Appendix F- Summary Tables of Salinity and Brine Studies

Associated with the Draft Staff Report Including the Draft Substitute Environmental Documentation for the Proposed Desalination Amendment

Table F-1. No observed effect (NOEC), lowest observed effect LOEC, and median effect concentration (EC50) or 25 percent effect concentration (EC25, denoted by the *) for range-finder and definitive tests. Mean EC is the average of the two definitive test results. All results are based on measured salinities in ppt. Modified From Hyper-Salinity Toxicity Thresholds for Nine California Ocean Plan Toxicity Test-Final Report. (Phillips et al. 2012)

Organism	Endpoint	Test	NOEC	LOEC	EC 50	Mean EC
Red Abalone	Development	Range Finder	34	>34	37.8	36.8
		Definitive 1	34.9	35.6	36.4	
		Definitive 2	34.9	35.6	37.1	
Purple Urchin	Development	Range Finder	34	40	36.9	38.1
		Definitive 1	35.5	36.8	37.9	
		Definitive 2	37.4	38.6	38.4	
Sand Dollar	Development	Range Finder	<43	43	37.8	39.6
		Definitive 1	37.7	38.6	39.5	
		Definitive 2	38.1	38.7	39.7	
Sand Dollar	Fertilization	Range Finder	<43	43	39.0	40.3
		Definitive 1	37.6	39.5	41.2	
		Definitive 2	37.6	39.5	39.5	
Mussel	Development	Range Finder	41	42	42.3	43.3
		Definitive 1	<40.2	40.2	42.2	
		Definitive 2	42.2	43.9	44.3	
Purple Urchin	Fertilization	Range Finder	40	47	43.3	44.2
		Definitive 1	41.1	43	44.4	
		Definitive 2	41.6	41.9	44	
Mysid Shrimp	Survival	Range Finder	43	49	50.1	47.8
		Definitive 1	44.9	50.2	48	
		Definitive 2	45.8	49.2	47.7	
	Growth	Range Finder	49	>49	>49*	>49.7*
		Definitive 1	50.2	>50.2	>50.2*	
		Definitive 2	49.2	>49.2	>49.2*	
Giant Kelp	Germination	Range Finder	49	57	59.1	55.5
		Definitive 1	49	54	55.8	
		Definitive 2	44	49	55.2	
	Growth	Range Finder	49	57	52.7*	47.3*
		Definitive 1	<45	45	48.3*	
		Definitive 2	<44	44	46.3*	

Organism	Endpoint	Test	NOEC	LOEC	EC 50	Mean EC
Topsmelt	Survival	Range Finder	56	63	60.2	61.9
		Definitive 1	55	60	60.4	
		Definitive 2	60	65	63.4	
	Biomass	Range Finder	56	63	57.3*	59.3*
		Definitive 1	55	60	57.3*	
		Definitive 2	60	65	61.2*	

Table F-2. No observed effect (NOEC), lowest observed effect (LOEC), and median effect concentration (EC50) or 25 percent effect concentration (EC25) for Monterey Bay Aquarium seawater RO brine effluent tests.

Protocol	Endpoint	NOEC	LOEC	EC50
Mussel	Development	38.8	42.7	43.3
Giant Kelp	Germination	53.0	>53.0	>53.0
	Growth	53.0	>53.0	51.8
Topsmelt	Survival	50.8	>50.8	>50.8
	Biomass	50.8	>50.8	>50.8

Table F-3. Biological impacts of concentrated discharges. Modified from Roberts et al. 2010.

Species	Study Type	Conditions/ Location	Observed Biological Effects	Reference
Seagrass				
Posidonia oceanica	Lab exposure	15-d exposure to 38-43 ppt	Decreased growth after exposure to salinities > 40 ppt; 50% mortality at 45 ppt	Latorre 2005
Posidonia oceanica	Lab exposure	15-d exposure to 23-57 psu	Reduction of vitality and mortality at salinities > 39.1, at 45 psu 50% of plants died	Sánchez-Lisazo et al. 2008
Cympodocea nodosa	Field study	Barranco del Toro Beach, Canary Islands	Decreased presence near outfall discharges. Farther away from the outfall discharge the seagrass improved condition	Perez and Ruiz 2001
Caulerpa prolifera	Field study	Barranco del Toro Beach, Canary Islands	Decreased presence near outfall discharges. Farther away from the outfall discharge the seagrass condition improved	Perez and Ruiz 2001
Posidonia oceanica	Field study	Formentera, Spain	Increased leaf necrosis and decreased carbohydrate storage near discharge site, relative to control locations	Gacia et al. 2007
Posidonia oceanica	Field study	Key West, Florida	Seagrass photosynthesis inhibited after exposure to 12% brines for 24 hours	Chesher 1971
Posidonia oceanica	Field study	Shark Bay, WA	Increased mortality and senescence at salinities of 50-65 ppt	Walker and McComb 1990

Species	Study Type	Conditions/ Location	Observed Biological Effects	Reference
Posidonia oceanica	Field study	Alicante, Spain	Exposed to brines in the field for 3 months. Exposures raised salinity to 38.4-39.2 ppt in experimental plots and caused mortality, surviving plants had reduced shoot and leaf abundance	Sánchez-Lizaso et al. 2008
Posidonia oceanica	Field study	Balearic Islands, Spain	Reduced growth and presence of necrotic tissue in seagrass from transects impacted by brine, but there was no extensive meadow decline	Gacia et al. 2007
Plankton				
	Field study	Key West, Florida	Reduced abundance in water surrounding brine discharge area. Majority of effects attributed copper levels in brine	Chesher 1971
Ascidians				
	Lab exposure	Key West, Florida	Relatively more sensitive than other invertebrates exposed in the study, 50% mortality after exposure to 5.8% effluent	Chesher 1971
	Field study	Key West, Florida	Reduced abundances in areas surrounding brine discharges. Majority of effects attributed to copper levels in brine	Chesher 1971
Mysids				
Leptomysis posidoniae	Lab exposure	15 d exposure to 23-57 psu	Mortality observed at salinities > 40 psu and it was temperature dependent	Sánchez-Lisazo et al. 2008
Echinoderms				
Paracentrotus lividus	Lab exposure	15 d exposure to 23-57 psu	Mortality observed at salinities > 40 psu and it was temperature dependent	Sánchez-Lisazo et al. 2008
	Field study	Alicante, Spain	Disappeared from meadow in front of desalination plant, lower vitality observed in seagrass in the same area	Fernandez-Torquemeda et al. 2005
	Field study	Key West, Florida	Reduced abundances in areas surrounding the effluent discharge area. Majority of effects attributed to copper levels in brine	Chesher 1971
	Lab exposure	Key West, Florida	Reduced survival after exposure to 8.5% dilutions	Chesher 1971
	Field study	Key West, Florida	Died within 2-3 days of exposure, survival improved when copper emissions were reduced following plant maintenance	Chesher 1971
Paracentrotus lividus	Field study	Balearic Islands, Spain	Sea urchins and sea cucumbers absent from transects impacted by brine	Gacia et al. 2007
Mollusks				

Species	Study Type	Conditions/ Location	Observed Biological Effects	Reference
Sepia apama (squid embryos)	Lab exposure	99-d exposure to 39-55 ppt	Total mortality observed after exposure to 50 ppt. Egg hatching decreased at 45 ppt. Reduced growth after exposure to 45 ppt	Dupavillon and Gillanders 2009
Crassostrea virginica (juveniles and adults)	Lab exposure	60-d exposure to 45-55 psu	Brines contained high Cu concentrations. Effects in juveniles and adults observed at Cu levels between 19 -43 ug/L. Effects included, reduced reproduction and increased fungal infections.	Mandelli 1975
Tapes philippinarum (clams)	Lab exposure	0.5-72 h exposure to 31-100 ppt	Mortality found at 60 ppt after 48 hours, sluggish behavior bserved after 24 hours at 60 and 70 ppt.	Iso et al. 1994
Fish				
Pagrus major (juveniles)	Lab exposure	0.5-72 h exposure to 31-100 ppt	Mortality observed at 50 ppt after 24hours, body coloration changed at this salinity after 0.5 hour of exposure.	Iso et al. 1994
Pleuronectes yokohumae (eggs/ larvae)	Lab exposure	0.5-144 h exposure to 31-100 ppt	Larvae mortality at 55 ppt after 140 hours of exposure; egg hatchability was delayed at concentrations > 50 ppt after 73 hours.	Iso et al. 1994
Benthic	**Communities**			
	Field study	Alicante, Spain	Communities close to outfall discharges were dominated by nematodes (up to 98%); polychaetes, mollusks and crustaceans more abundant with increasing distance from discharge	Del Pilar Ruso et al. 2007
	Field study	Alicante, Spain	Reduced polychaete abundance and diversity adjacent to outfall. Ampharetidae and Paraonidae were the most and least sensitive families (respectively)	Del Pilar Ruso et al. 2008
	Field study	Antarctica	A study of diatom communities found reduced richness and abundance in areas receiving brine, even though salinity measurements were not different at outfall and reference locations D46	Crockett 1997
	Field study	Grand Canaria, Canary Islands	A study of meiofauna communities found lower abundance of copepods and nematodes near outfall discharge, abundances increased away from the discharge point. A shift in particle size also contributed to the changes in abundance	Riera et al. 2011

Species	Study Type	Conditions/ Location	Observed Biological Effects	Reference
	Field study	Tampa, Florida	No changes in the abundance of the benthic community including sea grasses, algae, hard and soft corals, and other invertebrates despite salinity increases of up 40 times higher than baseline data	Blake et al. 1996
	Field study	Hurghada, Egypt	Many fish species declined and even disappeared, as well as many planktonic organisms and corals, near the area around the plant	Mabrook 1994
	Field study	Blanes, Spain	No significant impact found by discharges after visual census. Lack of effects attributed to high natural variability and to rapid dilution	Raventos et al. 2006