plant with a sophisticated fish return system.

References (see Appendix B)

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CA Power Plant CWS Estimates

Table 1. Entrainment estimates for larval fishes from California coastal power plants. Estimates include calculated values from design and average annual 2000–2005 flows using larval concentrations from recent studies and also estimates from recently published entrainment studies. References used in compiling the information in the table are provided in Appendix B.

Plant	Design Flow (mgd)	Average Flow (mgd) based on 2000-2005 data	Average Larval Fish Concentration (# per million gallons)	Average Concentration and Design Flow Entrainment Estimate	Average Concentration and Average Flow Entrainment Estimate	Study Result Entrainment Estimate (Design flow)	Study Result Entrainment Estimate (Actual flow)
Alamitos Generating Station Units 1&2	207	121	9880.6	748,306,544	437,854,835	nc	121,970,937
Alamitos Generating Station Units 3&4	392	281	9880.6	1,414,971,165	1,013,733,478	1,109,972,442	728,944,910
Alamitos Generating Station Units 5&6	674	413	9972.2	2,455,020,121	1,503,394,233	nc	835,841,962
Contra Costa Power Plant Units 6&7	440	257	no recent representative data available			nc	95,110,000
Diablo Canyon Power Plant	2,528	2,287	1912.5	1,765,916,778	1,597,319,020	nc	1,481,948,383
El Segundo Generating Station Units 1&2	207	69	1953.7	147,969,610	49,437,254	nc	35,743,328
El Segundo Generating Station Units 3&4	399	265	1953.7	284,430,472	189,290,759	276,934,913	186,532,003
Encina Power Plant	857	621	13950.2	4,366,667,796	3,162,648,118	4,494,849,115	3,627,641,744
Harbor Generating Station	108	59	3961.9	156,285,731	85,447,634	153,331,013	65,298,000
Haynes Generating Station	968	258	12305.3	4,349,235,947	1,159,662,085	4,527,644,084	3,649,208,392
Huntington Beach Generating Station	514	179	1596.1	299,647,084	104,339,074	344,570,635	nc
Mandalay Generating Station	253	234	1514.5	140,195,151	129,201,071	141,736,337	33,422,317
Morro Bay Power Plant	668	257	3404.0	830,540,168	318,942,511	859,337,744	nc
Moss Landing Power Plant Units 1&2	361	193	4429.9	584,101,411	311,537,103	522,319,740	nc
Moss Landing Power Plant Units 6&7	865	387	2958.3	934,658,478	418,350,825	888,204,836	nc
Ormond Beach Generating Station	685	521	168.9	42,276,804	32,133,537	40,810,043	6,351,783
Pittsburg Power Plant Units 5&6	462	274	no recent representative data available			nc	175,230,000
Potrero Power Plant	231	193	3593.3	303,519,077	252,843,159	289,731,811	nc
Redondo Generating Station Units 5&6	217	51	4485.6	354,702,404	83,037,227	356,000,276	101,659,379
Redondo Generating Station Units 7&8	675	254	3133.5	772,198,644	290,801,357	744,808,585	189,537,344
San Onofre Nuclear Generating Station U	1,219	1,139	7439.6	3,311,307,168	3,095,251,683	nc	3,555,787,272
San Onofre Nuclear Generating Station U	1,219	1,154	7439.6	3,311,307,168	3,136,923,690	nc	3,261,783,562
Scattergood Generating Station	495	309	2796.9	506,083,227	315,634,578	524,202,652	365,258,133
South Bay Power Plant	601	417	10951.6	2,404,046,574	1,667,406,878	2,420,527,779	nc
Totals	**15,245**	**10,191**	**119682.2**	**29,483,387,521**	**19,355,190,108**		
Average			**5440.1**				

nc = not calculated

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Table 2a. Impingement estimates for fish numbers and biomass (lb) from California coastal power plants. Estimates include calculated values for normal operations for design and average annual 2000–2005 flows using impingement rates from recent studies. These estimates are combined with estimates of impingement during heat treatments to estimate total impingement. References used in compiling the information in the table are provided in Appendix B.

					Annual Normal Operations Impingement				Heat Treatments (HT)			Total Estimated Impingement			
Plant	Design Flow (mgd)	Average Flow (mgd) based on 2000-2005 data	Average # fish per million gal	Average Biomass (lbs) fish per million gal	Based on Count and Design Flow	Based on Biomass (lbs) and Design Flow	Based on Count and Average Flow	Based on Biomass (lbs) and Average Flow	Average # per HT	Average Biomass (lb) per HT	Average Number of HT per year (2000-2005)	Design Flow Total # Estimate	Design Flow Total Biomass (lb) Estimate	Actual Flow Total # Estimate	Actual Flow Total Biomass (lb) Estimate
Alamitos Generating Station Units 1&2	207	121							n/a	n/a	n/a				
Alamitos Generating Station Units 3&4	392	281	0.1750	0.0078	81,419	3,514	52,108	2,249	n/a	n/a	n/a	81,419	3,514	52,108	2,249
Alamitos Generating Station Units 5&6	674	413							n/a	n/a	n/a				
Contra Costa Power Plant Units 6&7	440	257	no recent representative data available						n/a	n/a	n/a	—	—	—	—
Diablo Canyon Power Plant	2,528	2,267	0.0058	0.0009	5,330	785	4,821	710	n/a	n/a	n/a	5,330	785	4,821	710
El Segundo Generating Station Units 1&2	207	69	0.0103	0.0035	779	265	260	89	227.25	72.18	1.3	1,074	359	556	182
El Segundo Generating Station Units 3&4	399	265	0.0220	0.0068	3,209	995	2,138	662	229.00	94.60	3.7	4,057	1,345	2,983	1,012
Encina Power Plant	857	621	0.6128	0.0256	191,824	8,016	138,932	5,806	15,831.83	747.70	6	286,815	12,502	233,923	10,292
Harbor Generating Station	108	59	0.4945	0.1622	19,508	6,399	10,666	3,498	n/a	n/a	n/a	19,508	6,399	10,666	3,498
Haynes Generating Station	968	258	0.1893	0.0041	66,901	1,462	17,838	390	n/a	n/a	n/a	66,901	1,462	17,838	390
Huntington Beach Generating Station	514	179	0.4079	0.0227	76,582	4,270	26,666	1,487	5,887.00	338.70	4.8	104,840	5,895	54,924	3,112
Mandalay Generating Station	253	234	0.7940	0.0299	73,497	2,771	67,739	2,553	101.90	4.20	1.4	73,640	2,776	67,876	2,559
Morro Bay Power Plant	668	257	0.3497	0.0140	85,315	3,419	32,783	1,313	n/a	n/a	n/a	85,315	3,419	32,783	1,313
Moss Landing Power Plant Units 1&2	381	193	0.5804	0.0058	76,526	762	40,816	406	n/a	n/a	n/a	76,526	762	40,816	406
Moss Landing Power Plant Units 6&7	865	387	1.7895	0.0287	565,390	9,071	253,067	4,060	n/a	n/a	n/a	565,390	9,071	253,067	4,060
Ormond Beach Generating Station	685	521	0.0711	0.0164	17,808	4,094	13,534	3,112	677.80	87.20	4.5	20,856	4,487	16,584	3,504
Pittsburg Power Plant Units 5&6	462	274	no recent representative data available						n/a	n/a	n/a	—	—	—	—
Potrero Power Plant	231	193	1.5090	0.0337	127,464	2,847	106,182	2,371	n/a	n/a	n/a	127,464	2,847	106,182	2,371
Redondo Generating Station Units 5&6	217	51	0.0075	0.0034	593	268	139	63	10.08	7.32	2	613	282	159	77
Redondo Generating Station Units 7&8	675	254	0.0240	0.0085	5,913	2,084	2,227	785	157.50	37.90	4.8	6,669	2,266	2,983	967
San Onofre Nuclear Generating Station Unit 2	1,219	1,139	1.5787	0.0335	1,405,342	29,854	1,322,490	28,094	2,494.00	627.80	7.5	1,424,047	34,563	1,341,195	32,802
San Onofre Nuclear Generating Station Unit 3	1,219	1,154									7.8				
Scattergood Generating Station	495	309	0.8228	0.0814	148,840	14,727	92,829	9,185	10,155.00	788.40	5.2	201,846	18,827	145,835	13,285
South Bay Power Plant	801	417	1.5921	0.0049	349,490	1,082	242,401	751	n/a	n/a	n/a	349,490	1,082	242,401	751
Totals	**15,245**	**10,191**			**3,301,730**	**96,685**	**2,427,807**	**67,564**							

nc = not calculated

CA Power Plant CWS Estimates

Table 2b. Impingement estimates for fish numbers and biomass (lb) from California coastal power plants. The impingement estimates from recently published impingement mortality studies include impingement during heat treatment. Studies where impingement estimates were not calculated for design or actual flow conditions during the study are indicated as "nc". References used in compiling the information in the table are provided in Appendix B.

Plant	Design Flow (mgd)	Average Flow (mgd) based on 2000-2005 data	Reported Total Impingement Estimates			
			Design Flow Total # Estimate	Design Flow Total Biomass (lb) Estimate	Actual Flow Total # Estimate	Actual Flow Total Biomass (lb) Estimate
Alamitos Generating Station Units 1&2	207	121				
Alamitos Generating Station Units 3&4	392	281	nc	nc	29,013	1,252
Alamitos Generating Station Units 5&6	674	413				
Contra Costa Power Plant Units 6&7	440	257	—	—	107,621	2,741
Diablo Canyon Power Plant	2,528	2,287	nc	nc	nc	nc
El Segundo Generating Station Units 1&2	207	69	nc	nc	186	63
El Segundo Generating Station Units 3&4	399	265	2,521	542	1,527	473
Encina Power Plant	857	621	289,562	12,878	215,583	9,609
Harbor Generating Station	108	59	19,861	6,478	8,851	2,903
Haynes Generating Station	968	258	56,613	1,227	53,442	1,168
Huntington Beach Generating Station	514	179	nc	nc	51,082	2,848
Mandalay Generating Station	253	234	30,347	1,308	8,979	199
Morro Bay Power Plant	668	257	nc	nc	78,139	2,957
Moss Landing Power Plant Units 1&2	361	193	75,133	804	57,554	600
Moss Landing Power Plant Units 6&7	865	387	135,699	2,297	118,778	2,033
Ormond Beach Generating Station	685	521	7,821	844	517	76
Pittsburg Power Plant Units 5&6	462	274	nc	nc	220,364	2,580
Potrero Power Plant	231	193	146,098	3,035	108,727	2,446
Redondo Generating Station Units 5&6	217	51	263	71	133	60
Redondo Generating Station Units 7&8	675	254	2,910	1,315	1,101	388
San Onofre Nuclear Generating Station Unit 2	1,219	1,139	nc	nc	1,353,158	28,746
San Onofre Nuclear Generating Station Unit 3	1,219	1,154				
Scattergood Generating Station	495	309	108,843	11,619	95,241	9,422
South Bay Power Plant	601	417	385,588	1,226	nc	nc
Totals	**15,245**	**10,191**				

nc = not calculated

CA Power Plant CWS Estimates

Table 3. Information on cooling water intake system design at California power plants. Acronyms used for the various intake components and fish protection systems and provided below the table.

Region	Plant	Intake Location	Type of Intake	Screening or Fish Protection Devices*	Size of openings at Entrance to Intake	Vertical Distance from Riser to VC	Mammal Exclusion Bars Offshore?
NoCal	Contra Costa Power Plant	tidal river	shoreline	BR-TS-VFD	Bar racks 3.5" spacing	n/a	n/a
NoCal	Pittsburg Power Plant	tidal river	shoreline	BR-TS-VFD	Bar racks 3.5" spacing	n/a	n/a
NoCal	Potrero Power Plant	bay/harbor	shoreline	BR-TS	Bar racks 3.5" spacing	n/a	n/a
NoCal	Moss Landing Power Plant Units 1&2	bay/harbor	shoreline	BR-TS	Bar racks 3.5" spacing	n/a	n/a
NoCal	Moss Landing Power Plant Units 6&7	bay/harbor	shoreline	BR-TS	Bar racks 3" spacing	n/a	n/a
NoCal	Morro Bay Power Plant	bay/harbor	shoreline	BR-TS	bar racks 4" on center	n/a	n/a
NoCal	Diablo Canyon Power Plant	ocean	shoreline	BR-TS	bar racks 3" on center	n/a	n/a
SoCal	Mandalay Generating Station	bay/harbor	canal	BR-SS	bar racks 2.5" spacing	n/a	n/a
SoCal	Ormond Beach Generating Station	ocean	offshore	VCap-BR-TS	4' at VCap with bars every 18"	4'	18" spacing
SoCal	Scattergood Generating Station	ocean	offshore	VCap-BR-TS	5' at VCap with bars every 9"	5'	9" spacing
SoCal	El Segundo Generating Station Units 1&2	ocean	offshore	VCap-BR-TS	2' at VCap	2'	?
SoCal	El Segundo Generating Station Units 3&4	ocean	offshore	VCap-BR-TS	3' at VCap	3'	?
SoCal	Redondo Generating Station Units 5&6	bay/harbor	offshore	VCap-BR-TS	4' at VCap with bars every 18"	4'	18" spacing
SoCal	Redondo Generating Station Units 7&8	bay/harbor	offshore	VCap-BR-TS	4' at VCap with bars every 18"	4'	18" spacing
SoCal	Harbor Generating Station	bay/harbor	shoreline	BR-TS	bar racks 4.5" on center	n/a	n/a
SoCal	Haynes Generating Station	tidal river	canal	BR-TS/SS	bar racks 6" on center	n/a	n/a
SoCal	Alamitos Generating Station Units 1&2	bay/harbor	shoreline	BR-TS	bar racks 3" spacing	n/a	n/a
SoCal	Alamitos Generating Station Units 3&4	bay/harbor	shoreline	TS	no bar racks	n/a	n/a
SoCal	Alamitos Generating Station Units 5&6	bay/harbor	shoreline	BR-TS	bar racks 3" spacing	n/a	n/a
SoCal	Huntington Beach Generating Station	ocean	offshore	VCap-BR-TS	5' at VCap with bars every 18"	5'	18" spacing
SoCal	San Onofre Nuclear Generating Station Unit 2	ocean	offshore	VCap-Vanes-Fish Elevator-BR-TS	7' at VCap	7'	No
SoCal	San Onofre Nuclear Generating Station Unit 3	ocean	offshore	VCap-Vanes-Fish Elevator-BR-TS	7' at VCap	7'	No
SoCal	Encina Power Plant	bay/harbor	shoreline	BR-TS	bar racks 3.5" on center	n/a	n/a
SoCal	South Bay Power Plant	bay/harbor	shoreline	BR-TS	bar racks 3" spacing	n/a	n/a

* - VCap = velocity cap, BR = bar racks, TS = traveling screens, SS = Slide screens, Vanes = structures inside intake to divert fishes, VFD = variable frequency drive pumps

CA Power Plant CWS Estimates

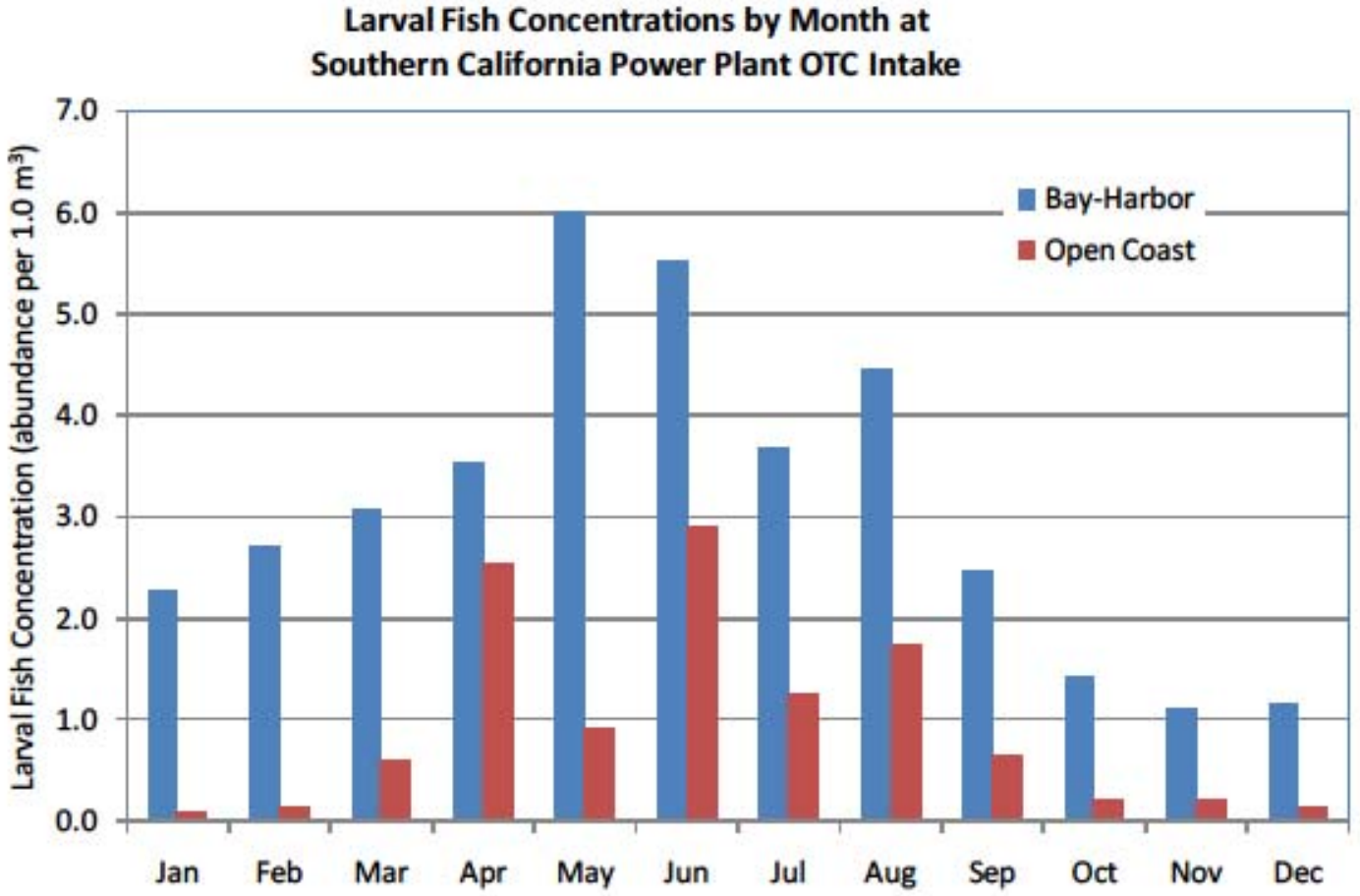

Figure 1. Total concentration of larval fishes by month at OTC intakes in southern California. Data sources based on most recent 316(b) sampling conducted at each power facility. Plants combined for bay-harbor concentrations were South Bay, Encina, Haynes, Alamitos, and Harbor, and the plants combined for the open coast concentrations were San Onofre, Huntington Beach, Redondo Beach, El Segundo, and Scattergood.

CA Power Plant CWS Estimates

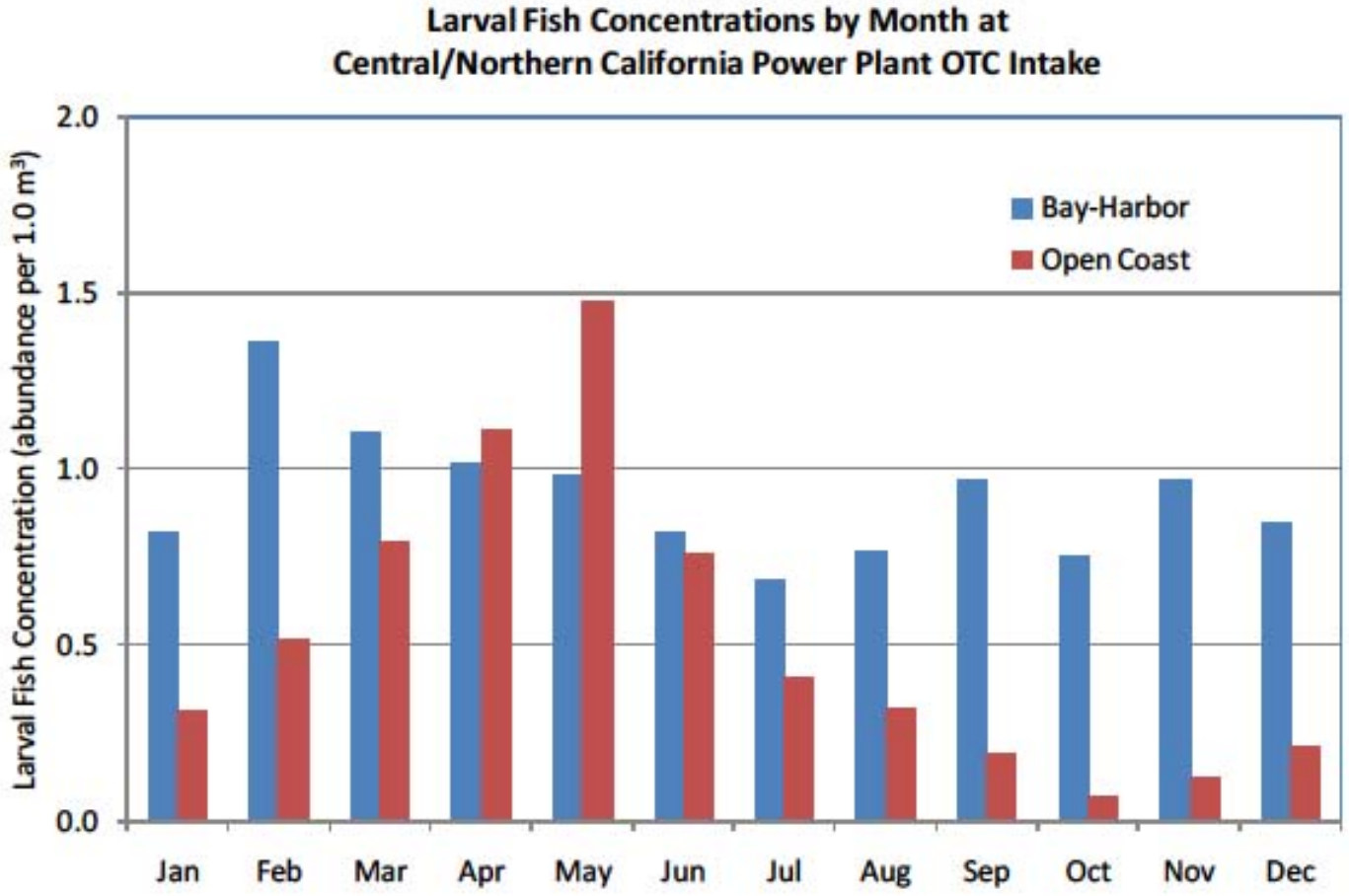

Figure 2. Total concentration of larval fishes by month at OTC intakes in central California. Data sources based on most recent 316(b) sampling conducted at each power facility. Plants combined for bay-harbor concentrations were Morro Bay, Moss Landing, and Potrero, and the plants used for the open coast concentrations was Diablo Canyon.

Appendix A. Sources for cooling water data used in calculations of entrainment and impingement estimates.

Plant	Design Flow (mgd)	Average Flow (mgd) based on 2000-2005	Data Sources
Alamitos Generating Station Units 1&2	207	121	data from SWRCB staff - 2000-05 actual monthly flows
Alamitos Generating Station Units 3&4	392	281	data from SWRCB staff - 2000-05 actual monthly flows
Alamitos Generating Station Units 5&6	674	413	data from SWRCB staff - 2000-05 actual monthly flows
Contra Costa Power Plant Units 6&7	440	257	data from plant staff - daily flows for 2000-2005
Diablo Canyon Power Plant	2,528	2,287	flows from plant source complete for 2000-05
El Segundo Generating Station Units 1&2	207	69	data from SWRCB staff - daily flows for 2000-2005
El Segundo Generating Station Units 3&4	399	265	data from SWRCB staff - daily flows for 2000-2005
Encina Power Plant	857	621	flows from plant source complete for 2000-05
Harbor Generating Station	108	59	data from SWRCB staff - 2000-01 actual monthly flows, 2002-05 daily flows
Haynes Generating Station	968	258	data from SWRCB staff - 2000-01 actual monthly flows, 2002-05 daily flows, 2005 missing for Units 3&4
Huntington Beach Generating Station	514	179	data from SWRCB staff - 2004-05 actual monthly flows, 2000-03 calculated from megawatt output
Mandalay Generating Station	253	234	data from SWRCB staff - 2000-05 actual monthly flows
Morro Bay Power Plant	668	257	flows from plant source complete for 2000-05
Moss Landing Power Plant Units 1&2	361	193	flows from plant source complete for 2000-05
Moss Landing Power Plant Units 6&7	865	387	flows from plant source complete for 2000-05
Ormond Beach Generating Station	685	521	data from SWRCB staff - 2000-05 actual monthly flows
Pittsburg Power Plant Units 5&6	462	274	data from plant staff - 2000-05 daily flows
Potrero Power Plant	231	193	data from SWRCB staff - 2000-05 actual monthly flows - also plant data provided same average
Redondo Generating Station Units 5&6	217	51	data from SWRCB staff - daily flows for 10/1/01-9/30/02 and 1/1/03-12/31/05
Redondo Generating Station Units 7&8	675	254	data from SWRCB staff - daily flows for 10/1/01-9/30/02 and 1/1/03-12/31/05
San Onofre Nuclear Generating Station Unit 2	1,219	1,139	data from SWRCB staff - 2004-05 actual monthly flows, 2000 and 2003 calculated from megawatt output
San Onofre Nuclear Generating Station Unit 3	1,219	1,154	data from SWRCB staff - 2004-05 actual monthly flows, 2000 and 2003 calculated from megawatt output
Scattergood Generating Station	495	309	data from SWRCB staff - 2000 -2005 actual monthly flows
South Bay Power Plant	601	417	flows from plant source complete for 2000-05

Appendix B. References and information on studies used in compiling the data presented in Tables 1 and 2.

Plant	Entrainment collection period & frequency / Reference	Impingemement collection period & frequency / Reference
Alamitos Generating Station Units 1&2	Jan-Dec 2006, bi-weekly / MBC and Tenera 2008a	Jan 2006 - Dec 2006; weekly / MBC and Tenera 2008a
Alamitos Generating Station Units 3&4	Jan-Dec 2006, bi-weekly / MBC and Tenera 2008a	Jan 2006 - Dec 2006; weekly / MBC and Tenera 2008a
Alamitos Generating Station Units 5&6	Jan-Dec 2006, bi-weekly / MBC and Tenera 2008a	Jan 2006 - Dec 2006; weekly / MBC and Tenera 2008a
Contra Costa Power Plant	Apr 1978 - Apr 1979, weekly / Ecological Analysts 1981a	Apr 1978 - Apr 1979; weekly sampling / Ecological Analysts 1981a
Diablo Canyon Power Plant	Oct 1996 - Jun 1999, weekly / estimates from Oct 96-Oct 98 Tenera 2000a	Feb 1985 - Mar 1986; weekly sampling / Tenera 1988
El Segundo Generating Station Units 1&2	Jan-Dec 2006, monthly / Tenera and MBC 2008	Jan 2006 - Dec 2006; monthly / Tenera and MBC 2008
El Segundo Generating Station Units 3&4	Jan-Dec 2006, monthly / Tenera and MBC 2008	Jan 2006 - Dec 2006; monthly / Tenera and MBC 2008
Encina Power Plant	Jun 2004 - May 2005, monthly / Tenera 2008	Jun 2004 - Jun 2005; weekly / Tenera 2008
Harbor Generating Station	Jan-Dec 2006, bi-weekly / MBC, Tenera, and URS 2008b	Jan 2006 - Dec 2006; weekly / MBC, Tenera, and URS 2008b
Haynes Generating Station	Jan-Dec 2006, bi-weekly / MBC, Tenera, and URS 2008a	Jan 2006 - Dec 2006; weekly / MBC, Tenera, and URS 2008a
Huntington Beach Generating Station	Sep 2003 - Aug 2004, weekly / MBC and Tenera 2005	Jul 2003 - Jul 2004; weekly / MBC and Tenera 2005
Mandalay Generating Station	Feb 2006 - Feb 2007; biweekly / ENSR Corp. 2008a	Feb 2006 - Feb 2007; biweekly / rates and totals from ENSR Corp. 2008a; average rates and HT data from NPDES data supplied by MBC
Morro Bay Power Plant	Jan 2000 - Dec 2000, weekly / Tenera 2001	Sep 1999 - Sep 2000; weekly / Tenera 2001
Moss Landing Power Plant Units 1&2	Mar 1999 - Feb 2000, weekly / Tenera 2000b	Nov 2005 - Nov 2006; weekly / Tenera 2007b
Moss Landing Power Plant Units 6&7	Mar 1999 - Feb 2000, weekly / Tenera 2000b	Nov 2005 - Nov 2006; weekly / Tenera 2007b
Ormond Beach Generating Station	Feb 2006 - Feb 2007; biweekly / ENSR Corp. 2008b	Feb 2006 - Feb 2007; biweekly / rates and totals from ENSR Corp. 2008b; average rates and HT data from NPDES data supplied by MBC
Pittsburg Power Plant Units 5&6	Mar 1978 - Mar 1979, weekly; Ecological Analysts 1981b	Mar 1978 - Mar 1979; weekly sampling / Ecological Analysts 1981b
Potrero Power Plant	Jan 2001 - Feb 2002, weekly (Dec-Mar) or monthly Apr-Nov) / Tenera 2007a	May 2006 - May 2007; weekly / Tenera 2007a
Redondo Generating Station Units 5&6	Jan 2006 - Jan 2007, monthly / MBC and Tenera 2008b	Jan 2006 - Jan 2007; weekly / MBC and Tenera 2008b
Redondo Generating Station Units 7&8	Jan 2006 - Jan 2007, bi-weekly / MBC and Tenera 2008b	Jan 2006 - Jan 2007; weekly / MBC and Tenera 2008b
San Onofre Nuclear Generating Station Un	Mar 2006 - Apr 2007; biweekly inside plant, monthly at offshore intakes /	Mar 2006 - May 2007; biweekly / MBC 2008
San Onofre Nuclear Generating Station Un	Mar 2006 - Apr 2007; biweekly inside plant, monthly at offshore intakes / MBC	Mar 2006 - May 2007; biweekly / MBC 2008
Scattergood Generating Station	Jan 2006 - Jan 2007, bi-weekly / MBC, Tenera, and URS 2008c	Jan 2006 - Jan 2007; weekly / MBC, Tenera, and URS 2008c
South Bay Power Plant	Feb 2001 - Jan 2002, monthly / Tenera 2004	Dec 2002 - Nov 2003; weekly / Tenera 2004