Santa Barbara County
Air Pollution Control District
Our Vision: Clean Air

To: Paul Milkey, California Air Resources Board

From: Joe Petrini, Santa Barbara County Air Pollution Control District

Regarding: Marine Vessel Growth Projections for Santa Barbara County

At the last meeting of the Marine Vessel Working Group on July 26, there was some question on the source of Santa Barbara County's marine vessel growth data. To aid in understanding the growth projections, Santa Barbara County Air Pollution Control District has put together a package that provides the source of the growth data and how the data were used to make marine vessel growth projections.

Growth data were obtained from the report, *Marine Vessels Emissions Inventory – Update to 1996 Report: Marine Vessel Emissions Inventory Control Strategies* prepared by ARCADIS, September 1999 for the South Coast Air Quality Management District. The growth values were then applied to 1999 base year vessel transit data for ships that traversed the Santa Barbara County coastline that year. Transit data were obtained from the Marine Exchange of Los Angeles - Long Beach Harbor, Inc.. The attached Microsoft Excel spreadsheet details how the growth data were applied to the transit data. Documentation directly out of the ARCADIS report, including the forecasting methodology, future year NOx emission factors, South Coast AQMD NOx emission projections, and growth rate tables and references used by ARCADIS is also included as a Microsoft Word file.

While this memo and the attachments focus on Santa Barbara's marine vessel growth data, our baseline (1999) emission inventory is also based on emission factors and other vessel characteristics presented in the ARCADIS report. ARCADIS data were used in conjunction with Marine Exchange transit data to determine emissions from vessels traversing the Santa Barbara County coastline.

If you have any questions regarding Santa Barbara County APCD's marine vessel growth data or emission inventory, please contact me at (805) 961-8894, or e-mail me at jep@sbcapcd.org.

Santa Barbara County Marine Vessel Growth Data
Growth Values From ARCADIS Report: Marine Vessel Emissions Inventory and Control Strategies
Prepared for South Coast AQMD, September 23, 1999

Number of Transits by Ship Type

Growth Data from1999 ARCADIS Report		Growth Factor	Base Year 1999	Projected Years (2000 to 2015) 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Auto	3.3% compounded annual growth rate	1.03300	581	600	620	640	662	683	706	729	753	778	804	830	858	886	915	946	977
Bulk	0.65% compounded annual growth rate	1.00650	1,033	1,040	1,046	1,053	1,060	1,067	1,074	1,081	1,088	1,095	1,102	1,109	1,117	1,124	1,131	1,138	1,146
Container	(see Container Growth Interpolation notes below)	1.00000	3,866	3,907	4,073	4,238	4,403	4,568	4,733	4,899	5,064	5,229	5,394	5,559	5,881	6,202	6,524	6,845	7,166
Gen Cargo	4.5% compounded annual growth rate	1.04500	289	302	316	330	345	360	376	393	411	429	449	469	490	512	535	559	584
Passenger	no growth	1.00000	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
Reefer	5% compounded annual growth rate	1.05000	212	223	234	245	258	271	284	298	313	329	345	363	381	400	420	441	463
RORO	3.3% compounded annual growth rate	1.03300	127	131	136	140	145	149	154	159	165	170	176	182	188	194	200	207	214
Tanker	0.09% compounded annual growth rate	1.00090	339	339	340	340	340	341	341	341	341	342	342	342	343	343	343	344	344
	Sum		6,479	6,574	6,796	7,019	7,244	7,471	7,701	7,933	8,167	8,404	8,644	8,887	9,288	9,693	10,100	10,511	10,926

Base Year Vessel Transit Data from Marine Exchange at Port of LA/LB

Container Growth Interpolation - Based on ARCADIS Fleet Data Projections

	Number of calls	%increase	factor
1997	2,345		
1998	2,371	1.094527	1.01094527
1999	2,396	1.082677	1.01082677
2000	2,422	1.071081	1.01071081
2001	2,524	4.227911	1.04227911
2002	2,627	4.056409	1.04056409
2003	2,729	3.898279	1.03898279
2004	2,832	3.752015	1.03752015
2005	2,934	3.61633	1.0361633
2006	3,036	3.490116	1.03490116
2007	3,139	3.372415	1.03372415
2008	3,241	3.262393	1.03262393
2009	3,344	3.159324	1.03159324
2010	3,446	3.062567	1.03062567
2011	3,645	5.780615	1.05780615
2012	3,844	5.464721	1.05464721
2013	4,044	5.181563	1.05181563
2014	4,243	4.926303	1.04926303
2015	4,442	4.695013	1.04695013
2016	4,641	4.484466	1.04484466
2017	4,840	4.291993	1.04291993
2018	5,040	4.115362	1.04115362
2019	5,239	3.952695	1.03952695
2020	5,438	3.802397	1.03802397

Transit Data in blue from 1999 ARCADIS report - linear interpolation between data points used to develop growth for container ships.
ARCADIS container ship growth projections take into account trend toward larger and faster container ships.

Growth Factors

2005/1999	1.189	**==> 18.9% growth from 1999 to 2005**
2010/1999	1.372	**==> 37.2% growth from 1999 to 2010**
2015/1999	1.686	**==> 68.6% growth from 1999 to 2015**

Growth Factors developed by ratioing projected transit data in future years(2005, 2010, 2015) to base year (1999)

sbapcd_growth.xls

2.9 FORECASTING METHODOLOGY AND RESULTS FOR 2000, 2010, AND 2020

2.9.1 Overview

Forecasting the emissions inventory for oceangoing vessels required making several assumptions. Most significantly, we assume an increase in annual ship calls on the San Pedro Bay Ports over time. For container vessels, an increase in the average design value (i.e., size and speed) of the vessels calling is assumed, as well. These assumptions are based on a recent cargo forecast model developed for the San Pedro Bay Ports (Mercer Management and Standard & Poor's DRI, 1998). We also assume that average ship emission levels will be impacted by the IMO emission limits beginning after January 1, 2000. The resultant changes in NOx, emission factors, taken from a recent study for the EPA (ARCADIS Geraghty & Miller, 1999), are incorporated into the emissions forecast models.

In the absence of better information, ship routes, the distribution of calls by route, and ship speeds are assumed to be the same in future years as in the baseline year of 1997. The one exception is that container vessel average speeds are modeled to increase over future years consistent with the assumed increase in design value. That is, the 2000, 2010, and 2020 year models distribute container calls increasingly into the higher design categories, which are associated with higher average speeds. The forecast models also use the same average ship rated power per design category as is used in the baseline model. This is a reasonable assumption provided hull designs are not radically changed in the future.

Source: ARCADIS Report

REFERENCES

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ARCADIS Geraghty & Miller, "Analysis of Marine Emissions in the South Coast Air Basin," Final Report FR-99-100, prepared for U.S. Environmental Protection Agency, Region IX, May 6, 1999

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Source: ARCADIS Report

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TRC Environmental Consultants, Mission Viejo, California, "Ship Emissions Control Study for the Ports of Long Beach and Los Angeles," Volumes I and II, December, 1989.

U.S. Environmental Protection Agency, "Draft Regulatory Impact Analysis: Control of Emissions from Compression-Ignited marine Engines," EPA420-R-98-017, November 1998.

Source: ARCADIS Report

Table 2-11. NOx. emissions factors for future years

Shiptype	Propulsion Type	Design Categories	2000 Cruise Emission NOx (g/kWh)	2000 P-Area Emission NOx (g/kWh)	2000 Maneuvering P-Area Emission (g/kWh)	2010 Cruise Emission NOx (g/kWh)	2010 P-Area Emission NOx (g/kWh)	2010 Maneuvering P-Area Emission NOx (g1kWh)	2020 Cruise Emission NOx (g/kWh)	2020 P-Area Emission NOx (g/kWh)	2020 Maneuvering P-Area EmissionNOx (g/kWh)
Auto Carrier											
	Motorships	0-200	16.02	16.02	22.93	16.02	16.02	22.18	16.02	16.02	21.56
		200-400	16.02	19.78	22.93	16.02	19.78	22.18	16.02	19.78	21.56
		400-600	16.02	19.78	22.93	16.02	19.78	22.18	16.02	19.78	21.56
		600-800	16.02	27.84	22.93	16.02	27.84	22.18	16.02	27.84	21.56
		1000-1200	16.02	19.78	22.93	16.02	19.78	22.18	16.02	19.78	21.56
Bulk Carrier											
	Motorships	0-200	17.05	17.20	20.74	17.05	17.20	19.93	17.05	17.20	19.27
		200-400	17.05	17.20	20.74	17.05	17.20	19.93	17.05	17.20	19.27
		400-600	17.05	17.69	20.74	17.05	17.69	19.93	17.05	17.69	19.27
		600-800	17.05	17.69	20.74	17.05	17.69	19.93	17.05	17.69	19.27
		800-1000	17.05	17.69	20.74	17.05	17.69	19.93	17.05	17.69	19.27
		1000-1200	17.05	20.74	20.74	17.05	2034	19.93	17.05	20.74	19.27
		1200-1400	17.05	18.07	20.74	17.05	18.07	.1993	17.05	18.07	19.27
	Steamships	600-800	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
		1000-1200	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
Container Ship											
	Motorships	600-800	17.09	.2078	28.74	17.09	20.78	27.93	17.09	20.78	27.27
		800-1000	17.09	23.82	28.74	17.09	23.82	27.93	17.09	23.82	27.27
		1000-1200	17.09	23.82	28.74	17.09	23.82	27.93	17.09	23.82	27.27
		1200-1400	17.09	23.82	28.74	17.09	23.82	27.93	17.09	23.82	27.27
		1400-1600	17.09	28.74	28.74	17.09	28.74	27.93	17.09	28.74	27.27
		1600-1800	17.09	28.74	28.74	17.09	28.74	27.93	17.09	28.74	27.27
		1800-2000	17.09	28.74	28.74	17.09	28.74	27.93	17.09	28.74	27.27
		2000-2200	17.09	28.74	28.74	17.09	28.74	27.93	17.09	28.74	27.27
		2200-2400	17.09	28.74	28.74	17.09	28.74	27.93	17.09	28.74	27.27
		2400-2600	17.09	28.74	28.74	17.09	28.74	27.93	17.09	28.74	27.27
		2600-2800	17.09	28.74	28.74	17.09	28.74	27.93	17.09	28.74	27.27
		2800-3000	17.09	28.74	28.74	17.09	28.74	27.93	17.09	28.74	27.27
		3000-3200	17.09	28.74	28.74	17.09	28.74	27.93	17.09	28.74	27.27
	Steamships	600-800	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
		800-1000	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
		1000-1200	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
		1200-1400	2.61	2.61	2.61	2.61	2.61	2.61	2,61	2.61	2.61
		1600-1800	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
		2000-2200	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
General Cargo											
	Motorships	0-200	16.32	16.32	20.06	16.32	16.32	19.29	16.32	16.32	18.66
		200-400	16.32	17.38	20.06	16.32	17.38	19.29	16.32	17.38	18.66
		400-600	16.32	20.06	20.06	16.32	20.06	19.29	16.32	20.06	18.66
		600-800	16.32	2006	.2006	16.32	2006	19.29	16.32	20.06	18.66
		2000-2200	16.32	28.09	20.06	16.32	28.09	19.29	16.32	28.09	18.66

Source: ARCADIS Report

Table 2-11. NOx emissions factors for future years (concluded)

Propulsion Shiptype Type	Design Categories	2000 ` Cruise Emission NOx (g/kWh)	2000 ` P-Area Emission NOx (g/kWh)	2000 ` Maneuvering P-Area Emission NOx (g/kWh)	2010 Cruise Emission N0x (g/kWh)	2010 P-Area Emission NOx (g/kWh)	2010 Maneuvering P-Area Emission NOx (g/kWh)	2020 Cruise Emission NOx (g/kWh)	2020 P-Area Emission NOx (g/kWh)	2020 Maneuvering P-Area Emission NOx (g/kWh)
Passenger Ship										
Motorships	0-100	16.17	18.86	22.12	16.17	18.86	21.42	16.17	18.86	20.84
	100-200	16.17	18.86	22.12	16.17	18.86	21.42	16.17	18.86	20.84
	200-300	16.17	18.86	22.12	16.17	18.86	21.42	16.17	18.86	20.84
	300-400	16.17	22.12	22.12	16.17	22.12	21.42	16.17	22.12	20.84
	400-500	16.17	27.01	22.12	16.17	27.01	21.42	16.17	27.01	20.84
Steamships	300-400	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
	1400-1500	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
Reefer										
Motorships	100-200	16.49	17.55	23.32	16.49	17.55	22.54	16.49	17.55	21.91
	200-300	16.49	20.22	23.32	16.49	20.22	22.54	16.49	20.22	21.91
	300-400	16.49	20.22	23.32	16.49	20.22	22.54	16.49	20.22	21.91
	400-500	16.49	23.32	23.32	16.49	23.32	22.54	16.49	23.32	21.91
	500-600	16.49	23.32	23.32	16.49	23.32	22.54	16.49	23.32	21.91
•	600-700	16.49	28.24	23.32	16.49	28.24	22.54	16.49	28.24	21.91
	2200-2300	16.49	28.24	23.32	16.49	28.24	22.54	16.49	28.24	21.91
RORO										
Motorships	0-200	16.83	20.54	20.54	16.83	20,54	19.74	16.83	20.54	19.09
	200-400	16.83	20.54	20.54	16.83	20.54	19.74	16.83	20.54	19.09
	600-800	16.83	17.47	20.54	16.83	17.47	19.74	16.83	17.47	19.09
	800-1000	16.83	23.61	20.54	16.83	23.61	19.74	16.83	23.61	19.09
	1000-1200	16.83	23.61	20.54	16.83	23.61	19.74	16.83	23.61	19.09
Tanker										
Motorships	0-200	17.01	17.64	20.70	17.01	17.64	19.89	17.01	17.64	19.23
	200-400	17.01	17.64	20.70	17.01	17.64	19.89	17.01	17.64	19.23
	400-600	17.01	17.64	20.70	17.01	17.64	19.89	17.01	17.64	19.23
	600-800	17.01	17.64	20.70	17.01	17.64	19.89	17.01	17.64	19.23
	800-1000	17.01	17.64	20,70	17.01	17.64	19.89	17.01	17.64	19.23
	1000-1200	17.01	17.64	20.70	17.01	17.64	19.89	17.01	17.64	19.23
Steamships	600-800	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
	800-1000	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
	1000-1200	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
	1200-1400	2.61	2.61	2.61	2.61	2.61 -	2.61	2.61	2.61	2.61
	1600-1800	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61

Source: ARCADIS Report

Table 4-5. Emissions results for oceangoing vessels (SCAQMD)

Total Tons Per Day

	1996 Marine Inventory			**Updated Analysis**			
	1993	**2000**	**2010**	**1997**	**2000**	**2010**	**2020**
NOx	24	26.8	34.7	29.75	33.01	44.67	65.10
HC	2.2	2.5	3.4	3.17	3.45	4.36	6.06
CO	2.4	2.8	3.7	3.54	3.88	5.21	7.55
PM	2.3	2.3	2.7	2.66	2.85	3.51	4.88
SOx	18.5	19.6	23.4	21.72	23.83	31.53	46.13

		Percent	**Change**			**Percent**	**Change**
	1993 - 1997	1997- 2000	2000- 2010	2010- 2020		2000 - 2000	2010 2010
NOx	24	11	35	46		23	29
HC	44	9	27	39		38	28
CO	48	10	34	45		39	41
PM	16	7	23	39		24	30
SOx	17	10	32	46		22	35

Note: For comparison purposes, updated analysis years are listed in the tables in bold. For example, the percentage of change between the emissions estimated for 2000 (from the 1996 study) and the updated estimates for 2000 is shown is the column headed: 2000 - 2000.

Source: ARCADIS Report

ARCADIS Growth Projection Data

MARINE EMISSIONS INVENTORY

Ocean-going Vessels - Motorships and Steamships Calling on SPB Ports: Distribution of Calls (Forecasted Call Numbers for 2020 and % Distribution)

Data Sources: Marine Exchange data for 1997, Worksheet 98W1S1 (Compound Annual Growth Rates used are cited in Notes section at the end of this worksheet)

Shiptype	Motor/Steam	Design Categories	Corresponding DWT Categories	2020 # of Bunker Calls/Category	1997 % of Bunker Calls*	2020 # of Non Bunker Calls	1997 % of Non Bunker Calls*	2020 Annual Total Calls	
AUTO	Motorships	0-200	0 - 5,900	2	0.38%	2	0.38%	4	
		200-400	5,900 - 16,700	17	3.04%	386	69.58%	403	
3.3%		400-600	16,700 - 30,700	4	0.76%	135	24.33%	139	
Compound Annual		600-800	30,700 - 47,300	0	0.00%	2	0.36%	2	
Growth Rate[a]		1000-1200	66,100 - 86,900	0	0.00%	6	1.14%	6	
	Motorships Total			23		532		555	
AUTO Total				23		532		555	
BULK	Motorships	0-200	0 - 12,400	8	0.82%	19	1.87%	27	
		200-400	12,400 - 35,300	157	15.75%	311	31.27%	468	
0.65%		400-600	35,300 - 64,800	124	12.49%	223	22.40%	347	
Compound Annual		600-800	64,800 - 99,800	49	4.32%	78	7.58%	127	
Growth Rate[b]		800-1000	99,800 - 139,500	10	1.05%	3	0.35%	14	
		1000-1200	139,500 - 183,400	10	0.12%	1	0.12%	12	
		1200-1400	183,400 - 231,100	1	0.12%	0	0.00%	1	
	Motorships Total			360		635		995	
	Steamships	600-800	64,600 - 113,300	0	0.58%	0	0.23%	0	
		1000-1200	139,100 - 182,900	0	0.93%	0	0.00%	0	
	Steamships Total			0		0		0	check:
BULK Total				360		635		995	995

Shiptype	Motor/Steam	Design Categories	Corresponding DWT Categories	2020 # of Bunker Calls/Category	1997 % of Bunker Calls*	2020 # of Non Bunker Calls	1997 % of Non Bunker Calls*	2020 Annual Total Calls	% Distribution by TEU group
CONTAINER									
2.32 TEU-Adjusted Growth Factor[d]	Motorships	600-800	10,300 - 15,800	0	0.04%	476	15.91%	476	1%
		800-1000	15,800 - 22,100	0	0.00%	70	6.44%	70	1%
		1000-1200	22,100 - 29,100	0	0.00%	67	11.68%	67	1%
		1200-1400	29,100 - 38,700	0	0.00%	209	18.21%	209	2%
		1400-1600	38,700 - 44,800	0	0.00%	114	9.94%	114	2%
		1600-1800	44,800 - 53,500	0	0.00%	149	1.58%	149	2%
		1800-2000	53,500 - 62,700	0	0.00%	440	10.96%	440	9%
		2000-2200	62,700 - 72,300	0	0.00%	1666	2.77%	1666	34%
		2200-2400	72,300 - 82,400	0	0.00%	1661	2.35%	1661	34%
		2400-2600	82,400 - 93,000	0	0.00%	293	6.35%	293	6%
		2600-2800	93,000 - 103,900	0	0.00%	98	1.71%	98	2%
		2800-3000	103,900 - 115,200	0	0.00%	98	1.45%	98	2%
		3000-3200	115,200 - 126,900	0	0.00%	98	0.43%	98	2%
	Motorships Total			0		5438		4886	100%
	Steamships	600-800	13,200 - 20,300	0	0.04%	0	7.55%	0	
		800-1000	20,300 - 28,400	0	0.00%	0	0.09%	0	
		1000-1200	28,400 - 37,400	0	0.00%	0	0.04%	0	
		1200-1400	37,400 - 47,100	0	0.00%	0	1.75%	0	
		1600-1800	57,800 - 68,700	0	0.00%	0	0.64%	0	
		2000-2200	80,500 - 92,900	0	0.00%	0	0.09%	0	
	Steamships Total			0		0		0	checksum
CONTAINER Total				0		5438		5438	5440
GEN CARGO									
4.5% Compound Annual Growth Rate[e]	Motorships	0-200	0 - 6,900	11	1.67%	47	7.11%	58	
		200-400	6,900 - 19,500	39	5.86%	410	62.34%	449	
		400-600	19,500 - 35,800	0	0.00%	91	13.81%	91	
		600-800	35,800 - 55,200	8	1.26%	28	4.18%	36	
		2000-2200	218,200 - 251,800	0	0.00%	25	3.77%	25	
	Motorships Total			58		600		658	
GEN CARGO Total				58		600		658	
PASSENGER									
Assume Constant Growth Rate[e]	Motorships	0-100	0 - 1,300	0	0.00%	3	0.94%	3	
		100-200	1,300 - 3,800	0	0.00%	102	32.08%	102	
		200-300	3,800 - 7,100	0	0.00%	88	27.67%	88	
		300-400	7,100 - 11,000	0	0.00%	115	35.53%	115	
		400-500	11,000 - 15,300	0	0.00%	10	2.52%	10	
	Motorships Total			0		318		318	
	Steamships	300-400	2,600 - 4,000	0	0.00%	0	0.63%	0	
		1400-1500	26,800 - 29,700	0	0.00%	0	0.63%	0	
	Steamships Total			0		0		0	
PASSENGER Total				0		318		318	

Shiptype	Motor/Steam	Design Categories	Corresponding DWT Categories	2020 # of Bunker Calls/Category	1997 % of Bunker Calls*	2020 # of Non Bunker Calls	1997 % of Non Bunker Calls*	2020 Annual Total Calls
REEFER	Motorships	100-200	1,600 - 4,700	15	1.83%	68	8.06%	83
		200-300	4,700 - 8,600	15	1.83%	114	13.55%	129
5.0%		300-400	8,600 - 13,300	22	2.56%	301	35.90%	323
Compound Annual		400-500	13,300 - 18,600	12	1.47%	246	29.30%	258
Growth Rate[a]		500-600	18,600 - 24,400	0	0.00%	34	4.03%	34
		600-700	24,400 - 30,800	0	0.00%	6	0.73%	6
		2200-2300	171,700 - 183,500	0	0.00%	6	0.73%	6
	Motorships Total			65		774		839
REEFER Total				65		774		839
RORO	Motorships	0-200	0 - 6,600	4	3.03%	0	0.00%	4
		200-400	6,600 - 18,800	0	0.00%	4	3.03%	4
3.3%		600-800	34,700 - 53,400	6	4.55%	78	56.06%	84
Compound Annual		800-1000	53,400 - 74,600	0	0.00%	13	9.09%	13
Growth Rate[a]		1000-1200	74,600 - 98,100	0	0.00%	34	24.24%	34
	Motorships Total			11		129		139
RORO Total				11		129		139
TANKER	Motorships	0-200	0 - 13,400	0	0.00%	5	0.64%	5
		200-400	13,400 - 38,100	0	0.00%	13	1.67%	13
0.09%		400-600	38,100 - 69,900	0	0.00%	25	3.08%	25
Compound Annual		600-800	69,900 - 107,700	18	2.18%	597	58.54%	616
Growth Rate[b]		800-1000	107,700 - 150,600	5	0.64%	39	1.54%	44
		1000-1200	150,600 - 197,900	0	0.00%	92	2.05%	92
	Motorships Total			23		771		794
	Steamships	600-800	56,200 - 86,600	0	0.13%	0	16.56%	0
		800-1000	86,600 - 121,000	0	0.00%	0	3.34%	0
		1000-1200	121,000 - 159,100	0	0.00%	0	3.34%	0
		1200-1400[f]	159,100 - 238,000	0	0.13%	0	6.03%	0
		1600-1800[f]	245,000 - 292,300	0	0.00%	0	0.13%	0
	Steamships Total			0		0		0
TANKER Total				23		771		795
Total calls (all shiptypes)				540		9196		9736

checksum
794

Notes:

* % of bunker/non bunker calls represents the fraction of bunker or non bunker calls respectively for each shiptype, engine type (motorship/steamship), and design category, out of the total number of calls (both bunkering and non bunkering calls) for that shiptype.

Design categories are based on a theoretical relationship between average speeds by shiptype and ship size (dead weight tonnage is used in this study, as is consistent with the 1996 study), and rated power and fuel consumption (Design Category $=(\text{ship speed})^3 \times (\text{dwt})^{2/3} / 10^4$)

In this study, a "bunker" is defined as a call that came only to bunker and for no other purpose. Bunker calls are broken out from the other calls because they (bunkers) are typically associated with shorter in-port times).

Notes (continued):

The estimated decrease in steamship calls is based on a steamship age histogram of 1997 actual call data from the Marine Exchange. Thus the percent of 1997 steamship calls extant in each forecast year is shown in the table below:

Forecast Year	% SS Extant
2000	93%
2010	38%
2020	0%

The projected increase in steamship calls of a given design category (based on the growth factor/rate for that shiptype) is added, with the estimated number of steamships decreased due to age (as explained above), to the grown motorship calls number for the forecast year to equal total forecasted motorship calls for that design category.

[a] Compound Annual Growth Rates from U.S. Army Corps of Engineers, and are consistent with 1996 study

[b] Compound Annual Growth Rate (CAGR) is calculated as a weighted average of Break Bulk and Dry Bulk CAGRs for 1996-2000 from *San Pedro Bay Ports Long-Term Cargo Forecast* (table, page 3), (Mercer Management Consulting, Inc., October 1998). Tanker growth rates (for liquid bulk vessels) were taken from the same study and table.

[c] Marine Exchange data for actual passenger vessel calls at POLA/POLB reported 381 (1990), 421 (1993), and 318 (1997). As there was no clear growth trend in these numbers, and based upon conversations with officials at the ports which confirmed a lack of additional data or other reliable forcasting information, the number of calls for 1997 is assumed to be constant and 318 is thus used in the forecasts for 2000, 2010, and 2020.

[d] TEU-adjusted growth factors for 1997-2000, 1997-2010, and 1997-2020 are derived from CAGRs for TEUs (on page 7 of the report cited in Reference b), percent distribution of calls from *Deep Draft Navigation Improvements, Los Angeles and Long Beach Harbors, San Pedro Bay, California*, Appendix G, Exhibit IV-19 (U.S. Army Corps of Engineers, September 1992), and actual vessel statistics from *Post-Panamax Containerships - 6,000 Teu and Beyond*. Drewry Shipping Consultants, London. 1996.

[e] For container ships, the forecasted calls were grouped by TEU-equivalent categories, and for the purposes of this study are evenly distributed to the appropriate design categories within each TEU category. Bunker and non-bunker calls for container ships are then distributed within each design category based on actual 1997 call data from the Marine Exchange.

[f] The number of tanker steamships that are projected to deline, and for which there were no equivalent motorship design categories (1200-1400 and 1600-1800), were "grown" into the largest motorship design category (1000-1200), so as to have conservation of ship calls.