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An Environmental and Economic Analysis of Cruise Ship Discharges in California State Waters

A Group Project submitted in partial satisfaction of the requirement for the degree of
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AN ENVIRONMENTAL AND ECONOMIC ANALYSIS OF CRUISE SHIP DISCHARGES IN CALIFORNIA STATE WATERS

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The Group Project is required of all students in the Master's of Environmental Science and Management (MESM) Program. It is a three-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Final Group Project Report is authored by MESM students and has been reviewed and approved by:

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COMMON ABBREVIATIONS AND ACRONYMS

μg	Micrograms
ADEC	Alaska Department of Environmental Conservation
BREA	Business Research & Economic Advisors
cm	Centimeters
CPI	Consumer Price Index
CWA	Clean Water Act
EPA	United States Environmental Protection Agency
GAO	United States General Accounting Office
ICCL	International Council of Cruise Lines
IMO	International Maritime Organization
LC50	Lowest concentration of toxicant to cause 50% mortality in an organism
m	Meters
mL	Milliliters
MPN	Most Probable Number (metric for reporting bacterial concentrations, units are MPN/100mL)
MSD	Marine Sanitation Device
nm	Nautical Mile
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
OLS	Ordinary Least Squares
RWQCB	Regional Water Quality Control Board
sec	Seconds
SMAV	Species Mean Acute Value
TCM	Travel Cost Model
USCG	United States Coast Guard
WET	Whole Effluent Toxicity

AN ENVIRONMENTAL AND ECONOMIC ANALYSIS OF CRUISE SHIP DISCHARGES IN CALIFORNIA STATE WATERS

ABSTRACT

In recent years, California has experienced an unprecedented increase in cruise ship traffic. While the cruise industry contributes significantly to California's economy, the wastewater discharges from cruise ships may also be contributing to the degradation of the state's coastal waters. Recently passed state regulations fail to address blackwater and graywater, two major wastestreams that could be affecting the health of California's coast. Our project focuses on identifying and quantifying the potential environmental effects of treated blackwater and untreated graywater discharges to California state waters under three regulatory scenarios – current federal regulations, Alaska state regulations, and the regulatory recommendations made by the California Cruise Ship Task Force Report.

We developed four models to analyze the environmental and economic effects of blackwater and graywater discharges. Our results show that under average weather conditions, nominal amounts of bacteria from cruise ship discharges reach the shore. However, considerably more reaches the shore under extreme weather conditions. Our economic analysis indicated that the effect of price on demand for beach recreation is negative, as expected, but not statistically significant. Nevertheless, the effect of an increase in water quality from its impact on price can be traced through to its effect on visitation. The two models examining the effects from heavy metals found in these wastestreams show no effect to the marine community from concentrations in the water column, but did find negative effects to the benthic community from concentrations of heavy metals in the pore water. However, the lack of existing data addressing this issue has prevented us from more accurately identifying the environmental and economic impacts associated with cruise ship discharges. We conclude that further regulation of cruise ship discharges is necessary to ensure the health and longevity of California's coastal resources.

EXECUTIVE SUMMARY

INTRODUCTION

In recent years, California has experienced an unprecedented increase in cruise ship traffic. For instance, in 2002 California ports handled over 700,000 cruise ship passengers, making it the second largest market (behind Florida) for the cruise industry in the United States. As a result, California received approximately 10% of the industry's direct spending, amounting to over $1 billion. While these figures show that cruise ships contribute significantly to California's economy, there is concern that cruise ships may also be contributing to the degradation of California's coastal waters.

An average one-week cruise ship voyage generates more than 50 tons of garbage, one million gallons of graywater (wastewater from sinks, showers, galleys, and laundry facilities), 210,000 gallons of sewage (blackwater), and 35,000 gallons of oil-contaminated water. This wastewater discharge rate is roughly equivalent to the wastewater production of a municipality with a population of 2,000. The problems associated with these wastewater streams and their potential impacts on California's coastal resources could escalate in the near future, as the cruise industry is expected to expand by 8.5% each year for the next ten years.

In an attempt to minimize the environmental effects that cruise ship discharges have on California's coastal resources, several state laws (AB 121, AB 433, and AB 906) have recently passed. However, these new state laws fail to address blackwater and graywater wastestreams, two major components that could be affecting the health of California's coasts. In addition, the California Cruise Ship Environmental Task Force Report made specific recommendations to increase regulation of cruise ships. Consequently, new state bills will be proposed this year calling for further regulation of cruise ship discharges, including blackwater and graywater. However, there is a lack of scientific information on the effects of blackwater and graywater on the environment and marine communities, making it difficult to determine the appropriate level of regulation required to keep California's coast safe from degradation. Our project focuses on these wastestreams and attempts to identify some of the potential environmental effects of treated blackwater and untreated graywater discharges to California state waters. In addition, we attempt to value these environmental effects upon California state beaches through an economic analysis. Our main objective for this project was to supply stakeholders with information to assist them in effectively regulating cruise ships in California.

PROJECT APPROACH

Our analysis of the effects of blackwater and graywater wastestreams is accomplished with the development of four mathematical models. The first model (Bacterial Load Dispersion Model) considers fecal coliform as an indicator of the amount of bacteria reaching the shore, thus affecting beach water quality, tourism and human health. We attempt to value these effects with an economic analysis that uses the outputs of the Bacterial Load Dispersion model to estimate a consumer's willingness to pay for an improvement in water quality. The last two models consider metals and heavy pollutants, thus affecting marine organisms. One of these (Priority Pollutant Dispersion Model) calculates the concentrations of metals and heavy pollutants in the water column and the other (Sinking Load Model) estimates the concentrations of these pollutants at the sediment-water interface on the seafloor. The results of the latter two models are used in an ecological risk assessment employing species sensitivity distributions to examine potential effects to both pelagic and the benthic marine communities.

We analyze the outcomes of these models under three scenarios (current federal regulations, Alaska state regulations, and regulatory recommendations made by the California Cruise Ship Task Force) in order to assess the effectiveness of each of the regulatory scenarios in protecting California's state waters.

RESULTS AND DISCUSSION

Our Bacterial Load Dispersion Model examines the percent change in bacterial concentration reaching the shore under each of the three scenarios. This model is based on a mass-balance approach using Fick's Law of Diffusion and accounts for the turbulent nature of currents in the ocean as well as the extinction rate of fecal coliform bacteria. It is run under average weather conditions and extreme weather conditions. The results show that under average weather conditions nominal amounts of bacteria reach the shore. However, under extreme weather conditions, when the velocity of the ocean current is greater than average, considerably more bacteria reaches shore. More specifically, under the Federal Regulations scenario during extreme weather conditions, 94% of the original bacterial concentration reaches the shore. In comparison, under average conditions in this scenario only 0.14% reaches the shore. The results also show that if graywater were to be treated to the same standards as blackwater, the concentration of bacteria reaching the shore under both average and extreme conditions would be reduced by 99%.

Bacteria at the ocean shore, for which fecal coliform bacteria are used as an indicator, have been shown to adversely affect human health. In addition, when concentrations of bacteria in the water exceed the state level water quality standards, beaches are closed thereby negatively impacting the local community and the state as a whole. For example, preliminary results from the Southern California Beach Valuation project indicate that closing Bolsa Chica state beach for just one day during peak summer months, would result in a loss of $7.3 million. This number includes the loss of revenue from projected beach spending, as well as the regulatory costs from both state and city employees involved in closing a beach. The results of this examination led us to agree with the Task Force recommendations and conclude that cruise ships should be required to move at least three nautical miles offshore before discharging in order to reduce the pollution that reaches the shore during extreme weather conditions. We also conclude that in addition to moving further offshore before discharging, graywater should be treated to the same standards as blackwater to most effectively eliminate the possibility of harmful bacteria reaching the shore.

We then used an economic travel cost model to determine how the demand for beach recreation changes with a change in water quality. We calculated the travel costs for visitors, including the opportunity cost of time, based on survey data collected by the California state parks visitor services section. Utilizing a hedonic equation, we regressed the average total cost of visiting a beach against the characteristics of the beach (water quality, amenities, air temperature of the beach). As anticipated, our model predicted that as water quality increases, people would pay more to visit a California state beach.

In order to account for simultaneity, the predicted "price" from the hedonic equation was then inputted into a Cobb-Douglas demand equation. The demand for beach recreation was shown to be inelastic. The results of this equation showed the effect of price on demand is negative, as expected, but statistically insignificant. Nevertheless, the effect of an increase in water quality from its impact on price can be traced through to its effect on visitation. For instance, the impact coefficient of water quality on price was $0.09/MPN/100ml; therefore, if the water quality at Bolsa Chica State Beach was improved by 50 MPN/100ml, visitors would be willing to pay $4.50 more to visit Bolsa Chica State Beach, a 43% increase from the predicted travel cost value.

We feel that the results could be strengthened by improving upon a number of factors, mainly the quality of the data available regarding beach visitation and beach water quality in California. In addition, California state beaches are not required to post water quality information, therefore it is possible that unless a beach is closed, visitors are not aware of the difference in water quality at various beaches. Consequently, water quality may not factor into a visitor's decision on where to recreate.

The Priority Pollutant Dispersion Model measures the average concentration of dissolved heavy metals along with other priority pollutants that are discharged one time from one average-size cruise ship. The pollutants remain in the water column over a period of five days, which is enough time to determine adverse effects on organisms. Heavy metals collect in living organisms and increase in concentration as they move up the food chain. This process is called bioaccumulation. In general, these pollutants are present at trace levels in uncontaminated waters and, in small amounts, these metals are essential micronutrients for living organisms. However if the threshold for the organism is exceeded by elevated levels of intake, heavy metals can: 1) seriously affect the respiration, photosynthesis, transpiration and growth of plants, 2) trigger important dysfunctions of the nervous system, blood and renal systems in animals, and 3) reduce growth and reproduction in animals. In order to determine the concentration of heavy metals in the water column under each of the three scenarios, this model takes into account the characteristic length of diffusion of metals and the depth of the ocean at three major California ports (Los Angeles, San Diego, and San Francisco).

The results of this model were compared to species sensitivity distributions for each of the pollutants that show the sensitivity of the marine community to increasing concentrations of the pollutant. The results show that there is no effect to the pelagic marine community from the concentrations of dissolved pollutants released in a single discharge from one cruise ship. However, our model was unable to account for the accumulation of metals and other priority pollutants in the water column that would result from multiple discharges in the same area. Repetitive discharges have the potential to lead to bio-concentration in organisms, and bioaccumulation of these metals in higher trophic levels. Thus, these metals may negatively affect marine organisms even though the results of our model predicted otherwise.

The Sinking Load Model measures the average concentration of heavy metals attached to particulate matter that sinks to the benthos. This model accounts for the area that metals will diffuse through given average turbulent conditions in the ocean, and the depth of the pore water at the sediment-water interface. The results of the model were then compared to species sensitivity distributions for each of the pollutants, showing the sensitivity of benthic marine organisms to increasing concentrations of the metals. The results show negative effects to 90% of the marine benthic community from the concentration of copper reaching the benthos. There were no negative effects shown for any of the other heavy metals analyzed. These results led us to conclude that future policies should consider the elevated loads of copper in cruise ship wastestreams. It is also important to note that the data used to calculate these models came from ships required to use Advanced Wastewater Treatment Systems (AWTS). However, cruise ships in California are not subject to the same regulations, and therefore many ships may not have this wastewater treatment capacity. Ships without this technology could be contributing more pollution to the marine environment than those predicted by this model. Therefore, the results presented here can be viewed as a best-case scenario.

RECOMMENDATIONS

Based on the results of our project, we have formulated a number of recommendations regarding the regulation of blackwater and graywater wastestreams from cruise ships. Foremost, we recommend that future policies require ships be at least 3 nautical miles offshore and away from critical habitats, such as marine sanctuaries. This would assure minimal impacts to coastal areas. In addition, we recommend that graywater be treated to the same standards as blackwater and that any standards applied to one wastestream be applied to the other since both wastestreams contain large amounts of bacteria and heavy pollutants. Due to the accumulation potential of heavy pollutants over time, as well as the likelihood of cumulative impacts of these constituents to the marine community, we recommend legislation that mandates the use of treatment systems that would remove these chemicals prior to discharge. However, if technology standards are not required by legislation, we recommend that depth be taken into consideration as a metric for determining where cruise ships can discharge. This would minimize the effects of pollutants on the marine community. Finally, we recommend further economic analyses on the adverse effects of cruise ship discharges in regards to beach closures, fisheries, and human health to bridge the gap in economic information regarding cruise ships in California.

1 INTRODUCTION

1.1 Problem Statement

In recent years, the coastal waters and ports of California have experienced an unprecedented increase in cruise ship traffic. While cruise ships contribute significantly to California's economy, they may also be contributing to the degradation of our coastal waters. An average one-week cruise ship voyage generates more than 50 tons of garbage, one million gallons of graywater (wastewater from sinks, showers, galleys, and laundry facilities), 210,000 gallons of sewage, and 35,000 gallons of oil-contaminated water. This wastewater discharge rate is roughly equivalent to the weekly wastewater production of a municipality with a population of 2,000. The problems associated with these wastewater streams and their potential impacts on California's coastal resources could escalate in the near future, as the cruise industry in California is expected to expand by 25%over the next decade. The cruise industry has also been showing interest in increasing travel to new ports-of-call, like Monterey and Santa Barbara. These ports are both home to National Marine Sanctuaries, and the risks of pollution could have even greater effects in these pristine marine areas.

Several recently passed state laws (AB 121, AB 433, and AB 906) target cruise ships and their discharges into state waters. California has also taken action on this issue by establishing the California Cruise Ship Environmental Task Force, whose report (released in August 2003) made specific recommendations regarding increased regulation of cruise ships. However, the new state laws fail to address blackwater and graywater wastestreams, two major components that could be affecting the health of California's coasts.

Our project focuses on these wastestreams and attempts to identify some of the potential environmental effects of treated blackwater and untreated graywater discharges to California state waters. This is accomplished with the development of three environmental models – one that considers fecal coliform as an indicator of bacteria reaching the shore, thus affecting beach quality, tourism and human health, and two that consider metals and heavy pollutants in the water column and marine sediments, thus affecting marine organisms. We then attempted to quantify some of these environmental effects with an economic analysis that used the outputs of one of our environmental models to evaluate the relationship between beach visitation and water quality at the beach.

We analyzed the outcome of these models under three regulatory scenarios (current federal regulations, Alaska state regulations, and regulatory recommendations made by the California Cruise Ship Task Force) in order to assess the efficacy of the regulatory scenarios in protecting our state waters. We then formulated recommendations on how to most effectively regulate these cruise ship wastestreams to ensure the health and longevity of California's coastal resources.

1.1.1 Significance

Due in part to post-September 11th safety concerns, an increasing number of Americans are selecting domestic travel over international travel. In response, the cruise ship industry has recently begun to increase visits to ports within California that were previously unexploited, such as Monterey and Santa Barbara. The industry has also committed to major expansion of ports already in use throughout the state, such as a new dock in San Francisco (Dunn, 2001). Numerous stakeholders are now concerned that if the cruise industry significantly expands without a corresponding expansion in pollution regulation, dramatic environmental costs could be imposed on California's coastal resources.

Discharges from cruise ships have the potential to be a significant additional source of pollution for California's coastal waters, an already challenged ecosystem. In response to that potential threat, new state bills will be proposed this year calling for further regulation of cruise ship discharges, including blackwater and graywater. There is currently a dearth of scientific information of the effects of blackwater and graywater on the environment and marine communities. We hope to contribute useful information to the current debate regarding the regulation of cruise ships off our coasts.

1.1.2 Objectives

Our analyses aim to supply policymakers with information to assist them in making decisions about regulating blackwater and graywater discharges from cruise ships in the future. Results from this project include scientific and economic information that we translate into recommendations regarding how and to what extent the cruise ship industry should be regulated in California.

This report also provides original analyses and recommendations that complement the California Cruise Ship Task Force Report (Report). The Report specifically identified the need for a "California-based" scientific analysis of cruise ship impacts, as well as an economic analysis of regulations on cruise ships.

Furthermore, the results of this project highlight areas where more data is needed in order to conduct further analyses on the effects of large vessel discharges on coastal marine ecosystems. It also provides numerous external stakeholders with preliminary economic and ecologically based information regarding the effects of blackwater and graywater discharges on California's economy, the health of its beaches and the well-being of its ecological communities.

1.1.3 Definition of Regulatory Scenarios

The three regulatory scenarios used in our analysis have distinct requirements regarding the discharge of treated blackwater and untreated graywater. These discharge scenarios are defined below:

Scenario 1: Current federal regulations remain as the only regulations regarding cruise ships.

Under current federal regulations, cruise ships are allowed to discharge treated blackwater and untreated graywater anywhere within state waters. Treated graywater is not addressed by federal regulations.

Scenario 2: California adopts current Alaska state legislation regarding cruise ships.

Alaska legislation requires treated blackwater and untreated graywater to be discharged no less than 1 nautical mile from shore at a speed not less than 6 knots. Alaska state law does not currently regulate treated graywater.

Scenario 3: California adopts regulatory recommendations detailed in the California Cruise Ship Environmental Task Force Report.

The Task Force Report recommended that untreated graywater be treated like untreated blackwater and be discharged at least 3 nautical miles from shore. Treated blackwater and graywater can be discharged anywhere within state waters, unless the cruise ship is within a state-designated no discharge zone.

Table 1.1 displays a comparative summary of the three regulatory scenarios to be considered.

	SCENARIO 1:	SCENARIO 2:	SCENARIO 3:
	Federal Regulations	Alaska Regulations	CA Task Force Recommendations
Treated Blackwater	Anywhere*	1 nautical mile at 6 knots	Anywhere*
Untreated Graywater	Anywhere	1 nautical mile at 6 knots	3 nautical miles
Treated Graywater	Not Regulated	Not Regulated	Anywhere

*Unless state designated No-Discharge Zone

Table 1.1. Summary of Regulatory Scenarios

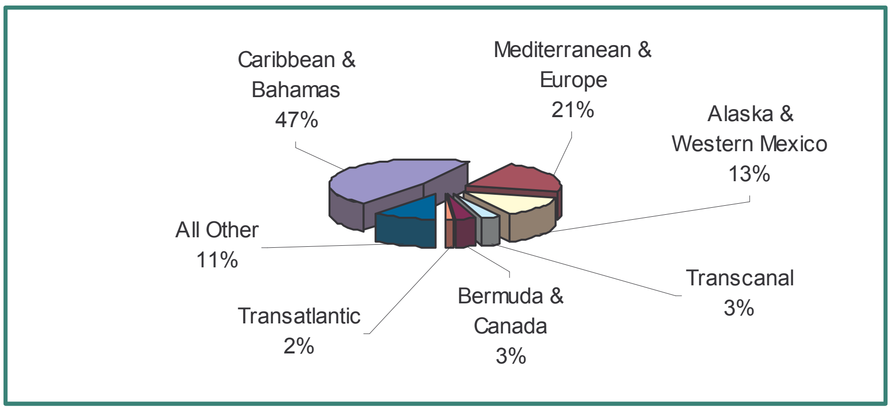
By comparing the results of our environmental models for each of the regulatory scenarios above, we were able to assess the effectiveness of current and recommended legislative schemes for protecting California's coastal resources. By analyzing these results, we are able to produce recommendations for policymakers on how to properly regulate these cruise ship discharges.

2 BACKGROUND

2.1 THE CRUISE INDUSTRY[1] WORLDWIDE AND IN THE UNITED STATES

2.1.1 Destinations

Cruise ships currently navigate in every ocean worldwide. As shown in Figure 2.1, the Caribbean accounted for 47 percent of the cruise industry's global capacity in 2002. The Caribbean market is primarily served by cruises originating from Florida and the Gulf Coast. Pacific Coast ports in the United States primarily serve the Alaska and western Mexico markets, which accounted for 13 percent of the industry's deployed capacity. The Bermuda and Canada market, which includes New England, accounted for 3 percent of the industry's capacity. Ports on the East Coast serve this market.



Source: (Business Research & Economic Advisors, 2003).

Figure 2.1. Global Destinations of Cruises, 2002

Cruise companies are constantly evaluating market conditions, port facilities, and tourist destinations in order to expand the industry into new regions. China, India, and Southeast Asia are some of the new markets currently under evaluation (Herz and Davis, 2002).

[1] In this report, the term "cruise industry" refers to the members and associate members of the International Council of Cruise Lines (ICCL). ICCL represents the interests of 14 passenger cruise lines that call on major ports in the United States and abroad. ICCL member lines include: Carnival Cruise Lines; Celebrity Cruises; Costa Cruise Line N.V.; Crystal Cruises; Cunard Line Ltd; Disney Cruise Line; Holland America Line; Norwegian Cruise Line; Orient Lines; Princess Cruises; Radisson Seven Seas Cruises; Royal Caribbean International; Seabourn Cruise Line; and Windstar Cruises. Vessels from ICCL member companies account for approximately 90% of the North American passenger cruise industry.

2.1.2 Growth

The cruise industry is one of the world's fastest growing tourism sectors. The worldwide cruise ship fleet includes more than 250 ships that carried an estimated 9.2 million passengers in 2002 (International Council of Cruise Lines, 2003). The number of cruise ship passengers has grown nearly twice as fast as any other travel sector over the last 10 years, and is expected to grow at 8.5 percent per year over the next decade (Sweeting and Wayne, 2003).

In North America, the cruise industry is undergoing unprecedented expansion – over the past five years, it has grown by at least 10 percent annually (Herz and Davis, 2002). The North American cruise industry[2] is comprised of 176 vessels with a combined capacity of 196,694 passenger berths. U.S. ports handled 6.5 million cruise embarkations during 2002, accounting for 71 percent of global embarkations and representing an increase of 10.2 percent from 2001 (Business Research & Economic Advisors, 2003). Table 2.1 gives a detailed account of port activity in North America for 2001 and 2002.

[2] Although cruises of the North American industry originate from ports throughout the world, the North American cruise industry is defined as those cruise lines that primarily market their cruises in North America. Thus, the definition is based upon where cruises are marketed rather than cruise originations or destinations.

	2001 Passengers	2002 Passengers
United States	5,900,000	6,500,000
Florida	4,019,000	4,413,000
Miami	1,700,000	1,821,000
Port Canaveral	1,065,000	1,197,000
Port Everglades	983,000	1,105,000
Tampa	271,000	290,000
California	643,000	705,000
Los Angeles	500,000	538,000
San Francisco	40,000	32,000
San Diego	103,000	135,000
New York	238,000	326,000
Other U.S.	1,000,000	1,056,000
Galveston	149,000	267,000
Seattle	77,000	112,000
Remaining U.S. Ports	774,000	677,000
Canada	505,000	527,000
Vancouver	492,000	513,000
Quebec	2,200	1,300
Other	10,800	12,700
San Juan	300,000	298,000
North America	6,705,000	7,325,000
Rest of World	1,695,000	1,895,000
Total	8,400,000	9,220,000

*All estimated cruise embarkations have been rounded to the nearest thousand.

Source: (Business Research & Economic Advisors, 2003).

Table 2.1. North America Cruise Ship Port Activity for 2001 & 2002

To accommodate the rapid increase in passengers, the North American cruise industry expanded its capacity by more than 13 percent in 2002, representing its largest single year increase in guest berths and its largest percentage growth since 1998 (Business Research & Economic Advisors, 2003). (See Table 2.2)

	2000	2001	2002
Capacity Measures			
Number of Ships	163	167	176
Passenger Berths	165,381	173,846	196,694
Carryings (millions)			
Global Passengers	8.00	8.40	9.22
Passengers Residing in U.S.	6.57	6.80	7.51
U.S. Embarkations	5.31	5.90	6.50

Source: (Business Research & Economic Advisors, 2003).

Table 2.2. Operating Statistics of the North American Cruise Industry in the United States, 2000-2002

2.1.3 Economic Impact

According to a report by Business Research & Economic Advisors (BREA), the cruise ship industry and its passengers contributed $20.4 billion to the U.S. economy during 2002. These direct and indirect contributions translate into more than 279,000 jobs throughout the country, paying a total of $10.6 billion in wages and salaries. On average, a cruise ship holding 2,000 passengers and 950 crewmembers generates approximately $180,000 in on-shore spending per U.S. port. In 2002, the average port-of-call passenger spent just short of $82 per visit (Business Research & Economic Advisors, 2003).

2.2 THE CRUISE INDUSTRY IN CALIFORNIA

2.2.1 Destinations

California ports handled over 700,000 cruise ship passengers in 2002, making it the second largest market (behind Florida) for the cruise industry in the United States (Cruise Ship Environmental Task Force, 2003). Cruise ships travel the entire length of the California coast and now call at ports in at least six different locations – San Diego, Los Angeles/Long Beach (also known as San Pedro), Monterey Bay, San Francisco, Avalon Bay (Catalina Island) and Humboldt Bay. As seen in Table 2.3, there are presently nine cruise ship lines operating out of California, involving over 20 vessels.

Cruise Line	Number of Vessels operating in CA Waters
Celebrity Cruise Line	3
Carnival Cruise Line	3
Royal Caribbean International	2
Cruise West	1
Crystal Cruises	3
Holland America	8
Norwegian Cruise Line	3
Princess Cruises	4
Radisson Seven Seas Cruises	2

Source: (Cruises Inc., 2003).

Table 2.3. Cruise Lines Operating in California, 2003

2.2.2 Growth

The cruise industry in California has experienced rapid growth over the last decade. California experienced a 67 percent increase in cruise ship traffic between 1990 and 1998 (Sierra Club, 2002). The cruise industry estimates a 25 percent increase in the number of vessels that will operate in California State waters over the next 10 years (Cruise Ship Environmental Task Force, 2003). An estimated 705,000 passengers embarked on their cruises from the ports of Los Angeles, San Francisco and San Diego in 2002 – a 9 percent increase from 2001. The Port of Los Angeles is the state's largest cruise port with 538,000 embarkations during 2002. The Port of San Diego experienced the strongest growth with a 31 percent increase over 2001 with 135,000 embarkations (International Council of Cruise Lines, 2003).

2.2.3 Economic Impact

With this volume of growth and activity, it is not surprising that the cruise industry is making a substantial contribution to California's economy. BREA found that California received just under 10 percent of the industry's direct spending, amounting to over $1 billion. This spending generated 40,302 jobs paying $1.7 billion in wages (Business Research & Economic Advisors, 2003).

2.3 Cruise Ship Wastestreams

Recent incidents have suggested that, along with these positive economic impacts, the cruise industry may also be causing significant negative environmental impacts. Carrying as many as 5,000 people on board at a time, cruise ships have been referred to as "small floating cities" (Wall, 2003). Like small cities, cruise ships have a full range of logistic and waste management issues that must be addressed. However, municipalities of comparable size are required under the Clean Water Act (CWA) to obtain discharge permits, monitor, and report on their discharges; cruise ships are not. In fact, they are exempt from the National Pollution Discharge Elimination System (NPDES) Permit Program of the Clean Water Act, which is designed to ensure proper handling and disposal of harmful pollution and discharges (Schmidt and Long, 2000). Over 30 types of wastes from vessels have been identified, including but not limited to: air emissions, wastewater, solid wastes, hazardous waste, and oily wastes. A complete list of these identified waste types is found in Table 2.4.

Air emissions	Graywater
Hazardous waste	Medical waste
Oil sludge and slops	Bilge water
Oily waste	Used oil
Oil filters	Ballast water
Sewage or blackwater	Incinerator residue
Dry cleaning solvents	Paints and solvents
Used sand or bead blasting residue	Food wastes
Plastics	Scrap metals
Photographic processing chemicals	Fluorescent light bulbs
Batteries	Glassware, bottles and crockery
Swimming pool chemicals	Cleaning agents
Miscellaneous spray cans	Expired medicines/drugs
Cardboard and paper products	Miscellaneous garbage
Printer cartridges	Insecticides

Source: (Cruise Ship Environmental Task Force, 2003).

Table 2.4. Summary of Wastes Discharged from Cruise Ships

2.3.1 Wastewater Discharges

Cruise ships have the capacity to discharge over 100,000 gallons of wastewater into state waters on a daily basis. According to estimates by the Bluewater Network, this may include as much as:

- 37,000 gallons of oily bilge water,
- 255,000 gallons of non-sewage wastewater (graywater),
- 15,000 to 30,000 gallons of human sewage,
- 15 gallons of toxic chemicals, and
- Tens of thousands of gallons of ballast water (bearing pathogens and invasive species from foreign ports) (Schmidt and Long, 2000).

The two major wastestreams to be discussed in this report – treated blackwater and untreated graywater – receive further definition below.

Blackwater (Sewage)

Wastes from toilets, urinals, medical sinks and other similar facilities are called "blackwater". Treated blackwater is processed using a Coast Guard-approved "marine sanitation device" (MSD) that is intended to prevent the discharge of untreated or inadequately treated blackwater. MSDs use physical, chemical and/or biological processes to generate effluents that are discharged with characteristics similar to the effluents from conventional shoreside wastewater treatment plants (International Council of Cruise Lines, 2001).

Graywater
The term graywater is used on ships to refer to wastewater that is generally incidental to the operation of the ship. The International Maritime Organization (IMO) defines graywater as including drainage from dishwasher, shower, laundry, bath and washbasin drains. The U.S. Clean Water Act includes galley, bath and shower water in its definition of graywater (International Council of Cruise Lines, 2001).

2.3.2 Potential Environmental Impacts of Cruise Ship Wastewater

Each of the wastewater streams produced by cruise ships (oily bilge water, blackwater, graywater, ballast water) has the potential to cause negative environmental impacts. For example, the effects of petroleum hydrocarbon (oil) pollution on the environment are well documented and varied. Oil has been proven to have adverse effects on numerous species, especially birds and fur-bearing marine mammals. These effects can be severe and include impacts to egg and larval forms of many species, which are especially sensitive to oil (National Research Council, 1985; Clark, 1986).

When ships discharge ballast water in port, it can contain invasive, non-native plant and animal species. Non-native species of plants, animals, pathogens and bacteria have been introduced and spread in coastal waters around the world by ballast water. Even a small number of invasive species can quickly establish themselves and over-run (or eliminate) local native species (Sweeting and Wayne, 2003). For example, the San Francisco Bay region is now home to at least 212 non-native species which "have had a profound impact on the ecology of this region…(with) no shallow water habitat now remain[ing] uninvaded by exotic species." (Cohen and Carlton, 1995)

In this report, we focus on the environmental effects of blackwater and graywater. The potential impacts of these wastestreams are discussed below.

Blackwater
The discharge of blackwater from cruise ships (which includes treated human sewage) can cause a variety of environmental and human health impacts by transporting bacteria, pathogens, diseases, viruses and harmful nutrients into coastal waters (Schmidt and Long, 2000; Herz and Davis, 2002). It is important to note that sewage on ships is typically diluted with smaller volumes of water than is sewage on land (3/4 of a gallon per flush compared with three to five gallons), and ship sewage is therefore more concentrated.

Ingesting contaminated fish or direct exposure to water contaminated with sewage pose health risks for humans. Bivalve mollusks (oysters and clams) and other filter-feeding marine organisms often inhabit waters with the greatest concentrations of nutrients from organic wastes, and they absorb high levels of these pollutants. Discharges of untreated or inadequately treated sewage from ships can cause bacterial and viral contamination of commercial and recreational shellfish beds, producing serious risks to public health(Herz and Davis, 2002).

Graywater

Graywater can contain a variety of substances including (but not limited to): detergents, shampoos, oil and grease, pesticides, and food waste (Eley, 2000). More than 1 million gallons of graywater are typically produced on a 7-10 day cruise, which makes it the largest source of liquid waste generated by cruise ships (Sweeting and Wayne, 2003).

U.S. Environmental Protection Agency (EPA) has determined that graywater "has the potential to cause adverse environmental effects," due to constituents such as nitrogen and phosphorous (Alaska Department of Environmental Conservation, 2002; Herz and Davis, 2002). These nutrients can over-stimulate the growth of aquatic plants and algae, a process known as eutrophication. Eutrophication depletes oxygen necessary to support life; it can affect fish and other organisms, leading to a decrease in animal and plant diversity and affecting the use of coastal waters for recreational and commercial activities (Schmidt and Long, 2000).

Furthermore, graywater samples taken by the state of Alaska found substantial contamination from fecal coliform bacteria, heavy metals, and dissolved plastics (Alaska Cruise Ship Initiative, 2000). Graywater from the ship's galley and sink wastestreams tested higher for fecal coliform than the ship's sewage lines.

2.4 Current Regulations and Legislation

There are a number of different regulatory responses to the issue of cruise ship wastes and discharges. Many state, federal and international laws currently address the environmental management practices of cruise ships and other types of large vessels, such as cargo ships. Below is a summary of the most significant laws that currently regulate the cruise industry.

2.4.1 International Regulation

The United Nations International Maritime Organization (IMO) establishes international maritime vessel safety and marine pollution standards. Created in 1958, IMO comprises representatives from 152 major maritime nations including the United States. The primary goals of IMO are to enhance shipping safety and to protect the ocean environment from shipping impacts. One of the main instruments used to achieve these goals is a legal framework of international treaties called "conventions". It is important to note that, while IMO is charged with developing and overseeing these conventions, IMO has no enforcement authority.

The MARPOL Convention (MARPOL 73/78) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively and updated by amendments through the years. Cruise ships flagged under countries that are signatories to MARPOL are subject to MARPOL's requirements, regardless of where they sail. The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations - and currently includes six technical Annexes. In order for these annexes to be binding, they must first be ratified by a total number of member countries whose combined gross tonnage represents at least 50 percent of the world's gross tonnage. To date, Annexes I through V have entered into force. Signatories must accept Annexes I and II, but the other annexes are voluntary. (See Table 2.5 and Appendix A for a more detailed description of the MARPOL Annexes).

Annex I:	Regulations for the Prevention of Pollution by Oil	Entered into Force: 2 October 1983
Annex II:	Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk	Entered into Force: 6 April 1987
Annex III:	Regulations for the Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form	Entered into Force: 1 July 1992
Annex IV:	Regulations for the Prevention of Pollution by Sewage from Ships	Entered into Force: 27 September 2003
Annex V:	Regulations for the Prevention of Pollution by Garbage from Ships	Entered into Force: 31 December 1988
Annex VI:	Regulations for the Prevention of Air Pollution from Ships	Adopted September 1997 – not yet entered into force

Source: IMO, 2003.

Table 2.5. MARPOL 73/78 Annexes and Status

The country where a ship is registered (the "flag state") is responsible for certifying the ship's compliance with pollution prevention standards, although many nations delegate this task to classification societies, which perform pollution prevention compliance inspections under contract. The country the ship visits (the "port state") can conduct its own examinations to verify the ship's compliance with international standards and can detain the ship if it finds significant noncompliance. The Coast Guard performs these examinations and enforces standards in U.S. ports (United States General Accounting Office, 2000).

It should be noted that the United States is not a party to MARPOL Annex IV, which will develop operational requirements for vessel sewage treatment plants or MSDs, and ensure that participating countries provide adequate port reception facilities for discharging sewage to land-based treatment facilities (Cruise Ship Environmental Task Force, 2003).

2.4.2 Federal Regulation

The Act to Prevent Pollution from Ships (33 U.S.C. 1901-1911) and the Clean Water Act (33 U.S.C 1319, 1321, 1322) are the key domestic laws governing the discharge of materials into U.S. waters. The Act to Prevent Pollution from Ships incorporates the provisions of MARPOL into U.S. law. The Clean Water Act generally prohibits the discharge of any pollutant within 3 nautical miles of the United States and of oil and hazardous substances within 12 nautical miles of the United States. It also requires those who discharge oil to immediately report the spill to the appropriate federal agency. These U.S. laws apply to foreign flagged ships while they are in U.S. waters. If violations of U.S. law occur, the U.S. Coast Guard can levy administrative civil penalties up to $25,000 per violation. The Coast Guard refers more serious cases to the Department of Justice for possible criminal prosecution (United States General Accounting Office, 2000).

Blackwater

Unlike the discharge of land-based sewage, the Clean Water Act (CWA) does not regulate sewage discharged by ships under the National Pollution Discharge Elimination System (NPDES) Permit Program. Instead, CWA Section 312 (33 CFR 159 and 40 CFR 140) requires cruise ships longer than 65 feet to install and use Coast Guard-approved marine sanitation devices Type II or III capable of treating or holding raw sewage. Type II MSDs must not allow effluent to exceed bacteria counts of 200 fecal coliform/100 milliliters and suspended solids of 150 milligrams/liter. Type III MSDs (holding tanks) require all sewage to be held on board until it can be properly disposed of. Federal regulations prohibit the discharge of untreated blackwater within three nautical miles of shore. Beyond the three-mile limit, however, there are no limitations on a ship's blackwater discharge. The Coast Guard inspects and enforces MSD requirements, while the EPA issues standards and regulations for MSDs. States may enact their own clean water laws within three miles of shore (Herz and Davis, 2002).

Graywater

Graywater is excluded from the Clean Water Act's permitting program (NPDES) through an exemption applicable to all wastewater discharges incidental to the normal operation of a vessel at 40 CFR section 122.3(a) (US Environmental Protection Agency, 2000). There are currently no federal regulations regarding the discharge of graywater in U.S waters.

However, because of the potentially harmful pollutants found within graywater, the United States recently recommended that graywater be subject to international regulation, even though graywater discharges in U.S. waters remain essentially unregulated. The U.S. General Accounting Office (GAO) has also proposed that the Coast Guard review the regulatory definition of graywater to "evaluate whether the current regulations adequately address the potential environmental hazards [of graywater] to marine life." (United States General Accounting Office, 2000).

Discharge Prohibition Zones
Under CWA section 312, there is a procedure that allows states to establish areas where the discharge of treated or untreated sewage from all vessels is prohibited. Establishment of a discharge prohibition zone applies only to discharge of treated or untreated blackwater; discharges of graywater, ballast water, or oily bilge water are not subject to prohibition under this procedure. It is also important to note that discharge prohibition zones created under CWA do not distinguish between classes of vessels. In other words, the state could not prohibit only cruise ships from discharging blackwater; all vessels in the zone would fall under this prohibition (Cruise Ship Environmental Task Force, 2003).

Some states in the northeastern United States have established extensive discharge prohibition zones that encompass most of their state waters. Currently, California has established ten no-discharge areas in marine waters. These areas are:

1. Mission Bay
2. San Diego Bay
3. Oceanside Harbor
4. Dana Point Harbor
5. Upper and Lower Newport Bay
6. Sunset Aquatic Park
7. Huntington Harbor
8. Channel Islands Harbor
9. Avalon Bay Harbor
10. Richardson Bay

2.4.3 State Regulation
Several states have independently addressed the issue of cruise ship discharges through additional legislation or contractual agreements with the cruise ship industry. These state's regulatory approaches are detailed below.

Alaska State Regulations
Alaska was the first state to implement laws more stringent than current federal regulations. In 2001, Alaska Governor Tony Knowles signed a law (HB 260) that establishes a monitoring and testing program for cruise ship discharges. It also sets specific graywater discharge standards, and requires that the discharge of treated blackwater and untreated graywater occur at least one nautical mile from shore at a speed of no less than six knots.

Furthermore, it requires all owners and operators of cruise vessels to register with the state, maintain records of all discharges, and collect routine samples of the vessels' wastewater. HB 260 also imposes a "head tax" to assist the state in paying for compliance costs incurred by the new law. (See Appendix B for the complete text of HB 260)

Memorandums of Understanding

Florida and Hawaii have signed Memoranda of Understanding (MOUs) with the cruise industry. These MOUs are voluntary agreements that outline expectations of the cruise industry operating in state waters regarding wastewater management, air emissions, and other environmental impacts. However, no provisions in the MOUs deal with penalties for non-compliance, fees for cruise ship compliance monitoring, or other enforcement mechanisms to ensure compliance (Alaska Department of Environmental Conservation, 2002; Dawson, 2002). Furthermore, a recent report commissioned by Bluewater Network and Ocean Advocates to examine the effectiveness of MOUs in protecting the environment concluded that MOUs are not an effective means for dealing with cruise industry pollution (Klein, 2003). (See Appendix C and Appendix D for the complete text of Florida and Hawaii MOUs)

California State Regulations

California began addressing the issue of cruise ship regulation in 2001 with the creation of the California Cruise Ship Environmental Task Force (henceforth known as CA Task Force). This Task Force, created by AB 2746, was charged with evaluating the practices and wastestreams of cruise ships. The Task Force released a report in August 2003 outlining recommendations for the regulation of cruise ship wastestreams in state waters. This report will be discussed in more detail later in this document.

While the Task Force was preparing its report, California passed three new bills related to cruise ship pollution into law in 2003:

> **AB 121**, introduced by Assemblyman Simitian (D-Palo Alto), prohibits cruise ships from discharging sewage sludge and oily bilgewater into state waters and the four national marine sanctuaries along the state's coast. The bill requires cruise ships to report dumping such wastes to the state within 24 hours, and imposes a $25,000 penalty for violations.
>
> Originally, this bill also contained quarterly reporting requirements and authorized the State Water Resources Control Board (SWRCB) to board and inspect vessels for the purpose of carrying out the bill. However, both of these provisions were deleted through Senate amendments.
>
> **AB 433**, introduced by Assemblyman Nation (D-Marin & Sonoma County), revises the California Ballast Water Management for Control of Nonindigenous Species Act and extends the Act's sunset date to January 1, 2010. This act requires all vessels entering state waters to manage ballast water according to prescribed measures, with a number of exceptions. The master or operator of a vessel is supposed to minimize the discharge of ballast water containing nonindigenous species into the waters of the state,
>
> Furthermore, AB 433 allows the State Lands Commission to take samples of ballast water and sediment to assess the compliance of vessels with the

requirements of the act, and requires the master or operator of a vessel to maintain and make available to State Lands Commission a ballast water log that outlines ballast water management activities for every ballast water tank on board the vessel.

AB 906, introduced by Assemblyman Nakano (D-Torrance), prohibits cruise ships from discharging hazardous waste and other waste (like photography lab chemicals, dry cleaning chemicals and medical waste) into state waters. The bill also requires cruise ships to report dumping such wastes to the state within 24 hours, and imposes a $25,000 penalty for violating the law.

The authors of this bill originally included language that would have prohibited the discharge of graywater in state waters, but State Senate amendments deleted graywater from all provisions of the bill.

Although these laws represent an accomplishment for parties interested in stricter regulation of the cruise industry, they do not take into account the two largest wastewater streams from cruise ships – treated blackwater and untreated graywater. According to members of the environmental groups Oceana and Blue Water Network, California legislators will introduce new bills addressing these wastestreams in 2004.

2.5 Cruise Industry Environmental Practices

In the United States, the fourteen major cruise lines that operate within U.S. waters are members of a professional association called The International Council of Cruise Lines (ICCL)[3]. The mission of ICCL is "to participate in the regulatory and policy development process and promote all measures that foster a safe, secure and healthy cruise ship environment". Under the direction of the chief executives of its member lines, ICCL advocates industry positions to key domestic and international regulatory organizations, policymakers and other industry partners (International Council of Cruise Lines, 2003).

In June 2001, ICCL adopted ICCL Standard E-1-01: *Cruise Industry Waste Management Practices and Procedures.* These environmental guidelines incorporate legal requirements and voluntary practices for waste management and are designed to meet or exceed legal standards. Compliance with these procedures is now mandatory for ICCL membership.

Below we briefly highlight some of the ICCL waste management practices that are relevant to our analysis. See Appendix E for the complete text of *Cruise Industry Waste Management Practices and Procedures.*

Blackwater & Graywater

ICCL member lines have agreed to discharge treated blackwater and untreated graywater only while the ship is underway and proceeding at a speed of no less than 6 knots. They

3 See Footnote 1 for a list of member companies.

have stated that graywater will not be discharged in port and will not be discharged within 4 nautical miles from shore (or such other distance as agreed to with authorities having jurisdiction or provided for by local law) except in the case of emergency, or where geographically limited. The guidelines also state that the discharge of blackwater and graywater will comply with all applicable laws and regulations.

Furthermore, blackwater will be treated by a "properly working approved Marine Sanitation Device prior to discharge". Untreated blackwater is discharged into the ocean "at a distance greater than 12 nautical miles from any land, coral reef or designated sensitive area in accordance with MARPOL or such other distance as agreed to with authorities having jurisdiction" (International Council of Cruise Lines, 2001).

2.5.1 Violations

In recent years, public scrutiny of the cruise industry has increased due to repeated violations of current regulations. The U.S. General Accounting Office (GAO) reported that from 1993 to 1998, cruise ships were involved in 87 confirmed cases of illegal discharges of oil, garbage, and hazardous wastes into U.S. waters. For example, on a number of cruise ships operated by one company, pollution control devices were deliberately bypassed and records were falsified, leading to criminal prosecution and an $18 million fine in 1999 (United States General Accounting Office, 2000). During this 5 year time period, cruise ships were also charged by the U.S. Coast Guard (USCG) with 490 safety or environmental violations (Herz and Davis, 2002).

USCG is charged with the extensive surveillance, inspection and compliance monitoring of cruise ships. The Coast Guard refers more serious cases to the Department of Justice for possible criminal prosecution. From 1993 to 1998, the Coast Guard levied civil penalties against cruise ship companies ranging from a warning with no penalty to a $17,500 penalty; Justice's criminal penalties against cruise ship companies ranged from $75,000 to $18 million (United States General Accounting Office, 2000).

However, GAO reported that USCG lacks the resources and time to completely fulfill its environmental regulatory responsibilities. As noted in the 2000 GAO report, "The Coast Guard's ability to detect and resolve violations is constrained by the narrow scope of its routine inspections, and significant reduction in aircraft surveillance for marine pollution purposes, and a breakdown of the process for identifying and resolving alleged violations referred to flag states" (United States General Accounting Office, 2000).

Furthermore, the combined USCG and Department of Justice civil and criminal assessments of approximately $30.5 million issued during 1993 – 1998 represent less than 4 percent of one cruise ship company's 1998 net income.[4] Because of this, many believe the deterrent effect of such fines is negligible (Herz and Davis, 2002).

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[4] For this example, Carnival Corporation's reported financial standing was used.

2.6 CALIFORNIA CRUISE SHIP ENVIRONMENTAL TASK FORCE REPORT

In August 2003, California's Cruise Ship Environmental Task Force (Task Force) issued a report entitled *"Report to the Legislature: Regulation of Large Passenger Vessels in California"*. The purpose of this report was to evaluate the environmental practices and wastestreams of large passenger vessels (cruise ships), and to provide recommendations for actions necessary to address the existing and potential environmental impacts of cruise ship operations in California state waters (Cruise Ship Environmental Task Force, 2003).

The following is a summary of relevant conclusions, wastewater recommendations, and priority recommendations. A complete copy of this report can be obtained online at http://www.swrcb.ca.gov/legislative/docs/cruiseshiplegrpt.pdf.

1. **Establish and fund a Cruise Ship Pollution Prevention Enforcement Program.**
   The Task Force concluded that marine sanitation devices (MSDs) frequently fail to meet current federal standards for discharge of effluent. This is mainly due to a lack of regular monitoring. To resolve this issue, the Task Force recommends an Interagency Cruise Ship Pollution Prevention Enforcement Program be established, and a lead agency to implement the program be assigned. Vessel pollution control equipment (including MSDs) should be inspected at least annually to ensure equipment is installed, maintained, properly functioning, and operated by crew with adequate knowledge of the equipment. The lead agency would be delegated limited authority to conduct these onboard inspections, some of which should be unannounced inspections. The program should be funded with a fee imposed to the cruise lines based on the number of passenger berths (or a similar funding mechanism).

2. **Require graywater to meet same standards required of MSD effluent.**
   Monitoring data published by Alaska indicated that graywater discharges have higher level of pollutants than previously known, and graywater samples frequently exceeded standards set for MSD effluent. Because of the potential risk of these discharges, graywater should be required to meet the same standards required of MSD effluent, or discharge should be withheld while in state waters.

3. **Wastewater discharge should be prohibited in California's National Marine Sanctuary.**
   Marine Sanctuaries are established to protect areas with unique or sensitive habitats. Due to public demand and potential for harm to aquatic resources, a wastewater discharge prohibition for cruise ships should be instituted in California's four marine sanctuaries.

4. **Amend the federal CWA to allow California to establish a statewide discharge prohibition zone for blackwater discharge from cruise ships only.**
   A procedure allowing a state to prohibit discharge of treated or untreated blackwater[5] from all vessels into all or portions of the waters of the state is available under CWA Section 312 (Cruise Ship Environmental Task Force, 2003). However, the discharge prohibition zones established under CWA do not distinguish between classes of vessels. Therefore, the state is currently unable to establish a statewide discharge prohibition zone along the coast solely for cruise ships.

   Federal legislation was passed in 2000 for the State of Alaska to establish such a zone. California should request the support and assistance of its congressional delegation to change federal law to allow the state to establish a discharge prohibition zone specifically for cruise ships in all state waters.

5. **When a discharge occurs in state waters, ships should report the discharge to the appropriate Regional Water Quality Control Board (RWQCB) and provide monitoring data.**
   The report should include the type and amount discharged, location of discharge, treatment received prior to discharge, and recent (within one year) monitoring results for that wastestream. This would enable the RWQCB to evaluate whether water quality was impaired due to the discharge.

[5] Discharge prohibition zones apply only to discharge of treated or untreated blackwater. Graywater, ballast water or oily bilge water are not subject to prohibition under this procedure.

3 METHODOLOGY

This report compares environmental effects of three regulatory scenarios on California's coastal marine systems using four analyses. The first analysis models the percent change in the concentration of bacteria from cruise ship discharges that reach the shore under the three scenarios. This analysis is referred to as the bacterial load dispersion model.

The second analysis attempts to quantify the relationship between beach visitation and water quality using the output in percent change of bacterial concentration reaching the shore from our bacterial load dispersion model and the environmental economic method of travel cost. This analysis is referred to as the travel cost model.

The third and fourth analyses predict the dispersion of metals and other heavy pollutants from cruise ship discharges into the marine environment. This pollutant concentration is then used in species sensitivity analyses to determine the mortality effects of those pollutant concentrations to organisms in the benthos. These analyses are referred to as the priority pollutant dispersion model and the sinking load model.

3.1 BACTERIAL LOAD DISPERSION MODEL

3.1.1 Data and Model Assumptions

The bacterial load dispersion model attempts to answer the question: What is the percent change in the total amount of bacteria reaching the shore from treated blackwater and untreated graywater discharges under the three defined regulatory scenarios?

In order to answer this question, we needed to first determine the discharges from a "typical" cruise ship entering California state waters. Currently, the only source of sample data from cruise ship blackwater and graywater discharges is the Alaska Department of Environmental Conservation (Morehouse, 2003). As of 2001, cruise ships visiting Alaska have been required by state law to report sampling data. This data is publicly available at the ADEC press release website "Cruise Ship Waste Disposal and Management"[6] (Morehouse, McGee et al., 2004). Using only data from medium and large size ships visiting Alaska (Cruises Inc., 2003) that also dock in California, we found average concentrations for each constituent discharged by taking the sum of each constituent from all the graywater and blackwater discharge portholes on each ship separately and then averaging the values over all the ships. Refer to Appendix F to view the specific concentrations we used and to view the data supplied to ADEC by cruise ships in 2002.

[6] This data is publicly available at the following website:
http://www.state.ak.us/dec/press/cruise/documents/impact/wastewatersampling.htm

It has been documented that some ships release graywater and blackwater through separate portholes while others release them through the same porthole (Morehouse, 2003). For our "typical cruise ship", we assumed that although graywater and blackwater are held in separate tanks aboard the ship, these discharges are released simultaneously through the same porthole into the ocean. Therefore, for our "typical ship," the mean graywater values for constituents and the mean blackwater values for constituents are averaged before being entered into the bacterial load dispersion model. In order to model a worst-case scenario, we have assumed that the ship is not moving when the discharge occurs. Furthermore, for simplicity, our model is only predicting the results of a "typical cruise ship" discharging one time under steady state conditions.

3.1.2 Model Development

We chose to use the transport of fecal coliform in our bacterial load model because fecal coliform is an indicator organism. In other words, fecal coliform is not necessarily pathogenic, but it indicates the presence of other pathogenic organisms in the water (California Department of Health Services, 1997). In addition, the coliform group of bacteria to which fecal coliform belongs is used as the principal indicator of the suitability of water for domestic and recreational uses. The reactions and characteristics of this group of bacteria have been studied extensively and the significance of the tests using coliform as a criterion of the degree of pollution in a water body is well established (Franson, 1985). Of the coliform group of bacteria, fecal coliform is considered to be a more specific indicator of the presence of feces and is considered less subject to variation in its test results than total coliform (California Department of Health Services, 1997). Recreational water quality programs worldwide collect water samples, test for indicator bacteria, and use this information to post beach closures and protect recreational users (Noble, Moore et al., 2003).

California itself established fecal coliform as a primary indicator of beach health in 1999, with the passage of Assembly Bill 411. The state changed its ocean recreational bacterial water quality standards from a standard of total coliform tests to one requiring testing which included fecal coliform (Noble, Moore et al., 2003). This bill also adopted standards for fecal coliform set by the Environmental Protection Agency of 400ug/100mL water (400MPN) in a 30-day sampling period (California Department of Health Services, 1997). This means that if one sample taken from recreational waters (such as a state beach) has a fecal coliform count of 400ug/100mL, the beach must be closed.

Assuming steady state conditions and that the flux of fecal coliform along the shoreline is zero, we modeled the amount of fecal coliform that finds its way to the coastline after being released from the cruise ship, while taking into account both eddy diffusivity and the extinction rate of fecal coliform. The equation for the model (See Equation 3.1) is based on a control volume approach to deriving a mass-balance using Fick's Law of Diffusion (Carslow and Jaeger, 1959). Because it does not define a precise domain, this model is unable to give the exact concentration of fecal coliform reaching the shore. However, it does allow us to compare the percent of the original concentration expected to reach the shore under our three regulatory scenarios. This model is run under both average conditions and extreme conditions[7]. In order to examine the effects of cruise ship discharges alone, we assumed that all other sources of pollution entering the ocean are at a constant level.

3.1.3 Model Structure

The bacterial load model predicts the movement of fecal coliform towards the shore. Figure 3.1 below shows how the bacteria are predicted to move from its initial point of discharge to shore. Equation 3.1 mathematically describes this movement. The solutions to Equation 3.1 for both average conditions when v=0 and extreme conditions when v>0 are displayed in Equation 3.2 and Equation 3.3.

Terms:
C_0 = initial concentration (MPN)
D = eddy diffusivity (cm^2/sec)
r = extinction rate of fecal coliform (1/sec)
y = distance traveled by discharge (cm)
L = total distance from point of discharge to shore (max y)
v = velocity of ocean current under extreme weather conditions (cm/s)

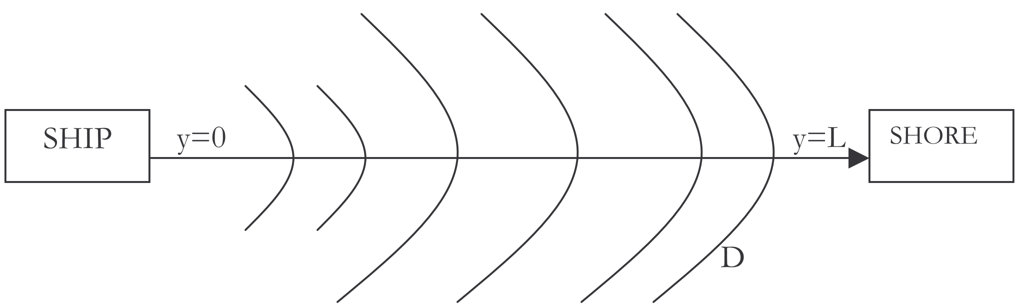

Figure 3.1. Schematic of the Bacterial Load Model

[7] Extreme conditions are defined by current velocities being higher than average.

Boundary Conditions:

1. $C_y = C_0$ when y=0
2. $\left.\frac{\partial C}{\partial y}\right|_{y=L} = 0$ when y=L

$$D\frac{\partial^2 C}{\partial y^2} + v\frac{\partial C}{\partial y} - rC = 0$$

Source: (Bird, Stewart et al., 1960)

Equation 3.1. Equation Describing Fecal Coliform Diffusion Towards Shore[8]

$$C_y = C_O * \frac{\cosh\left[\left(\sqrt{\frac{rL^2}{D}}\right)(1-(y/L))\right]}{\cosh\left(\sqrt{\frac{rL^2}{D}}\right)}$$

Source: (Bird, Stewart et al., 1960)

Equation 3.2. Final Solution for Average Conditions to Equation 3.1

$$C_y = a_1 e^{k_1 y} + a_2 e^{k_2 y} \text{ where } C_O = a_1 + a_2 \text{ and } k = \frac{-v \pm \sqrt{v^2 - 4Dr}}{2D}$$

Equation 3.3. Final Solution for Extreme Conditions to Equation 3.1

Initial Concentrations (MPN):

In all three of our regulatory scenarios, the initial concentration of fecal coliform inputted into Equation 1 was 4.3 x 10^5 MPN (based the data we received from ADEC). We obtained this number by averaging the concentrations over all portholes of each ship and then averaging the values of all ships docking in California. Under Scenario 3 (Task Force Recommendations), treated blackwater and treated graywater may be dumped anywhere, whereas untreated graywater must be taken 3 nautical miles from shore before being discharged. Since the data we obtained included only treated blackwater and untreated graywater (and our previous assumptions stated that graywater and blackwater

[8] See Appendix G for the complete solution to Equation 3.1 under extreme conditions.

are discharged through the same porthole), we have assumed that cruise ships will voluntarily hold treated blackwater until they are 3 nautical miles from shore and will then release the treated blackwater and untreated graywater together. Therefore, we were able to use the same initial concentration for all three scenarios.

Eddy Diffusivity

Flows in the ocean are generally turbulent. In this report, turbulence is defined as a type of random motion that consists of many eddies that increase in size as distance from the point of origin increases (Okubo and Levin, 2000). Therefore, it can be assumed that eddy diffusivity is representative of turbulent motion in the oceans during average weather conditions. We chose to use eddy diffusivity rather than the dilution factor described by both ADEC (Science Advisory Panel, 2002) and in the Task Force report because we are modeling the fate of the pollution if the ships are assumed to not be moving. In addition, turbulence associated with natural environments has horizontal scales much greater than vertical scales; therefore we have only considered the diffusivity of fecal coliform horizontally towards the shore and not vertically towards the ocean floor. We have also assumed that diffusion is only occurring towards shore and not in all directions in order for us to model a worst-case scenario.

We applied the 4/3 power law to determine eddy diffusivity parameters (Okubo, 1971). According to this law, the further the distance is between one point and another (in our case, from ship to shore), the faster the rate of diffusion will be as particles are moved through multiple eddies. Therefore, we inputted appropriate values for D (See Figure 3.1) according to the distance from shore each discharge was made under our regulatory scenarios. These distances are found in Table 3.1. The regulatory scenarios identify y in terms of nautical miles. Table 3.1 converts y into centimeters, which is how it is inputted into our model.

Scenario	y (n. miles)	y (cm)	D (cm^2/sec)
Scenario 1:Federal Regulations[9]	.25	46300	10^3
Scenario 2: California adopts Alaska's regulations	1	185200	$10^{3.5}$
Scenario 3: California adopts CA Task Force recommendations	3	555600	10^4

Table 3.1: Values of y and Eddy Diffusivity Used in Bacterial Load Model

Extinction Rate

The extinction rate coefficient of fecal coliform is dependent on variables such as salinity, water temperature, turbidity and mixing (Steets and Holden, 2003). We used an

[9] The distance from shore used in our Federal Regulations scenario is estimated. The actual regulations allow discharges to occur anywhere and we have assumed that ships would discharge immediately after leaving port or just before entering a port – this distance is estimated to be .25 nautical miles from shore.

extinction rate coefficient determined through laboratory experiments. The conditions used in these experiments are similar to the salinity and temperature conditions found off the coast of California (Gonzalez, 1995). We assumed an extinction coefficient of .0000247 MPN per second.

Velocity of the Ocean Current under Extreme Weather Conditions

A 1989 study tracked the speed and movement of drifters (floating particles) within the Southern California current system. The study concluded that, under average conditions, drifters diffused at a speed comparable to the 4/3 law, even when the mean eddies moved at a rate of 15 cm/s (Poulain and Niiler, 1989). Therefore, in our model, the velocity of the ocean current equals zero under average conditions and only eddy diffusivity was considered as a source of particle transport.

However, we felt it was important to examine the amount of fecal coliform that could reach the shore from cruise ship discharges during storm events, since this fecal coliform number could be substantially higher than typical levels and could pose greater threats to human health. The current velocity we used in our model to represent extreme weather conditions was 20 centimeters per second. We assumed that this velocity was representative of storm current velocities in all three counties.

To determine the current velocity, we searched NOAA's National Climate Data Center Database for storm events in each of the three counties studied. We looked only at data from years 2001-2003 and only at storms classified as "High Wind" in a coastal location or as "Heavy Surf". This storm data had been entered into the database with specific dates and times (National Climate Data Center, 2004). We cross-referenced these dates and times with current data provided by the National Data Buoy Center to assure a more accurate measurement of California current velocity during storm events.

Four buoys off the coast of California supply this data by measuring current direction and speed using the Acoustic Doppler Current Profiler. These buoys are spread both north and south of Point Conception, and although they are not all located directly off the coasts of the counties we examined, this data along with the data supplied by the National Climate Data Center provided us with a representative velocity of currents during storm events in both the Southern California Bight and in Northern California (Figure 3.2). We used the ocean current data from these buoys and matched the dates and times from our storm data to find a mean current velocity heading towards shore during storm conditions.

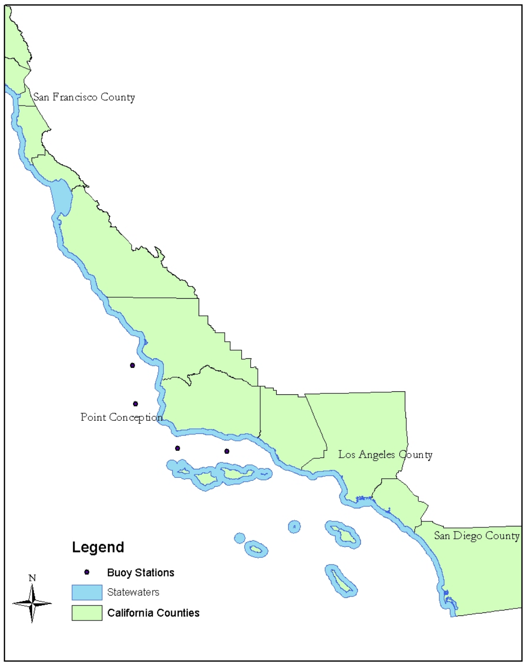

Figure 3.2. Map of Buoys using Acoustic Doppler Current Profile

3.1.4 Expected Results

The following were the expected results from the bacterial load dispersion model:

- There will be significantly more fecal coliform reaching shore under extreme conditions than average conditions.
- More fecal coliform will reach the shore under Scenario 1 than Scenario 2 or 3.

3.2 TRAVEL COST MODEL

Results from our first analysis (the bacterial load dispersion model) gave us the percent change in fecal coliform reaching the shore from cruise ship discharges under each regulatory scenario. This percent change in fecal coliform represents a corresponding change in water quality at California's beaches. It is possible that a degraded coastline (due to an increase in bacteria reaching the shore) may deter or otherwise influence a consumer's decision to visit a beach. Given that assumption, the objective of this economic analysis was to determine how the demand of an environmental good (beach recreation) changes with the quality of that good (water quality at the beach). More specifically, we determined if there is a change in demand for beach recreation at 13 California State beaches with an increase in water quality at those beaches.

In order to analyze this change in demand, we employed a travel cost model. This procedure utilizes travel cost as a price proxy in the estimation of demand relationships (or values) for outdoor recreation (Bell and Leeworthy, 1990). In addition, a travel cost model shows the consumer's willingness to pay for an improvement in an environmental good (e.g. water quality).

3.2.1 Model Structure

The travel cost approach, first suggested by Hotelling and applied to outdoor recreation, recognizes that in order to use the services of a site, individuals from different points of origin must get to the site. Therefore, the relevant measure will vary according to the travel and time costs of getting to the site (Smith, 1996).

The travel cost model (TCM) is based on the recognition that the monetary cost of traveling to a site (i.e. a state beach) is an important component of the full cost of a visit for any given site (Freeman, 2003). In order to complete our travel cost model, it was necessary to acquire information that described from where each beach visitor was traveling.

We acquired travel data from a beach visitor survey through the California State Parks Visitor Services Department. Appendix H shows the survey form that beach visitors were asked to fill out. The survey data was collected either on site while visitors were recreating at the beach, or collected by mail. We used survey data collected between 1994 and 2002. From this survey, we utilized the zip code and city of origin for each visitor to state beaches.

We selected state beaches as the focus of our travel cost analysis because they provided the most readily available data on beach visitation, entrance fees, and water quality measurements. Due to data constraints, we conducted a travel cost analysis on only 13 California state beaches. Table 3.2 shows the seven Northern California state beaches and the six Southern California state beaches that we analyzed.

California State Beach	County
San Gregorio	San Mateo
Pomponio	San Mateo
Pescadero	San Mateo
Half Moon Bay	San Mateo
Montara	San Mateo
Sunset	Santa Cruz
Manresa	Santa Cruz
San Elijo	San Diego
Torrey Pines	San Diego
San Onofre	San Diego
Silver Strand	San Diego
South Carlsbad	San Diego
Bolsa Chica	Orange

Table 3.2. California State Beaches Analyzed in Travel Cost Model

We calculated the cost of travel for each visitor to a particular beach via the travel cost equation (See Equation 3.4). We determined a travel cost value for each visitor and created a distribution of these values. We then determined the median travel cost value for each beach. We utilized this method for all 13 beaches, for a total of 13 travel cost values.

According to the survey data, each of the 13 beaches had several out-of-state visitors; however, the majority of visitors to each of these beaches were from California. The costs for out-of-state visitors to reach these beaches are significantly higher than for those who are traveling from within California. In other words, recreating at a beach cannot be attributed solely to attending the beach. Instead, visitors could be traveling to a site for many recreational activities. Therefore, when determining the travel cost of all out-of-state visitors, we could not attribute the cost directly to attending the beach (Freeman, 2003). Since the majority of visitors to these beaches were from California, the average travel cost value does not accurately represent what consumers are willing to pay to go to the beaches, thus the median travel cost is preferred over the average travel cost value.

3.2.2 Travel Cost Equation

In our analysis, the full price of a beach visit consisted of the following three components: the admission fee, the monetary cost of travel to the beach, and the time cost of travel to the beach (Freeman, 2003).

We calculated travel costs based on one-way travel from the origin to the destination beach as shown in studies conducted by Walsh et al. (Walsh, Johnson et al., 1990) and Bergstrom and Cordell (Bergstrom and Cordell, 1991). Our travel cost model (Equation 3.4) calculates the full price of a visit to the destination state beach by considering the three components of the travel cost model:

$P = a + d*r + (0.6*w)*t$

Equation 3.4. Travel Cost Equation

where,
P = the full price of a visit to the destination site
a = admission fee ($)
d = distance traveled (miles)
r = gasoline reimbursement rate ($)
w = wage rate ($)
t = travel time (hours)

Price of Visit
P represents the full price of a visit to the destination beach taking into consideration the relationships expressed in the travel cost equation.

Admission Fees
We used an entrance fee of $2.00 for all California state beaches. The fees were obtained from the California State Park's web page (www.parks.ca.gov)[10].

Distance Traveled
We calculated the distance traveled from visitor origin to the destination site using MapQuest (www.mapquest.com). MapQuest's data is made up of road links with start and end points and considers various attributes (freeway, over-ramp, one-way, etc); the routing algorithm looks for the shortest route (Frew, 2003).

The origin and destination addresses for the visitors used in this analysis were not available. Therefore, the distance obtained from MapQuest was based solely on zip code of origin to zip code of beach visited. When MapQuest uses zip codes to calculate distance, the algorithm computes distance from the center of the starting point to the center of the destination point (Frew, 2003). Since the beach sites do not have their own zip codes, the zip codes of the cities in which the beaches are located were used to determine the destination point.

Gasoline Reimbursement Rate
We utilized federal reimbursement rates to calculate the cost of travel. This provided a standard mileage reimbursement rate to compute the deductible costs of operating an automobile. We obtained these rates from the Internal Revenue Service web page (kindsvater.com/employ/mileage.html).

The appropriate reimbursement rates were used for each year corresponding to the year the visitor traveled to the beach. These values were then adjusted to bring them into

[10] Admission fees vary from $2.00 - $6.00 depending upon season and location.

2002 dollars. We calculated inflation by utilizing the Consumer Price Index for all urban consumers. The Consumer Price Index (CPI) measures the average change in the prices paid for a market basket of goods and services (U.S. Department of Labor Bureau of Labor Statistics, 2003). Escalation agreements often use the CPI—the most widely used measure of price change—to adjust payments for changes in prices. Please see Appendix K for a description of how we adjusted all values to 2002 dollars.

Wage Rate
We used median wage rate to estimate the occupational wage rate of the people traveling to the destination site. This wage rate represents the visitor's opportunity cost of time. We obtained this information from the United States Bureau of Labor Statistics web page (www.bls.gov). Due to the unavailability of the occupational wage rates of individuals traveling to the destination sites, we estimated the wages by using the median wage rates for 'all occupations'. Since the median wage rate was consistently lower than the average wage rate, we assumed we would be capturing a wider sample of beach visitors by taking into consideration the lower value.

We used 60% of the median wage rate to capture the opportunity cost of time. The wage rate was discounted because the action of traveling to a site is seen as voluntary, and thus does not represent an equal trade-off to time worked. There is considerable debate to what the opportunity cost of recreation travel should be; we chose to use 60% as estimated by McConnel and Strand (McConnell and Strand, 1981).

Travel Time
Travel time is the amount of time taken to arrive at a destination site from a starting point. Visitor travel time was estimated by dividing the distance obtained from MapQuest by 65 miles per hour (MPH). While there is no average MPH across the United States, according to the 2002 Highway Information Quarterly Newsletter (www.fhwa.dot.gov/ohim/hiq/hiqapr02.htm), most of the *Miles of Highway* and *Daily Vehicle-Miles Traveled* are posted at 65 MPH and 70 MPH. Of these two, 65 MPH postings are more numerous than 70 MPH postings; therefore, we chose 65 MPH as the travel speed for our analysis.

Assumptions
A. Myrick Freeman III provided the assumptions that create the basic version of a travel cost model (Freeman, 2003):

1. The wage rate is the relevant opportunity cost of time.
2. All visits entail the same amount of time on site.
3. There is no utility or disutility derived from the time spent traveling to the site.
4. Each trip to the site is for the sole purpose of visiting the site.
5. The individual's choice of where to live is independent of preferences for recreation visits.

For a more particular subset of these assumptions (those that concern the specification of the costs and opportunity costs of visiting a particular site) refer to Randall (Randall, 1994).

The list below states our assumptions specific to our travel cost calculations (Note: these assumptions are in addition to the basic travel cost model assumptions listed above):

1. Each visitor is seen as a household.
2. Consumers do not have other expenses while traveling.
3. All visitors arrived to state beaches by ground transportation.
4. The seven amenities listed reveal differences among beaches (discussed in section 3.2.3).
5. CFU (colony forming unit) are equivalent to MPN (most probable number) in water quality data.
6. The monthly beach attendance for 2002 – 2003 is representative of the time period 1994 - 2003.

3.2.3 Hedonic Equation

The first step of the economic analysis involved using a hedonic equation, whereby the individual's total costs of visiting a site are regressed against the characteristics of the site (water quality, temperature at beach location, and beach amenities). The regression coefficients express what change in Y (dependent variable) is associated, on average, with a unit change in X (independent variables) (Zar, 1999).

According to Jerrold H. Zar (Zar, 1999), the assumptions of a linear regression equation are:

1. For any value of x, there exists a normal distribution of y values.
2. The variances of y values must all be equal to one another.
3. The mean of the y's at a given x lies on a straight line with all other mean y's at the other x's (i.e., the relationship in the population is linear).
4. The values of y come at random and are independent of one another.
5. The measurements of x are obtained without error.

The following formula, referred to as the hedonic equation, yielded the components of the multiple-regression used in this analysis:

$$Y = \alpha + \beta_1 WQ + \beta_2 T + \beta_3 S$$

Equation 3.5. Hedonic Equation

where,
Y = the median price of a visit ($)
WQ = water quality measurements (MPN/100ml)
T = temperature at beach location (F^o)

S = beach amenities (number of amenities)

We chose each regression variable based on the assumption that it is a characteristic a consumer might take into consideration when deciding to visit a beach. According to Bockstael et al. (Bockstael, Hanemann et al., 1987):

The [hedonic travel cost] approach has as its sole focus the valuation of site characteristics. The travel cost model (Brown and Mendelsohn, 1984; Mendelsohn, 1984) attempts to reveal shadow values for characteristics by estimated individuals demands for the characteristics. The approach uses information on the extra costs of accessing a site with higher quality characteristics to estimate the demand for quality.

Water Quality Measurements

This measurement represents the state of the water quality at each beach visited for the time period analyzed in this study. We obtained water quality data from various California County Environmental Health Divisions. Please see Appendix I for a complete list of these agencies and contacts.

We averaged water quality over the months of April to September because this time period represented when most of the surveys were completed. Also, for each of the 13 beaches, the water quality data was averaged over the years that most closely corresponded to the years the survey information was taken; this correspondence was not exact in all cases. The range of years when surveys were completed varied from beach to beach.

In the hedonic equation, the water quality variable was adjusted accordingly for each of the three regulatory scenarios depending upon the percent reduction of fecal coliform provided by the results of our bacterial load dispersion model.

Temperature

The temperature variable captured the state of the weather during which visitors attended the beach sites under analysis. A weather variable was used in this equation because we expected temperature to influence a visitor's decision to recreate at a beach. We obtained the temperatures from historical data located on the Western Regional Climate Center's web page (www.wrcc.dri.edu/climsum.html). The 'average high' temperature was used. Please see Appendix J for a summary of the temperature data from the 13 state beaches used in this analysis.

Beach Amenities

Beach amenities considered in this analysis are services that the beaches provide such as hiking, camping, or wildlife viewing. These amenities may influence a consumer's decision in choosing one beach site over another. The seven categories of beach amenities used in our analysis are:

1. Bike trails
2. Camping
3. Exhibits
4. Guided tours
5. Hiking
6. Picnic areas
7. Wildlife viewing

We counted the number of amenities that each beach had out of the seven listed. We expected visitors would attend beaches that offered more amenities. The amenities used in this analysis were selected in order to create a difference among beaches (swimming and fishing are available at all beaches and thus are not included). Beach amenity information can be accessed at California's State Park web page (www.parks.ca.gov).

From the hedonic equation, we also obtained the predicted price of travel. In order to account for simultaneity (refer to Section 3.2.4), the predicted price was then inputted into the Cobb-Douglas demand equation.

3.2.4 Cobb-Douglas Demand Equation

The second step of our statistical analysis used the Cobb-Douglas demand equation (See Equation 3.6). This equation was fit to estimate the elasticity of demand for beach visitation. The elasticity is a constant value along the demand curve in this function.

$$\log(Q) = \alpha + \beta_1\log(F) + \beta_2\log(M) + \beta_3\log(N)$$

Equation 3.6. Cobb-Douglas Demand Equation

where,
Q = quantity of visitors to each beach in the sample (visitors/month)
F = "predicted" full price of visit ($)
M = average median household income for the counties of origin for each visitor ($)
N= average number of substitute site characteristics

We used the two-stage least squares method to account for simultaneity. Simultaneity is where the quantity and price are determined at the same time in a market (Aigner, 2003).

Quantity of Visitors
Q represents the demand of consumers to visit the beach. We represented this demand by calculating the average number of visitors per month between April and September for all 13 beaches, resulting in a total of 13 values. The months of April, May, and June were from the year 2003, while the months of July, August, and September were from the year 2002. This was due to the attendance data being taken from the fiscal year of July 2002-June 2003. The attendance data was not averaged over multiple years because

data was only available for the fiscal year of July 2002-June 2003. This information was acquired through the California State Parks Visitor Services Department (Sullivan, 2003).

Predicted Price

The predicted price can be viewed as the 'predicted' travel cost value taking into consideration the beach characteristics described above (water quality, beach amenities and temperature). The predicted price was calculated using the hedonic equation and then input into the demand equation as the 'price variable' in order to satisfy the two-stage-least-squares methodology.

Median Household Income and Substitution Site Amenities

The median household income value was calculated at the county level by averaging the median household income of all visitors who visited each beach. Therefore, each beach only had one value that represented the average median household income. The household income corresponded to the years the visitors visited the beach according to the survey data. The dollar value was made equivalent to 2002 dollars using the CPI.

The average number of beach amenities for substitute sites was determined by taking the average number of beach amenities offered at nearby beaches. For example, in Southern California, by averaging the beach amenities at all beaches except Torrey Pines, the average number of beach amenities of substitute sites was determined for Torrey Pines. Beach amenities at substitute sites were included in this analysis because we assumed beaches that offer different services will influence a consumer's decision on which beach to choose. Freeman (2003) states that if the travel costs of the relevant substitute sites were omitted from the estimated equation, its parameters would be biased. Rather than using travel costs to substitute beaches, we used attributes as a proxy.

The output of this regression analysis allowed us to graph the demand for recreation at the beaches studied. The x-axis represented *quantity*, which was the number of visitors that attended the beaches, and the y-axis represented the *price* of visiting the beach.

3.2.5 Expected Results

We expect to see the following results from our economic model and subsequent analyses:

1. Consumers pay more to attend beaches of higher water quality.
2. Beach visitation is positively correlated with beach temperature.
3. The more income a household generates, the more often beach visitation occurs.
4. Visitors will attend beaches that offer more amenities.

3.3 PRIORITY POLLUTANT DISPERSION MODEL

The priority pollutant dispersion model predicts the dispersion of heavy metals and other pollutants in the water column and calculates the concentration of these pollutants after a period of 96 hours. These pollutant concentrations are then compared to the sensitivity of various marine organisms to determine if cruise ship wastestreams have the potential to produce negative impacts on species in marine communities

3.3.1 Model Development

In addition to potentially harmful bacteria, cruise ships discharge heavy metals and other contaminants identified by the Environmental Protection Agency as "priority pollutants". Priority pollutants are defined by section 307(a) of the Clean Water Act. They are defined as toxic chemicals that are particularly harmful to animal or plant life. The EPA has identified these priority pollutants as having the potential to harm organisms within the marine environment. According to Alaska state law 46.03.460 – 46.03.490, the Alaska Department of Environmental Conservation requires cruise ships traveling in Alaskan waters to test for these priority pollutants prior to discharge and report the resulting concentrations annually (Alaska Department of Environmental Conservation, 2002). This model predicts the average concentration of priority pollutants within a calculated volume of seawater while taking into account eddy diffusivity[11] of pollutants in an oceanic environment, the initial load of pollutants from one cruise ship discharging one time, and the average depth of discharge associated with each regulatory scenario.

3.3.2 Model Structure

Terms:
P_0 = initial concentration of pollutant discharged (μg/L)
P_S = concentration of pollutant remaining in the water column (μg/L)
V = volume of water discharged (L)
D = domain ($\pi L^2 h$)
C^2 = characteristic area of dispersion (m^2)
t = critical time period (96hr)
d = diffusivity ($100 cm^2/sec$)
h = ocean depth

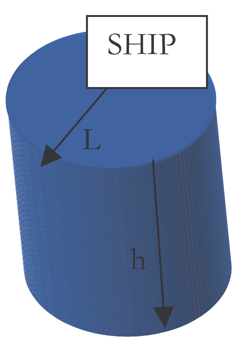

Figure 3.3. Schematic of Priority Pollutant Dispersion Model

[11] Refer to Section 3.1.3 for an explanation of eddy diffusivity.

$$\frac{P_0 * V}{D} = P_S \text{ where } D = \pi C^2 h \text{ and } C^2 = td$$

Equation 3.7. Equation for Priority Pollutant Dispersion Model

Initial Concentration
Only the fate of dissolved constituents from cruise ship wastestreams was modeled using our priority pollutant dispersion model. The constituents have densities greater than seawater and therefore over time, rather than float to shore like bacteria, these pollutants will either react with organic particles, and be removed from the water column to the sediments, or will remain suspended in the water column. These concentrations of these constituents, in both dissolved and total form, are listed in Table 3.3.

Pollutant	Total (μg/L)	Dissolved (μg/L)
Antimony	0.57	0.56
Arsenic	6.95	6.78
Bis(2-ethylhexyl) phthalate	N/A	13.69
Copper	150.17	31.68
Di-n-butylphthalate	N/A	3.49
Lead	9.80	4.36
Nickel	17.92	17.13
Selenium	12.53	12.53
Silver	0.67	0.40
Tetrachloroethene	N/A	1.54
Zinc	340.32	287.18

Table 3.3. Total and Dissolved Concentrations of Priority Pollutants Discharged

Dissolved pollutants reach the seafloor through reactions with large particles in the ocean. The largest transporter of heavy pollutants is marine snow. Marine snow includes a variety of particles ranging in size from 0.5mm to many centimeters in diameter. These particles have been shown to be an important pelagic food source and a mechanism for transporting surface-derived materials to depth at intermediate sinking rates of 50-100 meters per day (Alldredge, 1982). The total concentration of priority pollutants reported by ADEC[12] include dissolved pollutant concentrations as well as pollutants that were bound to organic particles while in the holding tanks of cruise ship. The concentration of pollutants that are adsorbed to organic particles, prior to discharge, were predicted to fall out of the water column rapidly in a period of one to four days

[12] Refer to Appendix F for total concentrations of pollutants reported.

based on the above reported sinking rates and the shallow depths[13] examined in this model. The adsorbed pollutants will be examined using the sinking load model in Section 3.4.

In contrast, dissolved concentrations of the priority pollutants will remain in the water column for a period of time before binding to particles and "sedimenting out" of the water column. Different pollutants bind to particles at varying rates. According to Ballistrieri and Murray, the dissolved constituents used in our model bind to particles in the water in a period of greater than five days (Balistrieri and Murray, 1984). Adsorption rates vary according to pH, concentration of other metals in the water column, and molecular structure. The typical rates of adsorption for heavy metals ranged from .8% to 78% adsorbed over a period of twenty days (Balistrieri and Murray, 1984). Therefore, it is assumed that the dissolved constituents used in our model will remain in the water column during the defined time period of 96 hours and will not be a contributor to concentrations in the sediments during this time period.

Characteristic Length of Diffusion

The domain, or volume, of our model has been determined by examining the characteristic length (L^2) of diffusion for metals in the ocean water and the depth associated with discharges under each of the regulatory scenarios. To determine L^2, we used a typical rate of diffusion for metals in ocean water (100 cm^2/sec) (Okubo, 1971) and multiplied this by the critical amount of time used to determine acute toxic effects to organisms. This critical amount of time is defined as 96 hours as determined by LC50 96hr values[14]. Diffusivity in the ocean is known to occur in the form of eddies (Okubo, 1971), therefore we estimated the radial distance of diffusion away from the point of discharge using L^2. Based on the rates of adsorption reported above, we have assumed that prior to 96 hours none of the dissolved metals will have adsorbed onto marine particles and therefore none of the dissolved pollutants would have "sedimented out" of the water column.

Height

The height of our domain was determined by the point depths associated with the required discharge distances used for each of our three regulatory scenarios (See Table 3.1 for distances). For San Francisco, we measured the distance from shore starting from the west side of the Golden Gate Bridge, rather than from inside the San Francisco Bay (U.S. National Ocean Service, 1989). This decision was based on the assumption that cruise ships will wait to discharge until they have left the bay and are in the open ocean. We measured the distance in San Diego from the point at which the San Diego Bay interfaces with the ocean near Point Loma (U.S. National Ocean Service, 1989). In Los Angeles, we measured distance from shore beginning at the cruise ship dock within the Port of Los Angeles (U.S. National Ocean Service, 1989).

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13 Depths for all scenarios evaluated do not exceed 32 meters.

14 LC50 refers to the lethal concentration at which 50% of the organism tested experiences mortality in a period of 96 hrs (U.S. Environmental Protection Agency, 2003).

Furthermore, we have assumed that cruise ships travel within the shipping lane when leaving a port. While we are aware that cruise ships do not necessarily stay in the shipping lanes during their voyage into and out of ports of call, for the purpose of this project we have chosen the shipping lanes as our case study of one likely route the ships may take out of ports. It is important to note, however, that depths inside the shipping lanes are on average no more than 5 to 10 meters different from depths outside the shipping lanes (U.S. National Ocean Service, 1989; U.S. National Ocean Service, 1989; U.S. National Ocean Service, 1989). Therefore, even if the cruise ships took an alternate route, we are likely to see the same results.

3.4 SINKING LOAD MODEL

3.4.1 Model Development

Although the priority pollutant dispersion model predicts the concentration of dissolved metals in the water column over a period of 96 hours, the model does not take into account heavy metals adsorbed to organic particulate matter prior to discharge. Adsorbed metals attached to suspended particles are not readily bioavailable to organisms in the water column due to their large surface area, however, these metals are ultimately available to organisms in the benthic system were they rapidly settle since complexation/dissociation reactions and adsorption/desorption reactions continually exchange free ions with seawater (Tetra Tech, 2004). These reactions frequently lead to an increase in the bioavailability of some heavy metals for animals and plants. Therefore, for the purposes of our model we have assumed that the concentrations of adsorbed metals in the pore waters will be bioavailable to benthic organisms.

These adsorbed metals, along with concentrations of dissolved metals, are measured as part of the total concentrations of priority pollutants reported by ADEC[15]. Referring back to Table 3.3**,** it is evident that a large percentage of some priority pollutants (such as copper and zinc) are in the form of adsorbed metals. In order to assess the potential effects of these adsorbed metals to benthic marine communities, the sinking load model predicts the average concentration of heavy metals within the pore water[16] of the benthos, after taking into account eddy diffusivity[17] of pollutants in an oceanic environment, the initial load of pollutants from one cruise ship discharging one time, an average height of water at the ocean-sediment interface, and the sinking rate of these pollutants.

Priority pollutants, including Tetrachloroethene, Bis(2-ethylhexyl) Phthalate, and Di-n-butylphthalate, were not modeled using the sinking load model, because these compounds are not heavy metals and therefore, due to their low specific gravity and lack

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[15] Refer to Appendix F for total concentrations of pollutant reported.

[16] Pore water is defined as the water filling the spaces between grains of sediment (Toxic Substances Hydrology Program, 2003).

[17] Refer to Section 3.1.3 for explanation of eddy diffusivity.

of reactivity with organic particles, will remain in the water column indefinitely. Selenium was also not modeled as this metal was only in dissolved form prior to discharge (See Table 3.3).

3.4.2 Model Structure

Terms:
T_o=initial concentration of total metal discharged
D_0 = initial concentration of dissolved metals discharged (μg/L)
C_S = concentration of adsorbed heavy metals within the pore water layer of the sediment (μg/L)
V = volume of water discharged (L)
L^2 = characteristic length of dispersion (m^2)
t = critical time period (96hr)
d = diffusivity (100cm^2/sec)
h=height of pore water layer (0.1 m)

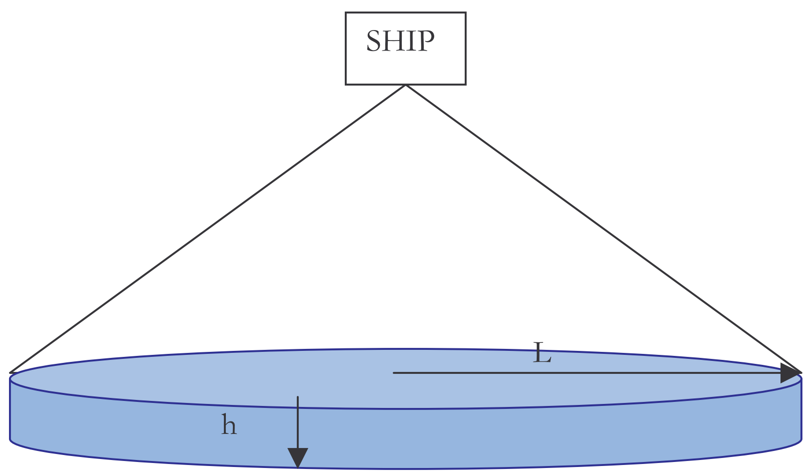

Figure 3.4. Schematic of Sinking Load Model

$$\frac{(T_0 - D_0) * V}{D} = C_S \text{ where } D = \pi L^2 h \text{ and } L^2 = td$$

Equation 3.8. Equation for Sinking Load Model

Initial Concentration
Table 3.4 summarizes the concentrations of adsorbed heavy metals that were used in the sinking load model to determine the concentration of these heavy pollutants in the pore water of the benthic sediments. These concentrations are the total concentration minus the dissolved concentrations of metals reported above in Table 3.3.

Pollutant	Adsorbed Concentration Prior to Discharge (μg/L)
Antimony	0.01
Arsenic	0.17
Copper	118.49
Lead	5.44
Nickel	0.79
Silver	0.27
Zinc	53.14

Table 3.4. Concentration of Adsorbed Heavy Metals Prior to Discharge

As mentioned previously, these adsorbed metals will sink to depths at an intermediate sinking rate of 50-100 meters per day (Alldredge, 1982). Therefore, it can be expected that adsorbed metals will arrive at the seafloor in the defined time period of 96 hours for all three regulatory scenarios and all three ports investigated due to the shallow depths[18] examined in this model. Because these metals are sinking rapidly and concentrate at the ocean-sediment interface, the domain can be visualized as a thin cylindrical layer of water in contact with the sediments.

Characteristic Length of Diffusion

Similarly to the priority pollutant dispersion model, the domain (or volume) of our model has been determined by examining the characteristic length (L^2) of diffusion for metals in the ocean water. Again, to determine L^2 for this model we used a typical rate of diffusion for metals in ocean water (100 cm^2/sec) and multiplied this by the critical amount of time used to determine acute toxic effects to organisms, defined as 96 hours.

Height

The difference between this model and the priority pollutant model is that the height of the sinking load domain is determined to be only the layer of water directly above and in contact with the sediment. We believe this is a reasonable assumption due to the fact that these heavy metals sink rapidly to the seafloor and accumulate there in higher concentrations than the surrounding seawater (United Nations Environment Programme, 2004). For the purposes of this model we have defined the height of pore water to be 0.1. This is a conservative estimate because this height is fifty times greater than the average diameter of gravel particles[19] that defines the upper range of sediment sizes (Rosati, 2001).

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[18] Depths for all scenarios and all ports evaluated do not exceed 32 meters.

[19] Gravel is classified as particles ranging in size from 2.0 to 20.00 mm (Rosati, 2001).

3.5 SPECIES SENSITIVITY ANALYSES

After utilizing the priority pollutant dispersion model to determine the concentration of pollutants in the water column after 96 hours, and the sinking load model to determine the concentration of heavy metals in the pore water of the sediments, we then analyzed if the predicted concentrations of priority pollutants would be acutely toxic to species within the marine community. This was accomplished by running species sensitivity analyses for all of the metals and pollutants pertinent to our study.

Using the Environmental Protection Agency's Ecotox database (www.epa.gov/ecotox), we found the lowest concentration of each pollutant that caused 50% mortality (LC50) for various salt-water aquatic species during a test period of 96 hours. We chose to plot 96-hour LC50 data because although data existed for other acute and chronic toxicity endpoints, LC50 96 hour tests are the most common toxicity test performed. We were therefore able to provide the largest amount of consistent data for our analyses using LC50 96 hour tests. This allowed us to look at each pollutant using the same endpoint (mortality), and we believe this makes our predictions as accurate as possible. For the sinking load model, we used only benthic species, defined as species that spend their entire lives on the sea floor, as these species will be exposed to the concentrations in the pore water continuously.

We then plotted the LC50 96 hour test results of each species using a probit scale and inserted a logistic trendline to describe the distribution of species sensitivity for each pollutant (Figure 3.5 below). Plotting concentration on a log scale and percent affected on a probit scale mathematically transforms the data to appear linear and facilitates comparisons between toxicants and their effects on organisms. Probit scales rely on the assumption of a Gaussian distribution of a population or community to straighten the plot and allow for extrapolation of percent response given a certain concentration of toxicant. Concentration is expressed as the log of the concentration, and percent affected is expressed in multiples of the standard deviation. The relationship between probit and percent affected (% response) is shown in Table 3.5 below (Coppoc, 2004).

Figure 3.5 represents the relationship between toxicant concentration and response (effect) wherein all possible degrees of response between minimum detectable response and a maximum response are producible by varying the toxicant concentration (i.e. the curve is continuous).

Table 3.5 shows the relationship between standard equivalent deviants and probits. Percent affect is not linearly related to probit because the probit scale relies on a Gaussian distribution (Coppoc, 2004).

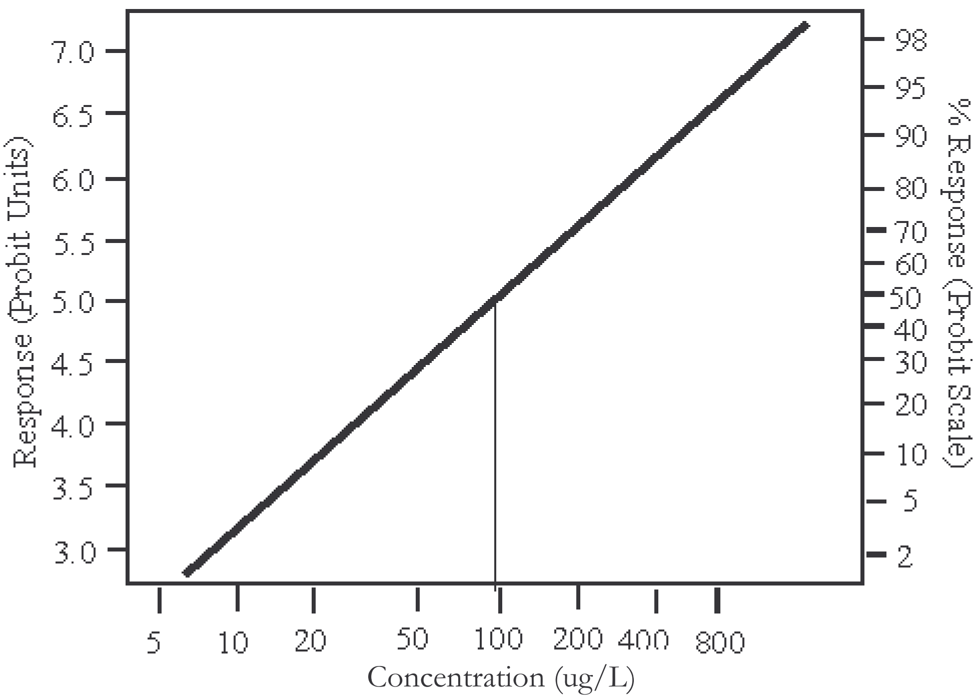

Figure 3.5. Sample Probit Plot[20]

[20] Distribution of Percent Responding is on the right-hand side and the distribution by Probability (Probit) is on the left-hand side.

Percent Responding	Normal Equivalent Deviate (Std. Dev.)	*Probit*
99.9	+3	8
97.7	+2	7
84.0	+1	6
50	0	5
16.0	-1	4
2.3	-2	3
0.1	-3	2
$\pm$ 1 SD (16% to 84%) includes 67% of the population $\pm$ 2 SD (2.3% to 97.7%) includes 95% of the population $\pm$ 3 SD (0.1% to 99.9%) includes 99.7% of the population		

Table 3.5. Relationship Between Percent Responding, Standard Equivalent Deviates and Probits

Species used in the species sensitivity distribution were not all native species to California. Instead, the species used are defined as ecotoxicology test species, and are meant to represent the sensitivity of the family from which they belong (Sutter II, Efroymson et al., 2002). Therefore, while some of the species we obtained data for are not found in California waters, we assumed that these species are representative of the sensitivity of the family to which they belong. Based on this assumption, representative species correspond to equivalent organisms found in California waters.

To attempt to address this discrepancy, we constructed a species sensitivity distribution for Monterey Bay using only species native to this location for the constituent copper. The results of this supplementary analysis can be found in the discussion (See Figure 5.1). With an assortment of families represented on the species sensitivity plots, each trendline describes the sensitivity of an entire marine community to a specific pollutant. While some of the data within the Ecotox database was collected in the laboratory and not the field, we assumed that these laboratory results were valid estimates of the consequences of pollution in the natural environment as they were conducted using parameters similar to those found in the natural salt-water environment.

3.5.1 Expected Results

The following were the expected results from the sinking load model and species sensitivity analyses:

- There will be acute toxicity effects to organisms from the concentrations of pollutants discharged.
- Copper, lead and zinc will show the greatest toxicity effects.

4 RESULTS

4.1 Bacterial Load Dispersion Model

The results of our bacterial load model predicted the percent of the original fecal coliform concentration that will reach California's coastline from the discharge of one typical cruise ship under the three regulatory scenarios.

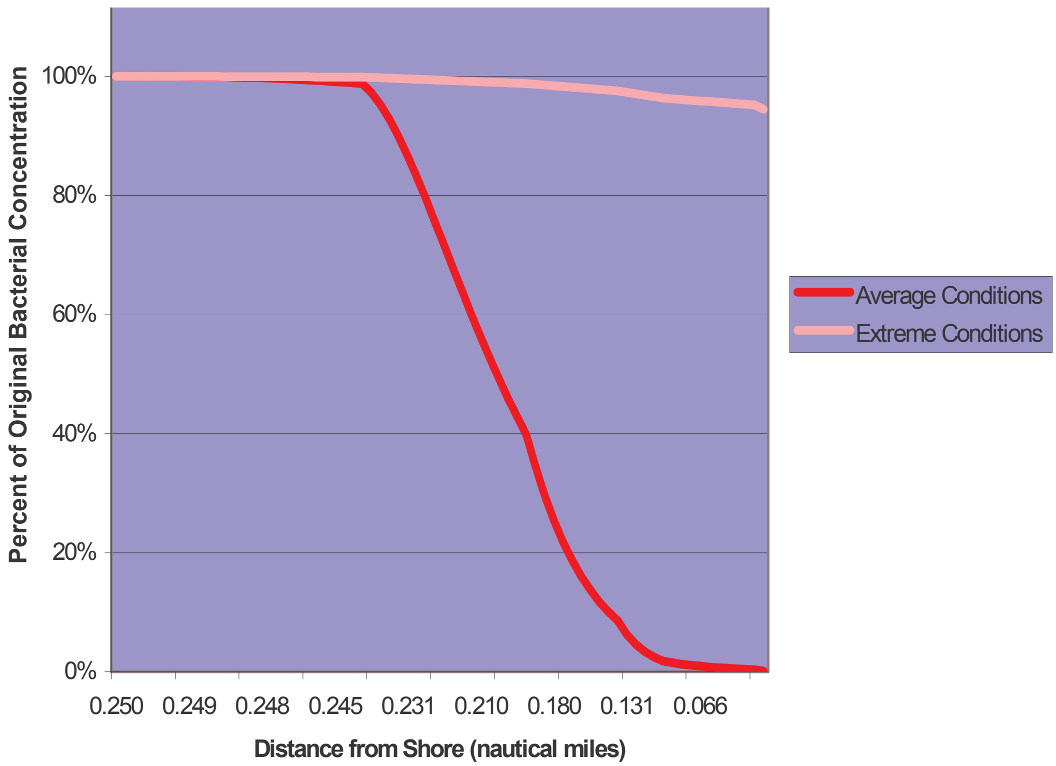

Figure 4.1. Diffusion of Fecal Coliform Bacteria Towards Shore Under Scenario 1

Scenario 1: Federal Regulations

Figure 4.1 shows that during extreme weather conditions, our model predicts that 94% of the original bacterial concentration released reaches the shore when discharged according to current Federal regulations (0.25 nautical miles from shore). In contrast, during average weather conditions, only 0.14% of the original concentration discharged reaches the shore.

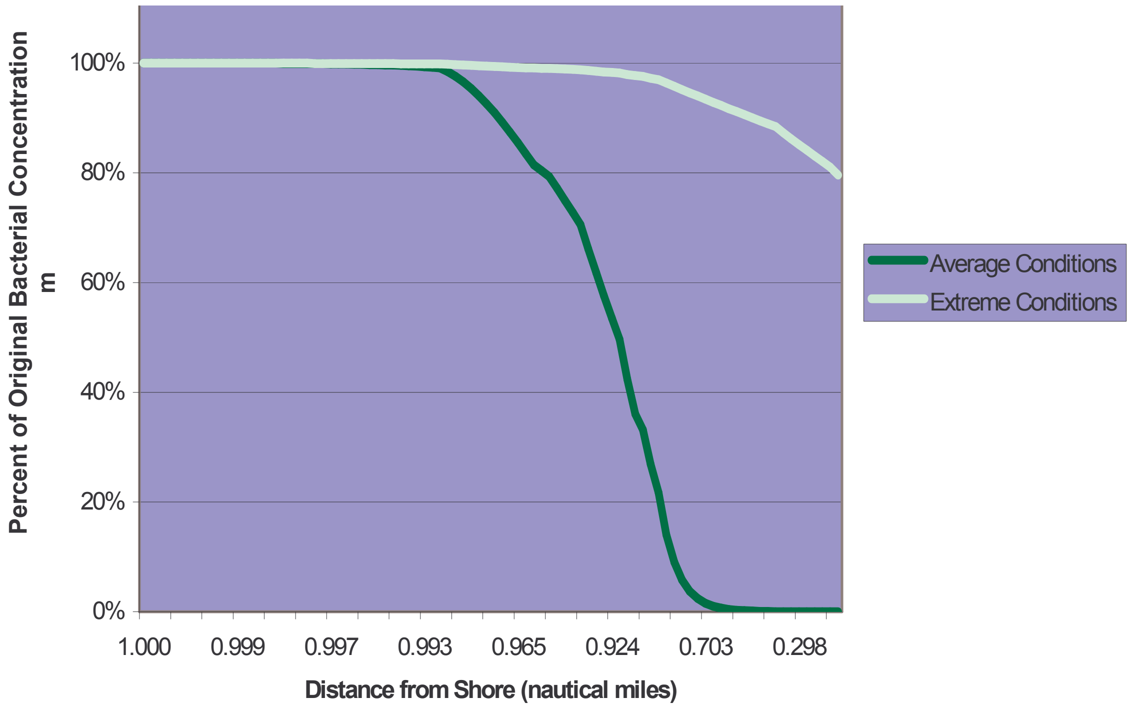

Figure 4.2. Diffusion of Fecal Coliform Bacteria Towards Shore Under Scenario 2

Scenario 2: California Adopts Alaska State Regulations
Modeling Alaska's regulations under extreme weather conditions, we see 79.6% of the original bacterial concentration reaching the shoreline. In contrast, less than 0.01% of the original bacterial concentration reaches the shore in average weather conditions (See Figure 4.2). This is only a 15% decrease in the bacterial concentration reaching the shore in average conditions as compared to Federal regulations, even though Alaska's discharge is made 4 times further from the shore.

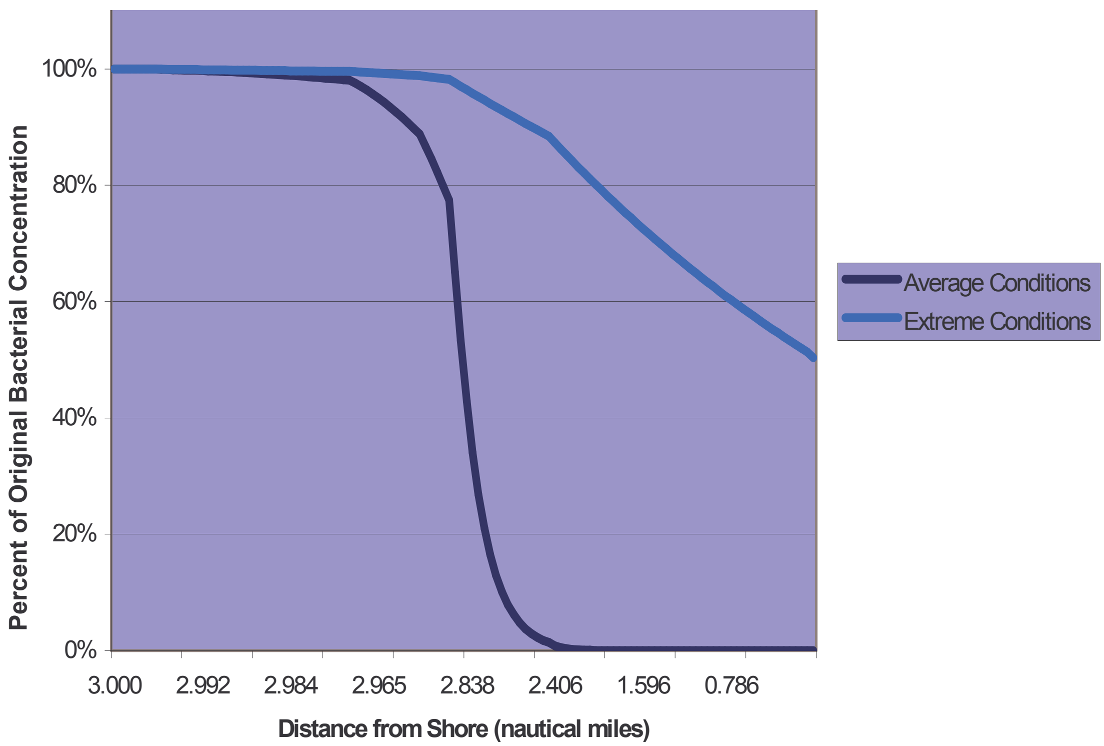

Figure 4.3. Diffusion of Fecal Coliform Bacteria Towards Shore Under Scenario 3

Scenario 3: California Adopts Task Force Recommendations
Figure 4.3 shows that if California were to adopt the Task Force recommendations, 50% of the original fecal coliform concentration reaches the shore under extreme conditions. This is 44% less than what reaches the shore under Scenario 1 and 30% less than what reaches the shore under Scenario 2. In contrast, less than 0.001% of the original bacterial concentration reaches the shore under average weather conditions.

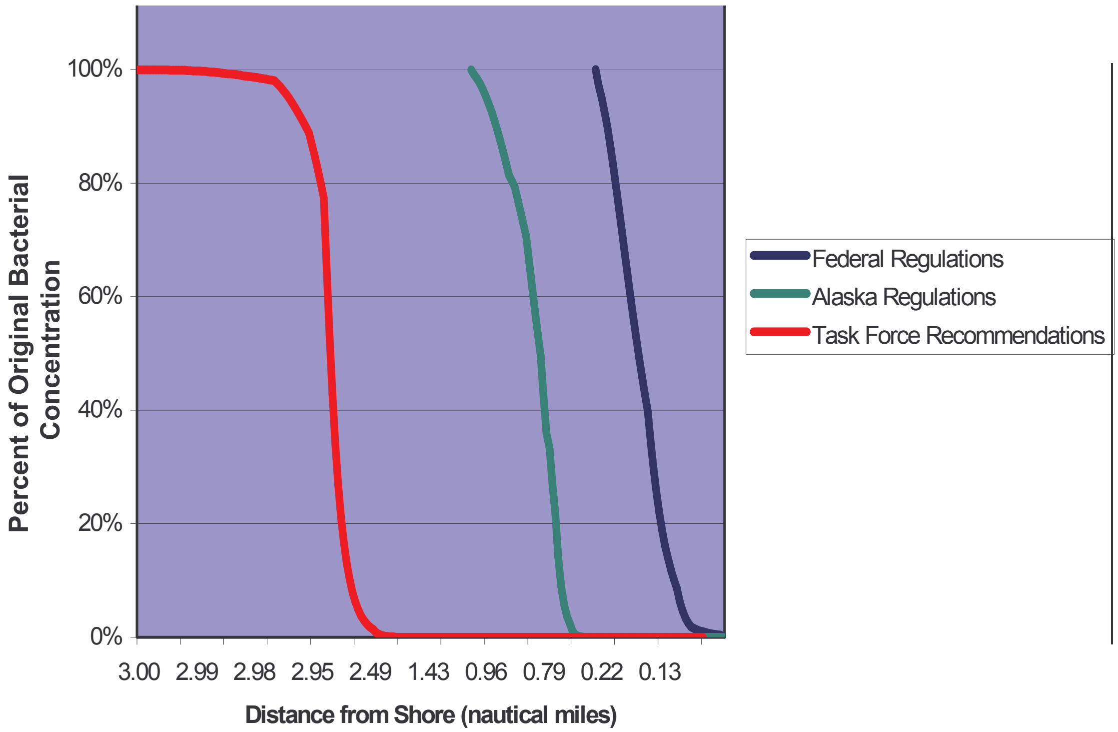

Figure 4.4. Diffusion of Fecal Coliform Bacteria Towards Shore under Average Weather Conditions

Summary of Scenarios

During average weather conditions, the bacterial concentration reaching shore is extremely small, such that the main portion of the wastestream has diffused out after a distance of only 0.5 nautical miles from the location where it was discharged. Specifically, our results show that under Federal Regulations only 0.14% of the original bacterial concentration reaches the shore. Under the other two scenarios, the percentage of the original concentration reaching the shore is exponentially less. (See Figure 4.4)

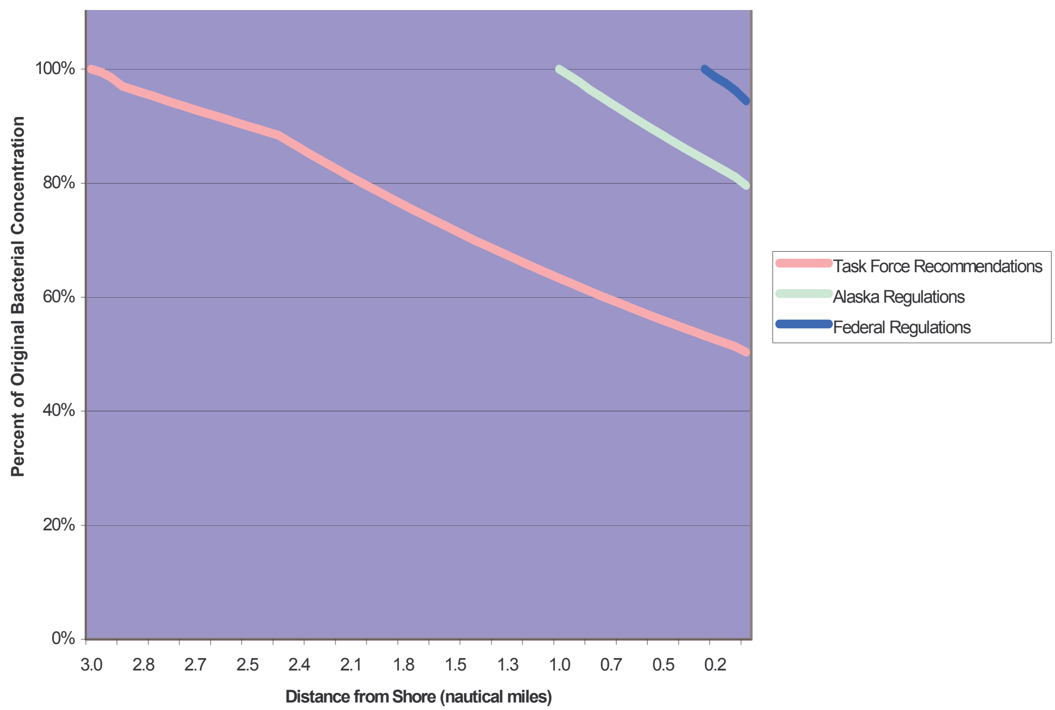

Figure 4.5. Diffusion of Fecal Coliform Bacteria Toward Shore under Extreme Weather Conditions

Under the extreme weather scenario, the concentration of fecal coliform reaching the shore is significantly greater than during average weather conditions. These results show that when current speed is accounted for as a factor bringing the discharge towards shore, a much greater concentration of bacteria reaches the shoreline than under average conditions (See Figure 4.5).

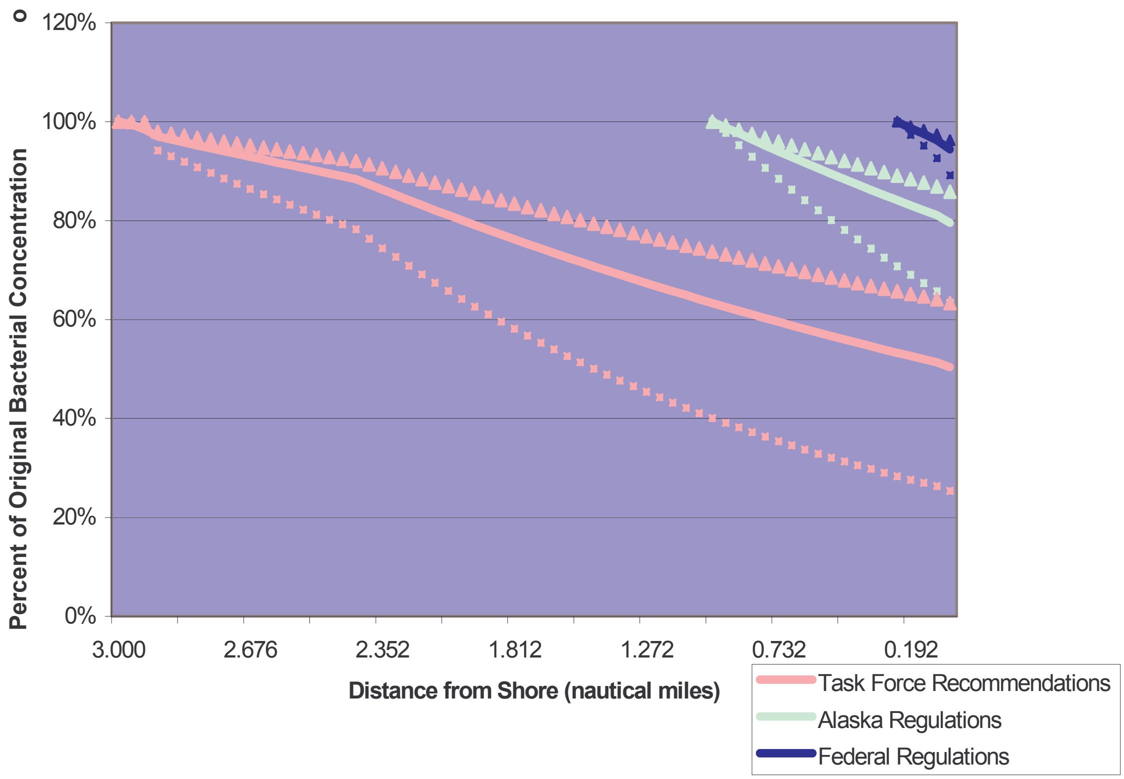

Figure 4.6. Sensitivity Analysis of Current Velocity on Extreme Conditions Results

Velocities under extreme conditions are liable to be variable. The current velocity we used to measure the percent of the original bacterial concentration reaching the shore was 20 centimeters per second. In this sensitivity analysis, we examined the results if the current velocity were 10 centimeters per second (marked on Figure 4.6 with squares) and if it were 30 centimeters per second (triangles). Figure 4.6 shows that even when current velocity is reduced by half under both the Alaska Regulations and Federal Regulations scenarios, still greater than 50% of the original bacterial concentration reaches the shore.

4.2 TRAVEL COST MODEL

Price of Visit

Using the travel cost equation (See Equation 3.4), we found the median travel cost to range from $10.41 - $57.62 per visit[21]. Consumers paid the most to travel to Sunset State Beach and paid the least to travel to Bolsa Chica State Beach. The results are summarized in Table 4.1.

Beach	Median of Calculated Travel Cost
Bolsa Chica	$10.41
Montara	$13.11
Silver Strand	$13.79
Torrey Pines	$17.87
Manresa	$25.81
Pescadero	$28.05
San Gregorio	$28.27
Pomponio	$29.11
Half Moon Bay	$29.88
San Onofre	$30.59
South Carlsbad	$36.80
San Elijo	$39.34
Sunset	$57.62

Table 4.1. Median Travel Costs for California State Beaches, 1994 – 2003

4.2.1 Statistical Analysis of Hedonic Equation

Temperature

The mean temperatures between April and September for all 13 beaches were similar. The average temperature during this time was 66.07 (^{o}F) (+/- 2.19).

Water Quality Measurements

All 13 beaches, with the exception of Torrey Pines and Bolsa Chica State Beaches, had water quality measurements of $\leq$15.4 MPN/100 ml. The fecal coliform standard set by the EPA for a beach closure is 400ug/100mL water (400 MPN/100 mL).

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[21] Each beach's visitor survey data consisted of different ranges of years, with some overlap. Refer to Appendix M to see the years at which the surveys were taken for each beach.

Beach Amenities

Each beach had an average of three amenities; the amenities offered most often were hiking, camping, and picnicking. Pescadero, Half Moon Bay, and Sunset State Beaches contained the widest variety of recreational activities (five of the seven analyzed). Torrey Pines State Beach had only one amenity available (picnicking). Results are summarized in Table 4.2 below.

Beach	Picnic Areas	Hiking	Camping	Wildlife Viewing	Exhibits	Guided Tours	Bike Trails
San Gregorio	1	0	0	1	0	0	0
Pomponio	1	1	0	0	1	0	0
Pescadero	1	1	0	1	1	1	0
Half Moon Bay	1	1	1	0	1	0	1
Montara	0	1	0	0	0	0	1
Sunset	1	1	1	0	0	1	1
Manresa	0	0	1	0	0	1	0
San Elijo	0	1	1	0	1	0	1
Torrey Pines	1	0	0	0	0	0	0
San Onofre	0	1	1	0	0	0	0
Silver Strand	1	0	1	0	0	0	0
South Carlsbad	1	0	1	0	1	0	0
Bolsa Chica	1	0	1	0	0	0	1

Table 4.2. Summary of Amenities at Beaches Analyzed

Figure 4.7[22] summarizes the results that were inputted into the hedonic equation. The x-axis lists all 13 beaches. The first seven beaches are in Northern California; the remaining six are in Southern California. The variables of median travel cost, temperature, water quality, and number of beach amenities have dissimilar units; therefore, the y-axis is unlabelled. This is an uncommon approach; however, in this case the variables can be depicted in this manner.

[22] Note: higher average water quality values correspond to lower water quality.

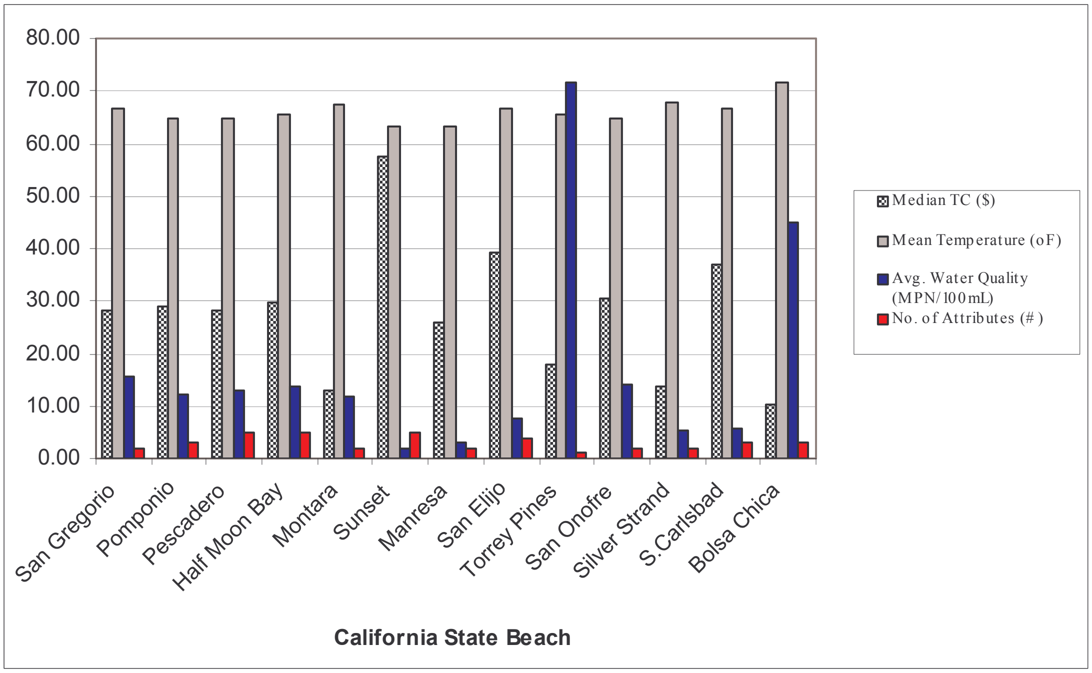

Figure 4.7. Calculated Variables for Use in the Hedonic Equation

Table 4.3 details the results after inputting these values into the hedonic equation; the values were estimated using an Ordinary Least Squares regression (OLS).

Summary Output:	Coefficients	P-value	Lower 95%	Upper 95%
Intercept	199.92	0.04	10.30	389.54
Weather (°F)	-2.77	0.06	-5.63	0.09
Water Quality (MPN/100ml)	-0.09	0.56	-0.43	0.25
Beach Amenities	4.13	0.08	-0.60	8.86
Regression Statistics				
R Square	0.63			
Significance F	0.03			

Table 4.3. Results of the OLS regression of the Hedonic Equation

The estimated coefficient for water quality was -0.09. Therefore, as anticipated, our model predicted that as water quality increases, people will pay more to visit a California state beach. However, the estimated water quality result showed that $p>0.05$, so *the null hypothesis cannot be rejected.* In other words, water quality does not significantly affect the price people are willing to pay to visit a beach.

The coefficient for beach amenities was 4.13. This means that the addition of one more amenity at a beach is worth $4.13 to the visitor. Therefore, beach amenities will influence a consumer's decision to attend one beach over another. This result is not significant at the 95% confidence level. However, using a 90% confidence level, this result is significant.

According to the temperature coefficient, people travel further to go to colder beaches, which is counter intuitive. This result cannot be stated with 95% confidence ($p>0.05$). However, this result is significant if a 90% confidence level is used.

The R^2 value of 0.63 indicates that the regression model we used was a good fit to our data.

4.2.2 Statistical Analysis of Cobb-Douglas Demand Equation

Table 4.4 shows the results that were estimated using a two-stage least squares regression of the Cobb-Douglas demand equation. The results show that the demand for beach recreation as a function of price is inelastic ($p>0.05$). The price elasticity of demand was -0.69, thus, for every one percent change in price, there is a 0.69 percent change in quantity in the opposite direction.

The household income result was -0.59. Therefore, as household income decreases, beach visitation increases, which suggests that beach visitation is an inferior good. The p-value equals 0.83, so this result cannot be stated with confidence ($p>0.05$).

The coefficient of substitute site amenities shows that as amenities at substitution sites decrease, visitation will increase to the destination beach, as expected. This result cannot be stated with 95% confidence. However, this result is significant using a 90% confidence level.

The R^2 value of 0.59 indicates that the regression model we used was a good fit to our data.

Summary Output	Coefficients	P-value	Lower 95%	Upper 95%
Intercept	10.44	0.41	-16.34	37.21
Predicted Price	-0.69	0.30	-2.12	0.74
Household Income	-0.59	0.83	-6.58	5.39
Substitute Site Amenities	-3.92	0.10	-8.79	0.96
Regression Statistics				
R Square	0.59			
Significance F	0.04			

Table 4.4. Results of the Cobb-Douglas Demand Equation

The Cobb-Douglas curve, with elasticity of 0.69, was evaluated at the price of visit (given from the travel cost equation), the mean of household income, and the mean of substitute beach amenities in order to obtain the demand for beach recreation. The graph is based upon the results given in Table 4.4.

Figure 4.8 shows the demand for beach recreation. Price is the y-axis and quantity is the x-axis. The demand line is downward sloping and inelastic.

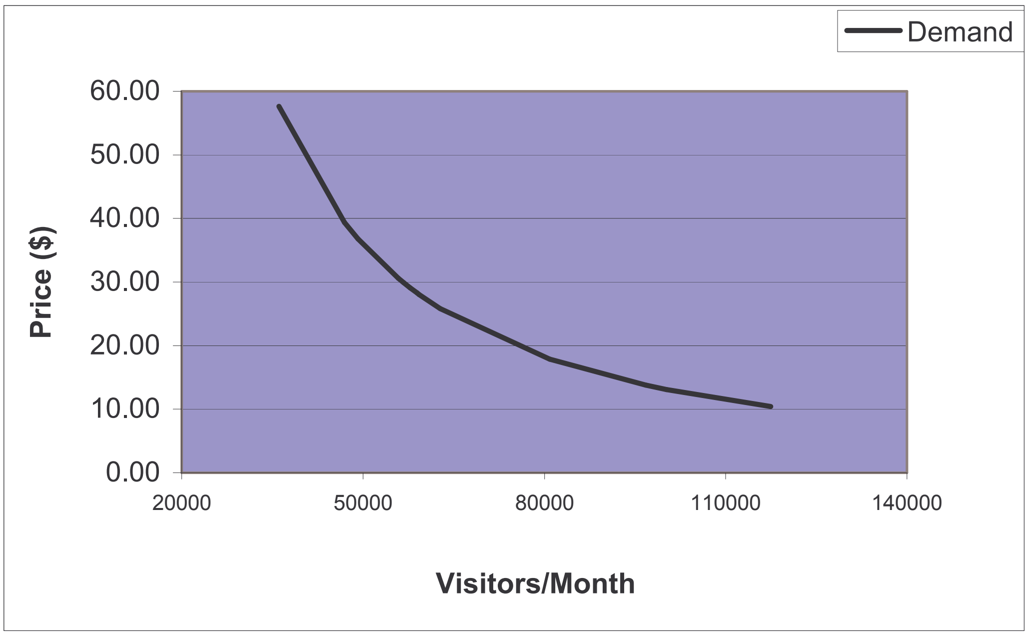

Figure 4.8. Demand for Beach Recreation

4.3 PRIORITY POLLUTANT DISPERSION MODEL

The results of the priority pollutant dispersion model predict what concentrations of dissolved priority pollutants from a single cruise ship discharge will remain in the water column within the model's domain after a period of 96 hours. The following are the results of this model in the three study port areas (Table 4.5: Los Angeles, Table 4.6: San Diego, and Table 4.7: San Francisco) while taking into account the three regulatory scenarios and the associated depths related to each regulation and location.

	FEDERAL: Total Input (μg/L)	ALASKA: Total Input (μg/L)	TASK FORCE: Total Input (μg/L)
Depth Associated with each Scenario (m)	24.994	25.603	24.384
Constituent			
Antimony	0.002	0.002	0.002
Arsenic	0.019	0.018	0.019
Bis(2-ethylhexyl) Phthalate	0.070	0.068	0.072
Copper	0.088	0.086	0.091
Di-n-butylphthalate	0.010	0.010	0.010
Lead	0.012	0.012	0.012
Nickel	0.048	0.047	0.049
Selenium	0.037	0.036	0.038
Silver	0.001	0.001	0.001
Tetrachloroethene	0.007	0.007	0.008
Zinc	0.802	0.782	0.822

Table 4.5. Los Angeles: Dissolved Constituent Concentrations Under Three Regulatory Scenarios

Table 4.5 summarizes the concentration of each dissolved priority pollutant that remains in the water column during a time period of 96 hours under the three regulatory scenarios. For the port of Los Angeles the depth associated with each scenario is very similar, therefore there is little difference in the mean concentration of priority pollutants that are diffused throughout the water column under each scenario.

	FEDERAL: Total Input (μg/L)	ALASKA: Total Input (μg/L)	TASK FORCE: Total Input (μg/L)
Depth Associated with each Scenario (m)	12.802	12.802	16.642
Constituent			
Antimony	0.003	0.003	0.002
Arsenic	0.037	0.037	0.028
Bis(2-ethylhexyl) Phthalate	0.136	0.136	0.105
Copper	0.173	0.173	0.133
Di-n-butylphthalate	0.019	0.019	0.015
Lead	0.024	0.024	0.018
Nickel	0.093	0.093	0.072
Selenium	0.072	0.072	0.055
Silver	0.002	0.002	0.002
Tetrachloroethene	0.014	0.014	0.011
Zinc	1.565	1.565	1.204

Table 4.6. San Diego: Dissolved Constituent Concentrations Under Three Regulatory Scenarios

Similar to the port of Los Angeles, our results in Table 4.6 show little difference in depth under the three scenarios for the port of San Diego. Therefore each scenario exhibits only minor differences in the mean concentration of pollutant. Furthermore, as San Diego is on average shallower than Los Angeles, the concentration of each constituent is greater at this location under each scenario than in the port of Los Angeles. For example, the concentration of dissolved zinc in San Diego under federal regulations is 1.565 ug/L while in the port of Los Angeles it is only 0.802 ug/L.

	FEDERAL: Total Input (μg/L)	ALASKA: Total Input (μg/L)	TASK FORCE: Total Input (μg/L)
Depth Associated with each Scenario (m)	31.090	25.908	17.069
Constituent			
Antimony	0.001	0.002	0.002
Arsenic	0.015	0.018	0.028
Bis(2-ethylhexyl) Phthalate	0.056	0.067	0.102
Copper	0.071	0.085	0.129
Di-n-butylphthalate	0.008	0.009	0.014
Lead	0.010	0.012	0.018
Nickel	0.038	0.046	0.070
Selenium	0.030	0.036	0.054
Silver	0.001	0.001	0.002
Tetrachloroethene	0.006	0.007	0.011
Zinc	0.644	0.773	1.174

Table 4.7. San Francisco: Dissolved Constituent Concentrations Under Three Regulatory Scenarios

The port of San Francisco shows the largest difference in depth between each scenario as compared to the other ports of interest. Therefore, in San Francisco, our model displays the largest difference in the concentration of constituents remaining in the water column between the three scenarios (See Table 4.7). However, it is important to note that as one moves farther from shore (Federal, Alaska, Task Force, respectively) the depths decrease at this location. Because of this, the Task Force scenario actually shows the highest concentration of dissolved pollutants within our domain as compared to the other scenarios.

4.4 Sinking Load Model

The results of the sinking load model predict what concentration of adsorbed heavy metals from a single cruise ship discharge will be in the pore water of the sediment given the model's domain of 96 hours. The following are the results of this model, keeping in mind that the concentration in the pore water is the same for all ports and scenarios given the rapid sinking rate of these adsorbed metals and the shallow depths associated with our scenarios.

	Concentration in Pore Water (µg/L)
Constituent	
Antimony	0.010
Arsenic	0.120
Copper	82.639
Lead	3.796
Nickel	0.549
Silver	0.165
Zinc	37.059

Table 4.8. Concentration in Pore Water for Heavy Metals Analyzed

Table 4.8 summarizes the concentration of heavy metals in the pore water of the benthic sediments given a time period of 96 hours. From this table, one can see that copper and zinc are at the highest concentrations in the pore water relative to the other heavy metals.

4.5 Species Sensitivity Distribution

Taking the concentrations predicted by the priority pollutant dispersion model and the sinking load model as reported above, we then used acute toxicity data (LC50 96hr) provided for various species by EPA's Ecotoxicology Database to perform a probit analysis (Please refer to Section 3.3 for complete description of methodology).

For each concentration, we created a species sensitivity distribution, which was used to predict the percent of the community affected under each regulatory scenario. An example of a species sensitivity distribution for the dissolved constituent zinc in the port of San Francisco can be seen in Figure 4.9 (U.S. Environmental Protection Agency, 2003). We provide a complete set of species sensitivity distributions for each chemical at the three port locations in Appendix L.

4.5.1 Percent of Benthic Community Affected as Predicted by Priority Pollutant Dispersion Model

None of the concentrations calculated using the priority pollutant dispersion model showed an effect greater than 1% to the marine community. Since a 5% effect is the normal threshold at which one would perceive an effect to a species, our results can be interpreted to mean that the priority pollutant concentrations calculated with our model are not having effects on the endpoint mortality (Forbes and Calow, 2002).

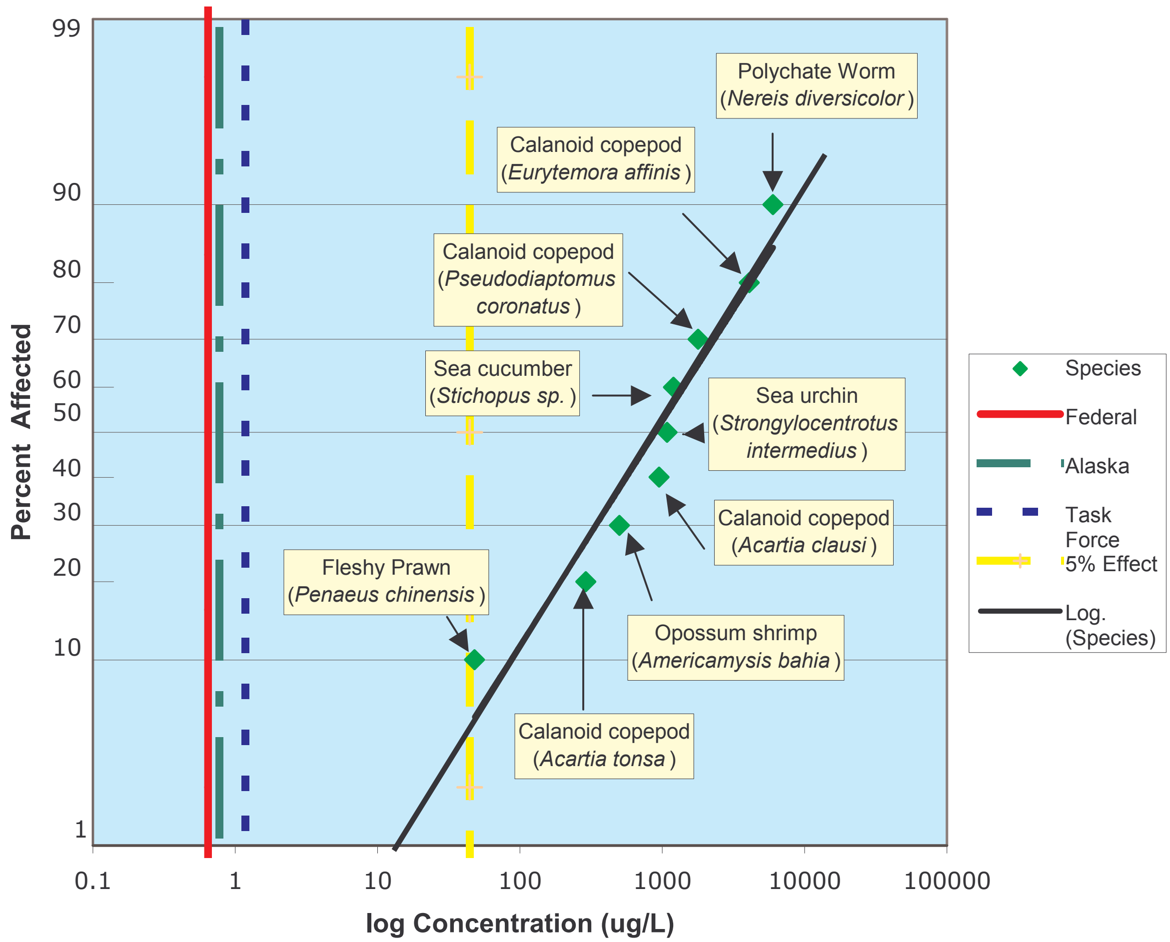

Figure 4.9. San Francisco: Species Sensitivity Distribution for Zinc Modeled Using the Priority Pollutant Dispersion Model

Figure 4.9 predicts the sensitivity of a marine community based on the sensitivity of each species, represented by their LC50 value in green. Species that are found at the top right corner of the trend line are considered less sensitive to zinc than species found in the bottom left corner. The concentration of dissolved zinc as a result of each regulatory scenario is also shown on the graph, and from these points one can predict the percent of the community experiencing mortality. However, due to the low concentrations predicted by the priority pollutant dispersion model, no effect was shown, as suggested by the fact that the predicted concentration and the species sensitivity trendlines do not intersect.

	FEDERAL: Total Input (μg/L)	ALASKA: Total Input (μg/L)	TASK FORCE: Total Input (μg/L)	Concentration Relating to 5% Effect (ug/L)
Depth Associated with each Scenario (m)	24.994	25.603	24.384	
Constituent				
Antimony	0.002	0.002	0.002	1890.460
Arsenic	0.019	0.018	0.019	116.561
Bis(2-ethylhexyl) Phthalate	0.070	0.068	0.072	244.449
Copper	0.088	0.086	0.091	9.671
Di-n-butylphthalate	0.010	0.010	0.010	244.449
Lead	0.012	0.012	0.012	19.116
Nickel	0.048	0.047	0.049	135.369
Selenium	0.037	0.036	0.038	1017.149
Silver	0.001	0.001	0.001	3.787
Tetrachloroethene	0.007	0.007	0.008	6032.231
Zinc	0.802	0.782	0.822	44.430

Table 4.9. Los Angeles: Comparison of Priority Pollutant Model and 5% Effect Concentrations

Table 4.9 describes the concentrations as predicted by the priority pollutant dispersion model and species sensitivity distributions for the port of Los Angeles, and compares these concentrations to the concentrations that are required to observe a 5% percent effect to the species in the marine community. One can see that the concentrations predicted by the priority pollutant model are far lower than the concentrations related to a 5% effect to the species in the community.

	FEDERAL: Total Input to Benthos (µg/L)	ALASKA: Total Input to Benthos (µg/L)	TASK FORCE: Total Input to Benthos (µg/L)	Concentration Relating to 5% Effect (ug/L)
Depth Associated with each Scenario (m)	12.802	12.802	16.642	
Constituent				
Antimony	0.003	0.003	0.002	1890.460
Arsenic	0.037	0.037	0.028	116.561
Bis(2-ethylhexyl) Phthalate	0.136	0.136	0.105	244.449
Copper	0.173	0.173	0.133	9.671
Di-n-butylphthalate	0.019	0.019	0.015	244.449
Lead	0.024	0.024	0.018	19.116
Nickel	0.093	0.093	0.072	135.369
Selenium	0.072	0.072	0.055	1017.149
Silver	0.002	0.002	0.002	3.787
Tetrachloroethene	0.014	0.014	0.011	6032.231
Zinc	1.565	1.565	1.204	44.430

Table 4.10. San Diego: Comparison of Priority Pollutant Model and the 5% Effect Concentrations

Table 4.10 shows that all constituent concentrations predicted for the port of San Diego also show no mortality to the species in the marine community. However, due to the fact that San Diego is on average shallower than Los Angeles, the priority pollutant concentrations predicted are closer to the 5% effect concentration at this location under all three scenarios.

	FEDERAL: Total Input to Benthos (µg/L)	ALASKA: Total Input to Benthos (µg/L)	TASK FORCE: Total Input to Benthos (µg/L)	Concentration Relating to 5% Effect (ug/L)
Depth Associated with each Scenario (m)	31.090	25.908	17.069	
Constituent				
Antimony	0.001	0.002	0.002	1890.460
Arsenic	0.015	0.018	0.028	116.561
Bis(2-ethylhexyl) Phthalate	0.056	0.067	0.102	244.449
Copper	0.071	0.085	0.129	9.671
Di-n-butylphthalate	0.008	0.009	0.014	244.449
Lead	0.010	0.012	0.018	19.116
Nickel	0.038	0.046	0.070	135.369
Selenium	0.030	0.036	0.054	1017.149
Silver	0.001	0.001	0.002	3.787
Tetrachloroethene	0.006	0.007	0.011	6032.231
Zinc	0.644	0.773	1.174	44.430

Table 4.11. San Francisco: Comparison of Priority Pollutant Model and the 5% Effect Concentrations

Again, the port of San Francisco is showing concentrations lower than the concentration that would be required to perceive a 5% effect. The important item to note in Table 4.11 is that due to decreasing depths as one travels farther offshore in the port of San Francisco, the concentration in the water column increases under the Federal, Alaska, and Task Force scenarios, respectively. Therefore, at this port of call, the Task Force scenario actually performs worse than the other scenarios, even though the discharge is made further from shore.

4.5.2 Percent of Benthic Community Affected as Predicted by the Sinking Load Model

Benthic species[23] LC50 96 hour data was used to perform species sensitivity analyses to determine if heavy metal concentrations at the sediment water interface had the potential to affect benthic communities. Benthic species, rather than pelagic species, were used specifically because these organisms would be exposed to the concentrations in the pore water continuously, due to their bottom-dwelling lifestyle. However, due to a limited availability of LC50-96 hour data for benthic species, only concentrations of zinc and

[23] Defined as species that spend their entire lives on the seafloor.

copper as predicted by the sinking load model, could be used to perform species sensitivity analyses specific to the species in a benthic community. The concentrations of the heavy metals predicted and their potential effects to the marine community that could not be used in this analysis will be addressed in the discussion section.

Zinc was not shown to have an effect, as the concentration predicted was less than the concentration necessary to observe a 5% effect. However, copper was shown to affect 90% of the species in the benthic community.

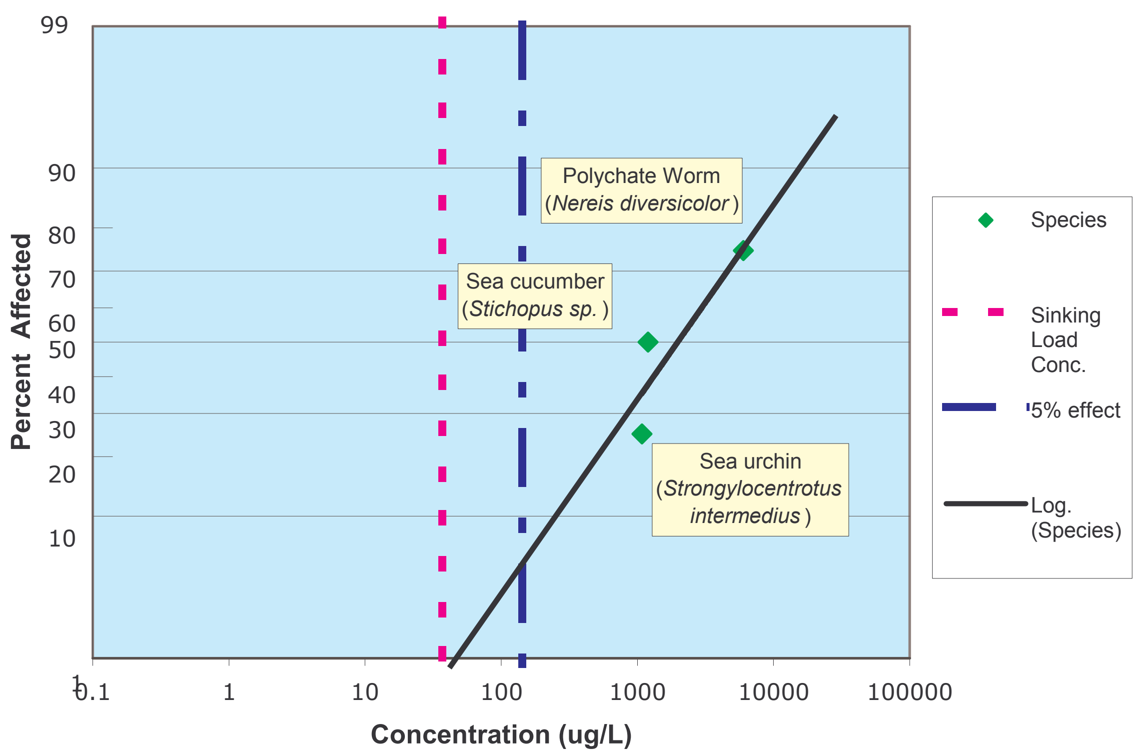

Figure 4.10. Concentration of Zinc in the Pore Water

Figure 4.10 shows that the concentration of zinc in the pore water is less than the concentration that would garner a 5% effect. It is important to note that this graph only predicts the effects to a benthic community as it utilizes only LC50-96hr data for species that spend there lives on the seafloor and therefore are exposed to the pore water continuously.

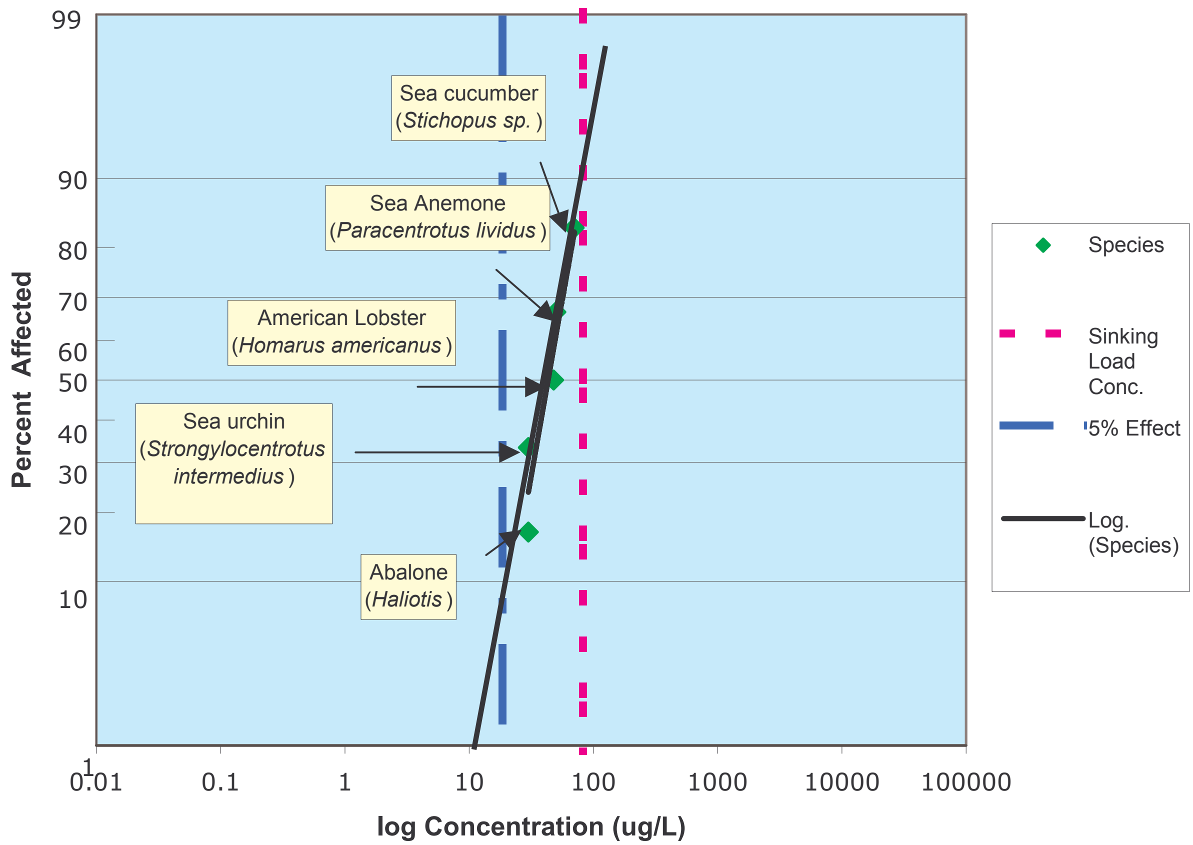

Figure 4.11. Concentration of Copper in the Pore Water

Figure 4.11 shows the concentration of copper in the pore water of the sediments is resulting in an effect to the species in the benthic community. An effect of approximately 90% can be attributed to the priority pollutant concentrations inputted into the sediments from one cruise ship discharging one time.

5 ANALYSIS AND DISCUSSION

The analysis and discussion presented in this chapter are based on the results provided in Chapter Four. We discuss the results of our four models under the three regulatory scenarios, and explore what these results could mean in relation to the health and economic well-being of California's coastal resources.

5.1 Bacterial Load Dispersion Model

The results of the bacterial load dispersion model (summarized in Table 5.1) show that, under average conditions, the amount of fecal coliform reaching the shore from a single average discharge of 4.3×10^5 MPN from a single ship under steady state conditions under current Federal regulations is only 0.14% of the original fecal coliform concentration, and is less than 0.1% under the Alaska and Task Force scenarios. However, our results also show that under extreme current conditions, the amount of fecal coliform reaching the shore increases by approximately 200% for each of the evaluated scenarios. This is because during days experiencing extreme weather conditions, the velocity of the current towards shore in addition to the rate of diffusion towards shore greatly influences the amount of fecal coliform reaching the shore.

	Average Weather Conditions		Extreme Weather Conditions	
	MPN	Percent of Original Bacterial Load	MPN	Percent of Original Bacterial Load
Scenario 1: Federal Regulations	5.96×10^3	0.14%	4.07×10^5	94.44%
Scenario 2: Alaska Regulations	6×10^{-2}	less than 0.01%	3.43×10^5	79.57%
Scenario 3: Task Force Recommendations	8.7×10^{-7}	less than 0.01%	2.17×10^5	50.36%

Note: (MPN = most probably number of bacteria/100mL)

Table 5.1. Comparison of the Concentration of Fecal Coliform Bacteria Reaching the Coastline Under the Three Regulatory Scenarios

Under the three regulatory scenarios that our group examined, only Scenario 3 significantly reduced the bacterial loading at the beaches during extreme weather conditions, leading us to conclude that cruise ships should move at least three nautical miles offshore before discharging treated blackwater and untreated graywater, as specified by the CA Cruise Ship Task Force recommendations. Under this scenario, the original bacterial load discharged from the cruise ship is reduced by 50% before reaching the shore. Furthermore, our sensitivity analysis (Figure 4.6) showed that even when the mean current velocity is reduced by half, the concentrations of bacteria reaching the shore under Scenarios 1 and 2 are not below 50%. While a 50% reduction in the concentration of bacteria is not necessarily significant, three nautical miles is the extent to which state regulations can require cruise ships to travel before discharging.

Also, it is important to remember that our model only measures the results of one discharge from a single ship and does not account for the possibility of discharges from multiple ships in the same area during a short time period. Multiple wastewater discharges could significantly increase the effect that bacterial loads from cruise ships may have on beach water quality.

Therefore, although cruise ship wastestreams contribute minimally to a decrease in nearshore water quality under average weather conditions, these same wastestreams have the potential to be a significant additional source of pollution to California's shoreline and beaches under extreme weather conditions. In addition, with the increase in cruise ship traffic expected over the next decade and the increase in size and capacity of cruise ships (see Chapter 1), the amount of bacteria discharged into California's coastal waters could increase considerably.

Moreover, as our model does not take into account the likely possibility that discharges are occurring from multiple sources, our results should be regarded as a best-case scenario. The risk associated with the added input of fecal coliform from cruise ships to nearshore water quality must therefore be considered when making policy decisions.

To further examine the differences in bacterial load reaching the shoreline, we investigated the results if graywater were treated to the same standards as blackwater under all three regulatory scenarios. Since fecal coliform bacteria is given in the form of a concentration, we were able to assume that even if treated graywater were added to the treated blackwater, the overall concentration of bacteria in the holding tank would remain constant as a result of averaging the concentrations. Under this assumption, the initial discharge of fecal coliform in the water would be reduced by 99%, resulting from the treatment of graywater, which is currently the source for the majority of fecal coliform discharged from cruise ships. The results of this examination showed that, under all three scenarios, the concentration of bacteria reaching the shore under extreme conditions would be 99% less than the concentration reaching shore under the Task Force Recommendations/Extreme Weather Conditions scenario, because of the reduction in the initial concentration discharged. Furthermore, the concentration would be 0.2% less than the concentration reaching the shore under the Federal Regulations/Average Weather Conditions scenario. These results added additional support to our previous conclusion that cruise ships should be at least three miles offshore before discharging. In addition, these results led us to conclude that graywater should be treated to the same standards as blackwater in order to noticeably reduce bacterial loading at the shore under extreme conditions.

5.1.1 Economic Effects of Bacterial Load

Coastal and marine health plays an important role in the economic well-being of the communities in which they are located. Healthy beaches can attract tourists and local visitors year-round. This is particularly true in California, where 88% of the state's population chooses to live within thirty miles of the coast (Office of Ocean Resources Conservation and Assessment, 1990).

People who recreate in the water at beaches that often have elevated bacteria levels may be posed serious risks to their health. In coastal communities where recreational users are exposed to the water year-round, high bacterial loads in the water may mean local hospitals devote more resources to treat beach-goers. A study completed at Duke University found that surfers and divers are at the greatest risk of illness from contaminated beach water along the entire west coast of the United States compared to occasional swimmers because they are in the water more often and thus are exposed to greater amounts of bacteria (Griggs, 1985). Health effects associated with recreating in the ocean when bacterial levels are elevated include gastrointestinal illness, stomach pain, fever, skin rashes, eye and ear discharge and nausea (Santa Monica Bay Restoration Project, 2003)

When bacteria levels rise above the state standard, 400 MPN/100mL, counties will close the beach. In 2001, there were 6,568 beach closures in California, a 14% increase from 2000 (Natural Resources Defense Council, 2003). More than 86% of the closings in 2001 were due to levels of bacteria that exceeded the state standard (Natural Resources Defense Council, 2003) of 400MPN/100mL fecal coliform in a single sample.[24] Consequently, beach closures are an issue of concern for coastal communities, especially those communities that rely on tourist dollars for a large portion of their income. Orange County is an illustrative example of such a coastal community; estimated expenditures by non-local visitors to Orange County beaches from June-August 2000 totaled over $220 million. In addition, economic studies show that beach visits to Orange County during this same time period generated close to $25 million in wages and salaries, the equivalent of 2,349 annual full and part-time jobs (Hanemann, Pendleton et al., 2001).

Given the large economic role that beaches play in the California economy, beach closures have the potential to cause a notable impact not only in the communities where the beach is located but to the state as a whole. For example, preliminary results from the Southern California Beach Valuation Project, currently in progress at the University of Southern California, indicated that closing Bolsa Chica State Beach one day during peak summer months would result in a loss of $7.3 million to California (Pendleton and Kite-Powell, 2003). This number includes the loss of revenue from projected beach spending as well as the regulatory costs from both state and city employees involved in closing a beach.

Extreme weather conditions such as heavy winds, high surf and strong offshore currents cause higher than normal levels of bacteria to reach the beach from both onshore and offshore sources (Natural Resources Defense Council, 2003). Cruise ships can contribute to this problem. Our bacterial load dispersion model run under extreme

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[24] Or 200MPN/100mL log mean over a 30-day sampling period.

weather conditions showed that even under our most stringent regulatory scenario (Scenario 3: Task Force Recommendations), 50% of the original bacterial concentration discharged from cruise ships reaches the shore (Figure 4.3).

In instances where bacterial levels exceed the legal limit requiring a beach to close, more stringent regulations on cruise ships may decrease the amount of bacteria reaching the shore. This may be enough to keep the beach open, potentially saving both the coastal communities and the state money. We were unable to quantitatively analyze this assumption due to a lack of detailed historical data on water quality during beach closure periods; however, we feel that following the regulations recommended under Scenario 3 could improve California's coastal ecosystem.

5.2 TRAVEL COST MODEL

The bacterial load model indicated that the cruise ship discharges examined in our study (treated blackwater and untreated graywater) could degrade water quality at the shoreline. Analyzing the potential impacts of a degraded shoreline on California State beaches is important because resource management agencies, legislators, and non-government interest groups are becoming more interested in the demand for and value of outdoor recreation (Bergstrom and Cordell, 1991). Additionally, a travel cost analysis of beaches could be particularly important to California because California is a coastal state and beaches are the leading tourist destination, where coastal states earn 85% of all U.S tourism revenues (Leeworthy, 2000).

Moreover, it is possible that a degraded coastline may result in consumers paying more to reach a cleaner beach. This study attempted to measure the change in consumer surplus associated with a change in water quality. The change in water quality was derived from the differences in discharge regulations between the three regulatory scenarios. Currently, cruise ship discharges are enforced under Federal regulations. If California were to adopt Alaska regulations, the amount of fecal coliform would be reduced by 99% under average conditions. Adopting the Cruise Ships Environmental Task Force recommendations would reduce fecal coliform concentrations reaching shore from cruise ships under average conditions by 100%. However, since the shipping industry only comprises 2% of overall marine pollution, where the cruise industry constitutes 2% of that (International Council of Cruise Lines, 2003) these reductions will not amount to a significant change in fecal coliform concentrations at the beaches. Furthermore, it is important to consider all potential impacts that cruise ships may cause because the estimated 2% of the shipping industry pollution that cruise ships contribute is based on a national average; this percentage may be different if estimates are based for California's coastline only.

5.2.1 Hedonic Equation

The results of this study indicated that water quality does not affect the price people are willing to pay to visit a beach. However, we did estimate a small impact coefficient for water quality ($0.09/MPN/100ml). For instance, if the water quality at Bolsa Chica State Beach was improved by 50 MPN/100ml, people would be willing to pay $4.50 more to visit Bolsa Chica State Beach, a 43% increase. This may influence a consumer's decision to choose one beach over another.

These unexpected results could be attributed to the following reasons:

1. The assumption that MPN and CFU provide equivalent measurements.
2. Small sample size provides no confidence in the answer.
3. There are measurable differences in the consistency of state beach water quality data.
4. State beaches are not required by law to post water quality. Therefore, it may be possible that consumers are unaware of differences in water quality among beaches. Consequently, this factor may not play into the decision on where consumers decide to recreate.

This raises an important point – if the beach is open, it is assumed by visitors that the water is 'clean'. In reality, the water quality of a beach could be measured near the level at which beach closure occurs. The two percent of fecal coliform reaching the shoreline from cruise ship discharges could drive the amount of fecal coliform over the beach closure limit. Thus, cruise ship discharges could potentially contribute to beach closures, which could result in a consumer having to travel to a beach of better water quality and increase the consumer's travel cost.

Travel cost was negatively associated with beach temperature; this result was unexpected and counterintuitive. This could be due to the method with which the temperature measurements were manipulated. Temperature had to be averaged over the years corresponding to the years that consumers visited the beach; the range of years were not the same for every beach. Additionally, there was very little variability in the temperature data between beaches, therefore this variable may not have a strong influence over a consumer's decision to attend a beach.

Beach amenities had the expected result that a consumer's decision to attend one beach over another is influenced by the presence of beach amenities; this result was not significant at the 95% confidence level. However, because the p-value was almost significant (0.08), we speculate that with a better data set the result would be significant.

5.2.2 Cobb-Douglas Demand Equation

The results of predicted price and substitute site amenity variables were as expected (-0.69 and -3.92 respectively), however the estimates are not statistically significant at the 95% confidence level. We believe that with an increase in sample size, the p-values of both predicted price and substitute site amenities would be statistically significant. Furthermore, holding all other factors constant, the more amenities a substitute site has than the subject beach, the more likely it is that visitors will go to a substitute site. Finally, it is not surprising that the predicted price result indicated that the more expensive it is to visit a beach, the less often one will visit the beach.

Our findings regarding household income pose many problems. The results indicated that the more income a household generates, the less frequently beach visitation occurs. This is contrary to intuition. However, the income coefficient is not statistically different than zero. In other words, income level does not affect beach visitation (zero income elasticity). These results could stem from the fact that the average median household income was estimated at the county level as specific income levels for the visitors who filled out the survey were unavailable. If the income data for each visitor was obtained, this may have resulted in a more representative household income value.

Even though some of the variables in the travel cost model contained problems, the linear regression models used to estimate these values were valid. The R^2 values for both the Hedonic Equation and Cobb-Douglas Demand Equation indicated that the regressions were a good fit to the data. In addition, according to our models, the demand for beach recreation was found to be inelastic. As mentioned previously, posting water quality is not a common practice among California beaches; therefore it is probable that water quality is not a determining factor for those who participate in beach recreation.

Furthermore, the inelasticity could be attributed to out-of-state beach goers. Our data set indicated that out-of-state beach goers regularly visit California state beaches. Thus, it is very likely that an out-of-state visitor will not change their destination plans if there is poor water quality at a beach site. This could be a factor of the time and money that has already been invested into the planned "vacation".

We had originally planned to analyze the change in water quality and the associated change in value given by the three regulatory scenarios. However, due to the small impact coefficient, a change in consumer surplus associated with a change in water quality could not be generated in our analysis.

In summary, we determined that the economic analysis conducted in this study could be significantly improved. Although the methodological approach used in this study was acceptable, the data in which this study was based upon has room for improvement.

5.3 PRIORITY POLLUTANT DISPERSION MODEL

In order to create a frame of reference for the results of the priority pollutant dispersion model and the sinking load model, it is important to discuss the impacts of heavy metals to the marine environment in general. Heavy metals are defined as metals or, in some cases, metalloids, which are stable and have a density greater than 4.5 g/cm3, or more generally, as all metals or metalloids with acknowledged hazards for health or the environment (Strumm and Morgan, 1996). These metals are persistent environmental contaminants that do not degrade in the environment like many organic compounds do. Therefore, they tend to accumulate in sections of the environment, such as soils, sediments, plants or animals (United Nations Environment Programme, 2004).

Heavy metals collect in living organisms and increase in concentration as they move up the food chain, through a process known as bioaccumulation. In general, these pollutants are present at trace levels in uncontaminated waters, and in small amounts, these metals can be essential micronutrients for living organisms. However, if the threshold for the organism is exceeded by elevated levels of intake, heavy metals can: 1) seriously affect the respiration, photosynthesis, transpiration and growth of plants, 2) trigger dysfunctions of the nervous system, blood and renal systems in animals, and 3) reduce growth and reproduction in animals (United Nations Environment Programme, 2004).

Bioaccumulation to excessive levels in seafood and sediments can also pose risks to humans. These risks include local gastrointestinal effects like vomiting, diarrhea, and colics, as well as numerous allergic skin reactions including eczema or damage to mucous membranes and eyes (this has been seen as a result of skin contact with nickel). Systematic effects due to the toxic action of heavy metals in humans include dysfunctions of the nervous system, kidney and liver diseases, and cancer of the skin (United Nations Environment Programme, 2004).

Concurrent exposure to multiple heavy metals (as is the case in our model) can have either a subtractive or cumulative effect. For example, selenium forms an insoluble salt with mercury in the body that reduces the toxicity of both mercury and selenium, whereas, for lead and cadmium, the toxicity of one is added on top of the other (United Nations Environment Programme, 2004).

5.3.1 Importance of Depth

The results of the priority pollutant dispersion model demonstrated that, as a result of only minor differences in depth between the three regulatory scenarios for each port, the contribution of each constituent to the marine environment under each scenario varies only slightly. In other words, the overall concentration of each constituent remaining in the water column during our time domain of 96 hours is only minimally affected by the difference in distance from shore as mandated under each regulatory scenario. For this reason, current policy and recommendations that demand cruise ships be a certain distance from shore before discharging generally only minimize the amount of pollution floating to shore, but do not affect the amount of pollution reaching the benthos. This is particularly important for the port of San Francisco where depth may actually decrease with distance from shore and thus, the farther offshore a cruise ship travels the higher the reported concentration becomes. This realization requires the consideration of depth in addition to distance from shore in the creation of new policies addressing cruise ship wastestreams.

The fact that our results showed little overall effects to mortality is reasonable as it is unlikely that a single discharge of pollutants from a one cruise ship would be large enough to show high concentrations in the water column given the excessive turbidity within the ocean environment and the depths used to define the domain of each scenario.

However, the dissolved pollutant concentrations reported in the priority pollutant model are concentrations that are bioavailable[25] to marine organisms (Prothro, 1993) and have the potential to bioconcentrate in the tissues of these organisms. For example, concentrations of copper and nickel in phytoplankton in the Lower South San Francisco Bay have been shown to exceed toxic thresholds due to bioconcentration of these metals in tissues (Tetra Tech, 2004).

Therefore, although concentrations predicted by our priority pollutant dispersion model are relatively low and did not show an effect from a single cruise ship discharge, repetitive discharges and bioconcentration have the potential to increase the concentration of these pollutants in organism tissues, thereby negatively affect marine organisms.

5.4 SINKING LOAD MODEL

Results of the sinking load model showed that due to the collection of heavy metals at the sediment-water interface, concentrations here are greater as compared to concentrations in the water column for all scenarios and ports analyzed. For example, the highest concentration of zinc in the water column was 1.174 ug/L for the Task Force scenario in the port of San Francisco, while the concentration of zinc in the volume of the pore water was calculated to be 37.059 ug/L. Furthermore, although the concentrations calculated for zinc did not predict effects, this concentration was much closer to the concentration of zinc in the water column necessary to observe a 5% effect. This indicates that organisms are potentially at a higher risk of exposure to zinc in the sediments than in the water column.

This result becomes more important as one recognizes that heavy metals have the potential to accumulate in marine sediments over time. Accumulation could occur if cruise ships were discharging wastestreams in relatively the same area over time. This is a reasonable expectation if one assumes that cruise ships follow the same routes over time, and have similar wastestream holding capacities that would require discharge at certain intervals. Accumulation of heavy metals caused by repetitive discharges of cruise ships could lead to further increases in concentrations of heavy metals in the pore water. This in turn could expose benthic organisms to concentrations that over time could exceed species toxicity thresholds, and thus negative effects may ensue. Within the scope of our project, we were not able to determine potential impacts caused by the cumulative effects of cruise ship wastewater discharge.

Furthermore, each priority pollutant is not being received into the environment independently. As stated above, there is the potential for cumulative impacts with the combination of certain constituents. For example, mercury and lead are extremely neurotoxic and cytotoxic, but their combined synergistic effect is much worse. A dose of

[25] Defined as chemicals or metals that are easily absorbed into the food chain and thereby are incorporated into the tissues of organisms. Chemicals that are not bioavailable cannot be toxic.

mercury sufficient to kill 1% of tested rats, when combined with a dose of lead sufficient to kill less than 1% of rats, resulted in killing 100 % of rats tested (Schubert, Riley et al., 1978). The accumulation of heavy metals combined with potential cumulative impacts as discussed above could lead to numerous negative effects to human health and the environment that should be considered in formulating new policies to protect our coastal resources.

5.5 SPECIES SENSITIVITY DISTRIBUTION

Species sensitivity analyses can be used to predict the percent of the community that would be affected given a certain concentration of pollutant. This tool was first used to analyze the effects of concentrations of pollutants in the water column as calculated by the priority pollutant dispersion model to both benthic and pelagic species. Species sensitivity distributions using only benthic species were then applied to the concentrations predicted by the sinking load model to analyze effect to the benthic community.

Pollutants that require smaller concentrations to observe an effect can be interpreted to be more toxic than chemicals that entail large concentrations to detect an effect. For example, organisms need only be exposed to 3 ug/L of silver for mortality to begin to occur in the community, whereas for selenium organisms must be exposed to 1017 ug/L to observe the same effect. Therefore, in general, silver can be deemed to be more toxic than selenium.

Although species mortality was not an observed result for the majority of our analyses, we determined copper concentrations in the pore water to have a large effect on the benthic species examined through the species sensitivity distribution. This result corresponds with the highly toxic nature of copper. However, it must be noted that this is a direct result of the specific species used in this distribution. Species used in this distribution were shown to be very sensitive to only small changes in concentration, as demonstrated by the steep slope of the trendline. Therefore, it is possible that if we used other species the magnitude of the effect might change.

The percent of the community affected could also increase if discharges were made in shallow, calm waters such as bays and harbors, since the volume of receiving water would be smaller in these areas and diffusivity would be diminished thus leading to higher concentrations of pollutants. This is particularly important for constituent loads into the sediments, such as zinc, which demonstrated concentrations that were near levels at which an effect would be observed (See Figure 4.10).

We were unable to analyze certain metals using species sensitivity data due to a lack of LC50 data on benthic species. However, under the 1977 Clean Water Act, Congress mandated EPA to develop ambient water quality criteria for 129 priority pollutants, including the pollutants modeled in our study (U.S. Environmental Protection Agency, 2004). EPA defines these criteria as concentration levels of water quality expected to render a body of water suitable for designated use. Criteria are based on specific levels of pollutant that would make the water harmful if used for drinking, swimming, farming, or fish production. These water quality criteria can be compared to the concentrations predicted by the sinking load model for metals that we were not able to evaluate using a species sensitivity distribution. In this way, one may decipher if it is likely that these constituents are showing an effect to benthic communities.

	Concentration in Pore Water (µg/L)	Applicable or Relevant and Appropriate Requirements (ARARS)-Marine (ug/L)	
		Acute	Chronic
Constituent			
Antimony	0.010	N/A	4300 [26]
Arsenic	0.120	69	36
Copper	82.639	4.8	3.1
Lead	3.796	210	8.1
Nickel	0.549	74	8.2
Silver	0.165	1.9	N/A
Zinc	37.059	90	81

Source: (U.S. Environmental Protection Agency, 2004).

Table 5.2. Concentrations of Heavy Metals Predicted by the Sinking Load Model Compared to EPA Ambient Water Quality Criteria

Table 5.2 shows that concentrations predicted by the sinking load model only exceed ambient water quality criteria for copper. Due to this result and the results of the species sensitivity distribution for copper concentrations in the pore water, we can state that copper discharged from cruise ships is having negative effects on the benthic marine communities. All other adsorbed metal concentrations are lower than concentrations defining ambient water quality criteria, and therefore we can conclude that these pollutants are not showing an effect from a single discharge of a cruise ship. However, as discussed above, these constituents have the potential to accumulate in the sediments over time and therefore the results of this model may actually underrepresent the cumulative effects caused by cruise ships wastestreams to the marine community.

Due to the impacts from copper, as well as the potential for accumulation of the other priority pollutants examined, we believe that cruise ship blackwater and graywater discharges have the potential to have a negative impact on pelagic and benthic fauna/marine communities. With respect to copper input into the sediments, this effect

[26] Water quality criteria for aquatic life could not be found for this metal, this value represents the criteria for human health.

is already being realized, and future policies should consider the elevated loads of this constituent in cruise ship wastestreams, as well as the highly toxic nature of this metal, particularly to benthic organisms.

Furthermore, the species sensitivity distributions only examined mortality as an endpoint. However, other endpoints (such as growth and reproduction) may be affected at even lower concentrations of pollution (U.S. Environmental Protection Agency, 2003). Impacts to these endpoints may result in decreased fitness of marine organisms, and thereby have the potential to increase stress on the marine communities in which these organisms reside (Fisher, Jones et al., 1981). Therefore, it is realistic to expect that the impacts caused by cruise ship wastestreams to marine communities could be greater than what has been predicted here.

It is also important to note that the data provided by ADEC was from cruise ships required by Alaska law to use Advanced Wastewater Treatment Systems (AWTS). However, cruise ships in California are not subject to the same regulations, and therefore many ships operating in California state waters may not have this wastewater treatment capacity. Ships with lesser technology could be contributing more pollution to marine and coastal requirements than those predicted by our models. Therefore, future policy should consider that the results presented here are a best-case scenario.

As the number of vessels operating in California increases (see Chapter 1), the impacts caused by cruise ships to marine communities are also expected to increase. These amplified impacts due to bioconcentration of pollutants could have serious consequences for fisheries, a major source of economic benefits for the state of California.

California's nearshore ecosystem, defined as the area from the coastal high tide line offshore to a depth of 120 feet, is one of the most productive ocean areas in the world. This area, comprising only about 2,550 square miles, generates almost $40 million in ex-vessel revenue[27] from the harvest of its resources. This totals to a little less than one third of the value of all of California's fisheries. The area is home to a wide variety of fishes, giant kelp, marine invertebrates (spiny lobster, abalone, sea urchin, crabs), and marine mammals, as well as a large number of sea and shore bird species (CA Department of Fish & Game, 2001).

California's marine invertebrate fisheries range among the crustaceans, mollusks, echinoderms and to a limited extent, the polychaetes. Commercial and recreational

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[27] Ex-vessel revenue is defined as the quantity of fish landed by commercial fishermen multiplied by the average price received by them at the first point of sale. As such, ex-vessel revenue captures the immediate value of the commercial harvest, but does not reflect multiplier effects of subsequent revenues generated by seafood processors, distributors, and retailers (National Marine Fisheries Service, 1996).

fishermen spend thousands of hours annually in pursuit of these species, which are among the most highly prized of our marine resources. In 1999, commercial invertebrates (excluding squid) accounted for only about 6 percent of the state's total commercial catch by weight, but over 30 percent of its ex-vessel value at over $44 million. Commercial catch records for invertebrate species, like most of California's fisheries, are more complete than for their recreational counterparts (CA Department of Fish & Game, 2001).

5.5.1 Justification of Species Sensitivity Distribution

There are three potential arguments in opposition to the use of species sensitivity distributions for the purposes of our study that should be addressed.

First, data limitations required us to use toxicity data in our study for species not necessarily found in California state waters. The species used were deemed suitable substitutes because they have been categorized by the EPA as "marine ecotoxicity test species". By definition, these "test species" display sensitivity representative of their phyla (Sutter II, Efroymson et al., 2002). Therefore, although non-native to California, the species used in our sensitivity distributions are adequate surrogates for species found in the marine communities along the California coast. However, the use of species specific to the ports of interest could only strengthen these species sensitivity distributions. Specifically, if native species sensitivity indexes were used, the percent affected would be a more accurate representation of the actual effect of these pollutants to California's marine ecosystems.

In order to validate our use of representative species in the sensitivity distributions, we constructed a species sensitivity distribution for Monterey Bay that includes only organisms that are native to the area. We analyzed the effects of one constituent, copper, on the following species found in Monterey Bay. The percentage of community found to be affected in each model is found in Figure 5.1.

Common Name	Scientific Name	Author	Species Mean Acute Value (SMAV) (ug/L)
Mussel	*Mytilus spp.*	(Martin, Osborn et al., 1981), (Walker, 1991a),(Walker, 1991b), (Walker, 1991c), (SAIC, 1993), (City of San Jose, 1998)	6.19
Purple sea urchin	*Strongylocentrotus purpuratus*	(City of San Jose, 1998)	12.81
Mysid	*Holmesimysis costata*	(Martin, Hunt et al., 1989)	15.45
Blue Mussel	*Mytilus edulis*	(CH2MHill, 1999)	21.50
Dungeness crab	*Cancer magister*	(Martin, Osborn et al., 1981), (Dinnel, Link et al., 1989)	41.06
Black abalone	*Haliotis cracherodii*	(Martin, Stephenson et al., 1977)	41.90
Red abalone	*Haliotis rufescens*	(Martin, Stephenson et al., 1977)	72.14
Cabezon	*Scorpaenichthys*	(Dinnel, Link et al., 1989)	86.36
Mysid	*Neomysis mercedis*	(Brandt, Fujimura et al., 1993)	123.40
Copepod	*Tigriopus californicus*	(O'Brien, 1988)	196.20
Topsmelt	*Atherinops affinis*	(Anderson, 1991)	220.90
Squid	*Loligo opalescens*	(Dinnel, Link et al., 1989)	280.90
Shiner perch	*Cymatogaster aggregata*	(Dinnel, Link et al., 1989)	380.00
Amphipod	*Corophium insidiosum*	(Reish, 1993)	502.80
Coho salmon	*Oncorhynchus kisutch*	(Dinnel, Link et al., 1989)	546.30
Striped bass	*Morone saxatillis*	Reardon&Harrell 1990	4648.00

Table 5.3. Monterey: Species and their Associated LC50 Values Used in the Species Sensitivity Distribution

The LC50 values are reported as species mean acute values (SMAV) in Table 5.3 because, in some instances, the values are the result of the average of LC50 data from various sources.

Figure 5.1 is a detailed species sensitivity distribution for copper in the port of Monterey. Each of these points in the figure below represents a species for which we have toxicity data for copper (See Table 5.3). The trendline in Figure 5.1 is meant to be representative of the sensitivity of entire benthic community. The x-axis is the concentration of copper reaching the seafloor. The y-axis is the percent of the community that will experience mortality with the corresponding concentrations. The species at the lower end on the trendline are more sensitive to the pollutant, whereas those at the top of the trendline are less sensitive.

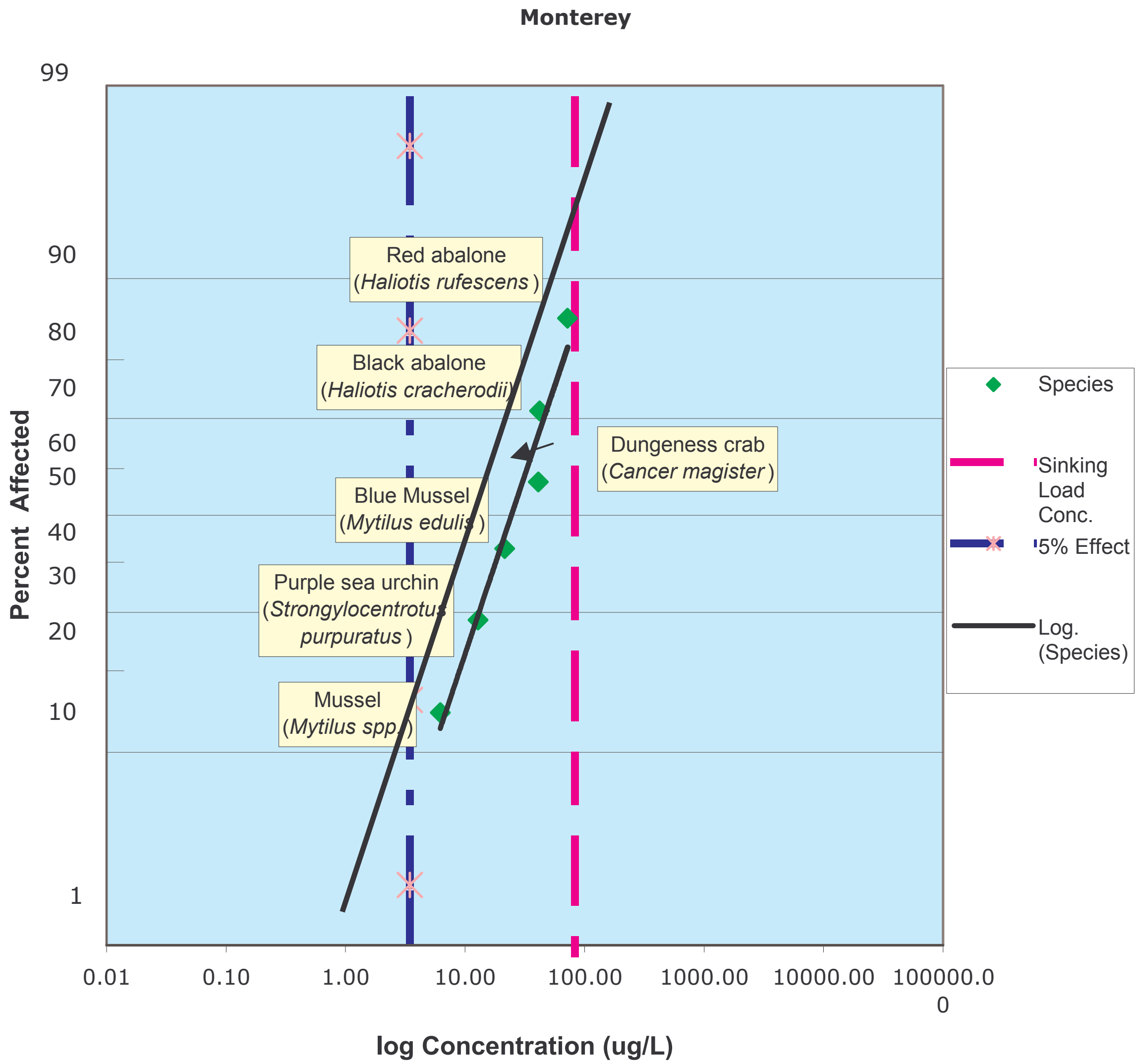

Figure 5.1. Monterey: Percent Affected by Copper in the Pore Water

The concentrations of adsorbed copper calculated by the sinking load model shows an effect on species in the Monterey Bay benthic community of approximately 85%. This is comparable to the 90% effect predicted using representative species (refer to Figure 5.1 copper concentration sinking load model) Therefore it can be concluded that the species sensitivity distributions using representative species are calculating a percent affected comparable to what would be calculated if only native species were used.

This case study shows that copper is indeed having impacts on California benthic species. Since many of the species use in the Monterey Bay case study are found throughout the coastal waters of California, we can conclude that the species sensitivity distributions performed for copper for the other ports of call are a adequate representation of the actual sensitivity of species native to California coastal waters.

A second argument that could arise regarding our use of species sensitivity distributions is that the marine community changes as one travels different distances offshore, and therefore one would expect to find different marine communities in each of our scenarios. In our analysis (with the exception of the Task Force and Alaska scenarios for Monterey and the Federal scenario for San Francisco) all areas have depths of less than 25m. Therefore, it is likely that similar communities exist throughout our scenarios. In the areas that are deeper than 25m and in the areas that are above this depth but harbor unusual communities because of abiotic or biotic influences, it can still be assumed that species used in species sensitivity analyses are representative of species in the marine environment that belong to the same family (Sutter II, Efroymson et al., 2002).

A final point could be raised about the sample size of the species sensitivity distributions. Due to data limitations, some of the sample sizes used to predict the trendlines (which represent the sensitivity of the marine communities) are small. For future research, it would be beneficial to gather further data on the acute toxicity of various species for each of these constituents. If this data were collected, the calculated trendline would be a more accurate representation of the sensitivity of the community.

6 RECOMMENDATIONS & PROPOSED FURTHER STUDY

6.1 FINAL RECOMMENDATIONS

Based on the results and discussion of our project, we recommend the following:

- **Future policies should require ships be at least 3 nautical miles offshore to minimize the amount of pollutants reaching shore.**
  Based on the results of the bacterial load model, we would recommend that regulations require ships wait until they are at least 3 nautical miles offshore and away from critical habitats, such as marine sanctuaries, before discharging blackwater and graywater wastestreams. 3 nautical miles is the minimum distance to assure minimal impacts to coastal areas from bacterial loads under both average and extreme weather conditions.

- **Depth must be taken into consideration if technology standards are not required.**
  The priority pollutant dispersion model, the sinking load model, and species sensitivity distributions showed that depth of the benthos is an important factor when considering impacts to the marine environment Due to the shallow nature of the California Continental Shelf and only small increases in depth as ships travel through state waters out to sea, regulators must consider depth, at the point of discharge, in addition to distance from shore when creating new policies. Alternatively, treatment standards can help to minimize these negative impacts. These are discussed in the following section.

- **Removal of heavy metals from blackwater and graywater prior to discharge.**
  Due to the potential of heavy pollutants to accumulate over time, as well as the likelihood of cumulative impacts of these constituents to the marine community we recommend legislation, which would mandate treatment systems that would remove these chemicals prior to discharge. The most common and effective method of removing heavy metals from wastestreams is hydroxide precipitation. This method involves adjusting the pH of the water by adding caustic water[28] so that the metals react with the hydroxide ions and form insoluble precipitates. The precipitates can then be easily removed before the water is discharged (Ayres, Davis et al., 1994). The cost of performing hydroxide precipitation is $0.50 to$1.00 per 1000 gallons of wastewater treated. This price range includes the fixed costs of installing the chemical addition system, the mixer settler, and the sludge filter, as well as variable costs such as operating and maintenance labor, sampling and process control, site supervision, off-site disposal of sludge and safety performance procedures (Naval Facilities Engineering Service Center, 2003).

[28] Caustic refers to sodium hydroxide ($NaOH$). Adding caustic water causes liquids to become highly alkaline (Ayres, D., A. Davis, et al., 1994).

Furthermore, regulations that require cruise ships to discharge at depths that would produce minimal effects to the marine community, as discussed above, may be unrealistic because constituents which display high rates of input (such as copper) would require cruise ships to travel to depths many miles offshore due to the extent of California's continental shelf. For this reason, a technology standard might be a more feasible alternative to depth consideration when formulating policies to regulate cruise ships. International Council of Cruise Lines (ICCL) has voiced its support for the installment of Advanced Water Treatment Systems (AWTSs) instead of a prohibition on certain wastestream discharges (International Council of Cruise Lines, 2003). Based on this, industry might prefer a technology standard in place of a depth standard.

- **Graywater must be treated to the same standards as blackwater prior to discharge.**
  As the raw data collected by Alaska Department of Environmental Conservation (ADEC) has shown graywater is the source for the majority of fecal coliform presently being discharged by cruise ships. Treating graywater to the same standards as blackwater would decrease the total amount of bacteria being discharged from each ship by 99%, thereby decreasing the amount of bacteria reaching California's shoreline and improving water quality. Furthermore, since both wastestreams contain heavy metals and pollutants that have the potential to produce negative impacts to marine communities, we also recommend legislation requiring that any standards applied to one wastestream be required for the other wastestream as well. Therefore, it is our recommendation that the legislation require cruise ship operators to run graywater through the same type of Marine Sanitation Device (MSD) as blackwater prior to its discharge.

- **Prohibit discharge of all wastestreams while in Sensitive Marine Areas**[29]
  Future policy must take into account the risk to specific marine communities associated with the location of cruise ship wastewater discharges. Sensitive Marine Areas, such as marine sanctuaries and reserves, may be at greater risk of degradation by impacts from cruise ships than areas already highly degraded due to a history of high input rates of pollution (such as the Los Angeles port area). Moreover, because certain constituents of cruise ship wastestreams may remain unknown due to lack of testing and reporting, policy makers must consider the potential impacts associated with these unknown constituents, particularly to extremely sensitive areas. For that reason, it would be advantageous to restrict discharge of cruise ship wastestreams more heavily in pristine or susceptible locations to insure the continued well-being of California's ecosystems.

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[29]Including but not limited to Marine Protected Areas, Marine Sanctuaries, National Monuments, National Parks, Habitat Areas of Particular Concern (HAPC) as defined by NOAA (National Oceanic and Atmospheric Administration, 2003) and Particularly Sensitive Sea Areas (PSSA) as defined by IMO (International Maritime Organization, 2002).

Until future regulations can address the suggestions above, we recommend the following action be taken immediately:

- **Conduct economic analyses on the adverse effects of cruise ship discharges in regards to beach closures, fisheries, and human health.**
  Until California legislation requires treatment of graywater and blackwater to the same standards, it is important to conduct an economic analysis on the adverse effects of cruise ship discharges.

  Cruise ship discharges include high levels of fecal coliform, yet there is very little primary data associated with the adverse effects of these discharges reaching California's coastline. Fecal coliform has been known to cause beach closures, fish kills, and risks to human health (gastrointestinal illness, headaches, fatigue, etc). These adverse effects may have significant monetary consequences to the state of California due to the potential loss of revenues from the tourism and fishing industries. Additionally, the presence of fecal coliform at public beaches poses serious health risks. Contingent valuation studies could be performed to determine how much people are willing to pay to avoid these adverse affects of fecal coliform at California beaches. This method could be applied to estimate the monetary damages the adverse effects of cruise ship discharges could have on beach closures, fisheries, and human health.

6.2 PROPOSED FURTHER STUDY

As our bacterial load model only gives a general idea of the concentration of fecal coliform that reaches the coast from one direction, ship to shore, the model could be expanded with further research to determine exactly what amount of bacteria reaches the shore in a specific location. Specifically, in our model the amount of fecal coliform reaching the shore is assumed to be "bundled," or in other words the pollution reaching the shore is doing so as a concentrated package of pollution rather than a dispersed plume as would be realistic. Although this was acceptable for the purposes of our study in which we examined the percent change of the total amount of pollution reaching the shore under each of the scenarios, the model is not entirely realistic. Therefore, it would be beneficial to model the movement of this pollution as a plume over a given domain for the purposes of determining the exact amount of fecal coliform reaching the shore at any given location. Inserting the dilution factor for ships moving greater than six knots could also expand the model. In addition, the storm velocity could be more exact if buoys measuring current velocity were placed closer to the three ports of interest.

The bacterial load model we have used to estimate the fate of cruise ship wastestreams is based on a mass balance transfer equation, and is similar to that used for air pollution dispersion models (Bird, Stewart et al., 1960). These equations are based on the general principles of diffusion and mass transfer. Therefore, while we use these equations to estimate effects from cruise ships, they could very well be applied to other sources of coastal pollution, such as those coming from land-based sources, as well as plumes from storm drains and pipes from sewage treatment facilities, both of which contain much of the same constituents as graywater and blackwater discharges from ships. Further research into bacterial pollution entering the marine environment could therefore utilize this model to examine the effects to the environment from the other potential sources of coastal pollution.

Our priority pollutant dispersion and sinking load model could also be made more precise if the exact routes of the cruise ships were followed, along with a log of when the discharges were made. Our model does not take into account the velocity of the ships when discharging the load, as the amount of each constituent that sinks is dependent on the reactivity rate each particle has with larger, denser particles. However, the velocity of the ships may affect the size of the domain that is affected and may dilute the discharge so that it is spread more thinly along the characteristic length of diffusion within the water column. A more detailed model with the capacity to take ship velocity into account may have less extreme results.

Furthermore, one way to approach the question of accumulation of these chemicals over time would be to attempt to model accumulation taking into account flux of marine sediments into and out of the domain of study, uptake by marine organisms, and burial in the sediments. In our project we were not able to estimate this, yet as cruise ship traffic increases into California ports it is imperative that we consider the impacts of these constituents to pelagic and benthic communities. The species sensitivity distributions that we completed for each port under each scenario were a first attempt at quantifying some of these potential impacts.

The practice of extrapolating data from laboratory experiments to solve real world questions is one that is generally criticized. However, time limitations did not provide the opportunity to perform primary research in this area. Field experiments conducted to address this weakness would greatly strengthen the results of this type of research

If legislature requires more data on potential impacts of cruise ship discharges, then there is a need for better water quality data. It is recommended that state beaches standardize the dates (day, month, year) in which they perform water quality testing. The vast inconsistencies in how many times per week and the inconsistencies over what time frame each state beach tested water quality led to many "holes" in the water quality data. As a result, it was necessary to manipulate the data and determine water quality values more indirectly than desired. A "complete" and matching time series of water quality testing amongst all state beaches could lead to better results. Although a minor point, a standardized method for testing fecal coliform should also be implemented in order to improve credibility of water quality data.

In addition, to perform valuable economic analyses, there is a need for visitor survey data across all state beaches. If every state beach conducted a standardized survey once per year, the state of California would have better data to conduct a more accurate and comprehensive demand for beach visitation in California. Additionally, we recommend that such a survey be conducted during the same time of year for each state beach in the same manner. Currently, how a survey is performed (if at all) is up to the discretion of each district. Standardized methodologies and comprehensive data sets may result in vastly improved outcomes.

Finally, there is a need for establishing a centralized database for all water quality data from California state beaches. At this time, individual districts maintain water quality data for every state beach. It is worth noting that during collection of our data, individual state beach districts were not well informed as to when or how other state beach districts were testing water quality. A centralized database with all results of water quality from all state beaches would be beneficial. This may ease access to this type of data for coastal managers, the public, and other academic or government related officials who wish to conduct economic analyses, or other analyses related to California State Beaches. This might also benefit coastal managers by allowing them to access one central database with water quality information and history to serve as a tool for better managing water quality issues along the California coastline.

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Appendix A. MARPOL 73/78 Annex Descriptions

Annex I: Prevention of pollution by oil

Entry into force: 2 October 1983

The 1973 Convention maintained the oil discharge criteria prescribed in the 1969 amendments to the 1954 Oil Pollution Convention, without substantial changes, namely:

Operational discharges of oil from tankers are allowed only when all of the following conditions are met:

1. The total quantity of oil that a tanker may discharge in any ballast voyage whilst under way must not exceed 1/15,000 of the total cargo carrying capacity of the vessel;

2. the rate at which oil may be discharged must not exceed 60 litres per mile travelled by the ship; and

3. no discharge of any oil whatsoever must be made from the cargo spaces of a tanker within 50 miles of the nearest land.

An oil record book is required, in which is recorded the movement of cargo oil and its residues from loading to discharging on a tank-to-tank basis.

In addition, in the 1973 Convention, the maximum quantity of oil permitted to be discharged on a ballast voyage of new oil tankers was reduced from 1/15,000 of the cargo capacity to 1/30,000 of the amount of cargo carried. These criteria applied equally both to persistent (black) and non-persistent (white) oils.

As with the 1969 OILPOL amendments, the 1973 Convention recognized the "load on top" (LOT) system which had been developed by the oil industry in the 1960s. On a ballast voyage the tanker takes on ballast water (departure ballast) in dirty cargo tanks. Other tanks are washed to take on clean ballast. The tank washings are pumped into a special slop tank. After a few days, the departure ballast settles and oil flows to the top. Clean water beneath is then decanted while new arrival ballast water is taken on. The upper layer of the departure ballast is transferred to the slop tanks. After further settling and decanting, the next cargo is loaded on top of the remaining oil in the slop tank, hence the term load on top.

A new and important feature of the 1973 Convention was the concept of "special areas" which are considered to be so vulnerable to pollution by oil that oil discharges within them have been completely prohibited, with minor and well-defined exceptions. The 1973 Convention identified the Mediterranean Sea, the Black Sea, and the Baltic Sea, the

Red Sea and the Gulfs area as special areas. All oil-carrying ships are required to be capable of operating the method of retaining oily wastes on board through the "load on top" system or for discharge to shore reception facilities.

This involves the fitting of appropriate equipment, including an oil-discharge monitoring and control system, oily-water separating equipment and a filtering system, slop tanks, sludge tanks, piping and pumping arrangements.

New oil tankers (i.e. those for which the building contract was placed after 31 December 1975) of 70,000 tons deadweight and above, must be fitted with segregated ballast tanks large enough to provide adequate operating draught without the need to carry ballast water in cargo oil tanks.

Secondly, new oil tankers are required to meet certain subdivision and damage stability requirements so that, in any loading conditions, they can survive after damage by collision or stranding.

The Protocol of 1978 made a number of changes to Annex I of the parent convention. Segregated ballast tanks (SBT) are required on all new tankers of 20,000 dwt and above (in the parent convention SBTs were only required on new tankers of 70,000 dwt and above). The Protocol also required SBTs to be protectively located - that is, they must be positioned in such a way that they will help protect the cargo tanks in the event of a collision or grounding.

Another important innovation concerned crude oil washing (COW), which had been developed by the oil industry in the 1970s and offered major benefits. Under COW, tanks are washed not with water but with crude oil - the cargo itself. COW was accepted as an alternative to SBTs on existing tankers and is an additional requirement on new tankers.

For existing crude oil tankers (built before entry into force of the Protocol) a third alternative was permissible for a period of two to four years after entry into force of MARPOL 73/78. The dedicated clean ballast tanks (CBT) system meant that certain tanks are dedicated solely to the carriage of ballast water. This was cheaper than a full SBT system since it utilized existing pumping and piping, but when the period of grace has expired other systems must be used.

Drainage and discharge arrangements were also altered in the Protocol, regulations for improved stripping systems were introduced.

Some oil tankers operate solely in specific trades between ports which are provided with adequate reception facilities. Some others do not use water as ballast. The TSPP Conference recognized that such ships should not be subject to all MARPOL requirements and they were consequently exempted from the SBT, COW and CBT requirements. It is generally recognized that the effectiveness of international conventions depends upon the degree to which they are obeyed and this in turn depends largely upon the extent to which they are enforced. The 1978 Protocol to MARPOL therefore introduced stricter regulations for the survey and certification of ships.

The 1992 amendments to Annex I made it mandatory for new oil tankers to have double hulls – and it brought in a phase-in schedule for existing tankers to fit double hulls.

Annex II: Control of pollution by noxious liquid substances

Entry into force: 6 April 1987

Annex II details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk.

Some 250 substances were evaluated and included in the list appended to the Convention. The discharge of their residues is allowed only to reception facilities until certain concentrations and conditions (which vary with the category of substances) are complied with.

In any case, no discharge of residues containing noxious substances is permitted within 12 miles of the nearest land. More stringent restrictions applied to the Baltic and Black Sea areas.

Annex III: Prevention of pollution by harmful substances in packaged form

Entry into force: 1 July 1992

The first of the convention's optional annexes. States ratifying the Convention must accept Annexes I and II but can choose not to accept the other three - hence they have taken much longer to enter into force.

Annex III contains general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications for preventing pollution by harmful substances.

The International Maritime Dangerous Goods (IMDG) Code has, since 1991, included marine pollutants.

Annex IV: Prevention of pollution by sewage from ships

Entry into force: 27 September 2003

The second of the optional Annexes, Annex IV contains requirements to control pollution of the sea by sewage.

Annex V: Prevention of pollution by garbage from ships

Entry into force: 31 December 1988

This deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of. The requirements are much stricter in a number of "special areas" but perhaps the most important feature of the Annex is the complete ban imposed on the dumping into the sea of all forms of plastic.

Annex VI: Prevention of Air Pollution from Ships

Adopted September 1997

Entry into force: 12 months after being ratified by 15 States whose combined fleets of merchant shipping constitute at least 50% of the world fleet.

The regulations in this annex, when they come into force, will set limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibit deliberate emissions of ozone depleting substances.

Source: International Maritime Organization (www.imo.org)

Appendix B. Alaska State Law Regarding Cruise Ships (HB 260)

Sec. 46.03.460. Program established.

(a) There is established the commercial passenger vessel environmental compliance program providing for

(1) terms and conditions of vessel discharges;

(2) independent verification of environmental compliance; and

(3) allowing the department to monitor and supervise discharges from commercial passenger vessels through a registration system.

(b) The department may adopt regulations to carry out the purposes of AS 46.03.460 - 46.03.490. The department shall use negotiated regulation making under AS 44.62.710 - 44.62.800, when appropriate, to develop those regulations.

Sec. 46.03.461. Registration requirements.

(a) Except as provided in AS 46.03.487 , each calendar year in which the owner or operator of a commercial passenger vessel intends to operate, or cause or allow to be operated, the vessel in the marine waters of the state, the owner or operator of the vessel shall register with the department. The registration shall be completed before the time any commercial passenger vessel of the owner or operator enters the marine waters of the state in that calendar year. The registration must include the following information:

(1) the vessel owner's business name and, if different, the vessel operator's business name for each commercial passenger vessel of the owner or operator that is scheduled to be in the marine waters of the state during the calendar year;

(2) the postal address, electronic mail address, telephone number, and facsimile number for the principal place of each business identified under (1) of this subsection;

(3) the name and address of an agent for service of process for each business identified under (1) of this subsection; the owner and operator shall continuously maintain a designated agent for service of process whenever a commercial passenger vessel of the owner or operator is in the marine waters of the state, and the agent must be an individual resident of this state, a domestic corporation, or a foreign corporation having a place of business in and authorized to do business in this state;

(4) the name or call sign of and Port of Registry for each of the owner's or operator's vessels that is scheduled either to call upon a port in this state or otherwise to be in the marine waters of the state during the calendar year and after the date of registration; and

(5) an agreement to comply with the terms and conditions of vessel discharges specified under AS 46.03.462 .

(b) Registration under (a) of this section shall be executed under oath by the owner or operator.

(c) Upon request of the department, the registrant shall submit registration information required under this section electronically.

Sec. 46.03.462. Terms and conditions of discharges.

(a) An owner or operator required to register under AS 46.03.461 shall comply with either the standard terms and conditions of vessel discharges specified in (b) of this section or the alternative terms and conditions of vessel discharges specified in (c) of this section.

(b) The standard terms and conditions of vessel discharges are that the owner or operator

(1) may not discharge untreated sewage, treated sewage, graywater, or other wastewater in a manner that violates AS 46.03.463 ;

(2) shall maintain records and provide the reports required under AS 46.03.465(a);

(3) shall collect and test samples as required under AS 46.03.465 (b) and (d) and provide the reports with respect to those samples required by AS 46.03.475 (c);

(4) shall report discharges in accordance with AS 46.03.475 (a);

(5) shall allow the department access to the vessel at the time samples are taken under AS 46.03.465 for purposes of taking the samples or for purposes of verifying the integrity of the sampling process; and

(6) shall submit records, notices, and reports to the department in accordance with AS 46.03.475 (b), (d), and (e).

(c) The department may establish alternative terms and conditions of vessel discharges applicable to an owner or operator of a vessel who cannot practicably comply with the standard terms and conditions of vessel discharges under (b) of this section, or who wishes to use or test alternative environmental protection equipment or procedures. Except as specified in alternative terms and conditions set by the department under this subsection, the alternative terms and conditions of vessel discharges must require compliance with the standard terms and conditions of vessel discharges under (b) of this section. The department, on a case-by-case basis, may set alternative terms and conditions of vessel discharges if

(1) the vessel owner or operator demonstrates to the department's reasonable satisfaction that equivalent environmental protection can be attained through other terms or conditions appropriate for the specific configuration or operation of the vessel;

(2) the vessel owner or operator agrees to make necessary changes to the vessel to allow it to comply with the standard terms and conditions of vessel discharges under (b) of this section but demonstrates to the department's reasonable satisfaction that additional time is needed to make the necessary changes; or

(3) an experimental technology or method for pollution control of a discharge is being used or is proposed as one of the alternative terms and conditions of vessel discharges and the department determines that the experimental technology or method has a reasonable likelihood of success in providing increased protection for the environment.

(d) Alternative terms and conditions of vessel discharges approved by the department under (c) of this section may, if determined appropriate by the department, include a waiver by the department of portions of the requirements of AS 46.03.463 and 46.03.465, for the time period that the department determines to be appropriate.

Sec. 46.03.463. Prohibited discharges; limitations on discharges.

(a) Except as provided in (h) of this section, a person may not discharge untreated sewage from a commercial passenger vessel into the marine waters of the state.

(b) Except as provided in (h) of this section or under AS 46.03.462 (c) - (d), a person may not discharge sewage from a commercial passenger vessel into the marine waters of the state that has suspended solids greater than 150 milligrams per liter or a fecal coliform count greater than 200 colonies per 100 milliliters except that the department may by regulation adopt a protocol for retesting for fecal coliform, if this discharge limit for fecal coliform is exceeded, under which a discharger will be considered to be in compliance with the fecal coliform limit if the geometric mean of fecal coliform count in the samples considered under the protocol does not exceed 200 colonies per 100 milliliters. Upon submission by the owner or operator of a small commercial passenger vessel of a plan for interim protective measures, the department shall extend the time for compliance of that vessel with this subsection.

(c) Except as provided in (h) of this section or under AS 46.03.462 (c) - (d), a person may not discharge graywater or other wastewater from a commercial passenger vessel into the marine waters of the state that has suspended solids greater than 150 milligrams per liter or a fecal coliform count greater than 200 colonies per 100 milliliters except that the department may by regulation adopt a protocol for retesting for fecal coliform, if this discharge limit for fecal coliform is exceeded, under which a discharger will be considered to be in compliance with the fecal coliform limit if the geometric mean of fecal coliform count in the samples considered under the protocol does not exceed 200 colonies per 100 milliliters. Upon submission by the owner or operator of a large commercial passenger vessel of a plan for interim protective measures, the department shall extend the time for compliance of that vessel with this subsection for a period of time that ends not later than January 1, 2003. Upon submission by the owner or operator of a small commercial passenger vessel of a plan for interim protective measures, the department shall extend the time for compliance of that vessel with this subsection.

(d) The department may by regulation establish numeric or narrative standards for other parameters for treated sewage, graywater, and other wastewater discharged from commercial passenger vessels. In developing regulations under this subsection, the department shall consider the best available scientific information on the environmental effects of the regulated discharges, the materials and substances handled on the vessels, vessel movement effects, and the availability of new technologies for wastewater.

(e) Except as provided in (g) and (h) of this section or under AS 46.03.462(c) - (d), a person may not discharge any treated sewage, graywater, or other wastewater from a large commercial passenger vessel into the marine waters of the state unless

(1) the vessel is underway and proceeding at a speed of not less than six knots;

(2) the vessel is at least one nautical mile from the nearest shore, except in areas designated by the department;

(3) the discharge complies with all applicable vessel effluent standards established under the federal cruise ship legislation and any other applicable law; the standards under the federal cruise ship legislation and other applicable law may be adopted by regulation by the department; and

(4) the vessel is not in an area where the discharge of treated sewage, graywater, or other wastewater is prohibited.

(f) Except as provided in (h) of this section, a person may not discharge sewage from a small commercial passenger vessel unless the sewage has been processed through a properly operated and properly maintained marine sanitation device.

(g) The provisions of (e)(1) and (e)(2) of this section do not apply to a discharge permitted under sec. 1404(b) or (c) of the federal cruise ship legislation.

(h) The provisions of (a) - (f) of this section do not apply to discharges made for the purpose of securing the safety of the commercial passenger vessel or saving life at sea if all reasonable precautions have been taken for the purpose of preventing or minimizing the discharge.

Sec. 46.03.465. Information-gathering requirements.

(a) Except as provided under AS 46.03.462 (c) - (d), the owner or operator of a commercial passenger vessel shall maintain records and, upon request of the department, provide to the department a report, with copies of the records related to the period of operation in the marine waters of the state, detailing the dates, times, and locations, and the volumes or flow-rates of any discharge of sewage, graywater, or other wastewater into the marine waters of the state.

(b) Except as provided under AS 46.03.462 (c) - (d), while a commercial passenger vessel is present in the marine waters of the state, the owner or operator of the vessel shall collect routine samples of the vessel's treated sewage, graywater, and other wastewater that are being discharged into the marine waters of the state with a sampling technique approved by the department before the sample is collected. The number of routine samples for each vessel to be collected under this subsection shall be the greater of two per calendar year or the number of samples required to be collected under federal statutes and regulations for sewage, graywater, or other wastewater discharges.

(c) Except as provided under AS 46.03.462 (c) - (d), while a commercial passenger vessel is present in the marine waters of the state, the department, or an independent contractor retained by the department, may collect additional samples of the vessel's treated sewage, graywater, and other wastewater that are being discharged into the marine waters of the state.

(d) Except as provided under AS 46.03.462 (c) - (d), the owner or operator of a vessel required to collect samples under (b) of this section shall have the samples tested to measure fecal coliform, ammonia, residual chlorine, pH (degree of acidity or alkalinity), chemical oxygen demand (COD), biochemical oxygen demand (BOD), total suspended solids, and other parameters as required by the department in the samples with an analytical testing method that was approved by the department before the testing is conducted. A laboratory used for testing under this subsection shall agree not to disclose the testing results to any person other than to the department, the United States Coast Guard, or the owner or operator of the vessel.

(e) The owner or operator of a commercial passenger vessel shall pay for all routine sampling under (b) of this section and the testing of routine samples. The department shall pay for all additional sampling under (c) of this section and the testing of the additional samples.

(f) If the owner or operator of a commercial passenger vessel has, when complying with another state or federal law that requires substantially equivalent information gathering, gathered the type of information required under (a), (b), or (d) of this section, the owner or operator shall be considered to be in compliance with that subsection so long as the information is also provided to the department.

Sec. 46.03.470. Record keeping requirements.

An owner or operator subject to AS 46.03.465 shall record the information required to be gathered under that section and shall maintain the records for three years after the date the information was gathered.

Sec. 46.03.475. Reporting requirements.

(a) An owner or operator of a commercial passenger vessel who becomes aware of a discharge in violation of AS 46.03.463 shall immediately report that discharge to the department. There is no audit report privilege under AS 09.25.450 for this information.

(b) If the owner or operator of a commercial passenger vessel operating in the marine waters of the state is required by the Administrator of the Environmental Protection Agency or the secretary of the federal department in which the United States Coast Guard is operating to collect samples and test sewage, graywater, or other wastewater and keep records of the sampling and testing, the owner or operator shall, within 21 days after the sewage, graywater, or other wastewater is tested, submit to the department a copy of the records.

(c) Within 21 days after the testing required under AS 46.03.465 (d), the owner or operator shall submit a written report to the department that contains the measurements required under AS 46.03.465 (d) and describes the sampling technique and analytical testing methods used. The information in the report required under this subsection may be provided by referring to, and including copies of, other reports that are required by substantially equivalent state or federal reporting requirements.

(d) If the owner or operator of a commercial passenger vessel operating in the marine waters of the state is required by the laws of the United States or by the laws of Canada or of a province or territory of Canada to file a report or provide notice of a discharge or offloading of a hazardous waste, as defined in AS 46.03.900 , or of a hazardous substance, as defined in AS 46.03.826 , that was generated, discharged, or offloaded while the vessel was operating in the marine waters of the state, the owner or operator shall submit to the department a copy of the report or notice within 21 days after having provided the report or notice to an agency of the government of the United States or to an agency of the government of Canada or of a province or territory of Canada.

(e) Before the operation of a commercial passenger vessel in the marine waters of the state, the owner or operator of the vessel shall provide to the department a plan that describes the vessel's policies and procedures for

> (1) offloading in this state or disposing into the marine waters of the state of nonhazardous solid waste other than sewage; and
>
> (2) offloading of hazardous waste or a hazardous substance from the vessel while it is operating in the marine waters of the state to the extent that the offloading is not covered by (d) of this section.

(f) Upon request of the department, the information required under this section shall be submitted electronically.

(g) This section does not relieve the owner or operator of a commercial passenger vessel from other applicable reporting requirements of state or federal law.

Sec. 46.03.480. Fees.

(a) There is imposed an environmental compliance fee on each commercial passenger vessel operating in the marine waters of the state.

(b) The fee imposed by (a) of this section for all commercial passenger vessels, other than vessels operated by the state, is a separate fee for each voyage during which the commercial passenger vessel operates in the marine waters of the state. The fee shall range from $.70 to $1.75 per berth, based on the overnight accommodation capacity of the vessel, determined with reference to the number of lower berths, according to the following categories:

> (1) $75 for a commercial passenger vessel with overnight accommodations for at least 50 but not more than 99 passengers for hire;
>
> (2) $175 for a commercial passenger vessel with overnight accommodations for at least 100 but not more than 249 passengers for hire;
>
> (3) $375 for a commercial passenger vessel with overnight accommodations for at least 250 but not more than 499 passengers for hire;
>
> (4) $750 for a commercial passenger vessel with overnight accommodations for at least 500 but not more than 999 passengers for hire;
>
> (5) $1,250 for a commercial passenger vessel with overnight accommodations for at least 1,000 but not more than 1,499 passengers for hire;

(6) $1,750 for a commercial passenger vessel with overnight accommodations for at least 1,500 but not more than 1,999 passengers for hire;

(7) $2,250 for a commercial passenger vessel with overnight accommodations for at least 2,000 but not more than 2,499 passengers for hire;

(8) $2,750 for a commercial passenger vessel with overnight accommodations for at least 2,500 but not more than 2,999 passengers for hire;

(9) $3,250 for a commercial passenger vessel with overnight accommodations for at least 3,000 but not more than 3,499 passengers for hire;

(10) $3,750 for each commercial passenger vessel with overnight accommodations for 3,500 or more passengers for hire.

(c) The fee imposed by (a) of this section for a commercial passenger vessel that is operated by this state shall be determined by agreement between the commissioner of environmental conservation and the commissioner of transportation and public facilities.

(d) A commercial passenger vessel operating in the marine waters of the state is liable for the fee imposed by this section. The fee is due and payable to the department in the manner and at the times required by the department by regulation.

Sec. 46.03.482. Commercial passenger vessel environmental compliance fund.

(a) The commercial passenger vessel environmental compliance fund is created in the general fund.

(b) The fund consists of the following, all of which shall be deposited in the fund upon receipt:

(1) money received by the department in payment of fees under AS 46.03.480;

(2) money received under AS 46.03.760 (e) as a result of a violation related to AS 46.03.460 - 46.03.490 unless the money would otherwise be deposited in the oil and hazardous substance release prevention and response fund established by AS 46.08.010 ;

(3) money appropriated to the fund by the legislature;

(4) earnings on the fund.

(c) The legislature may make appropriations from the fund to the department to pay for the department's operational costs necessary to prepare reports that assess the information received by the department for the cruise ship seasons of 2000, 2001, 2002, and 2003 and for the department's operational costs necessary to carry out activities under AS 46.03.460 - 46.03.490 relating to commercial passenger vessels.

(d) The unexpended and unobligated balance of an appropriation made from the fund to the department for the purposes described in (c) of this section lapses into the fund on December 31 following the end of the period for which the appropriation was made.

(e) Nothing in this section creates a dedicated fund.

Sec. 46.03.485. Recognition program.

The department may engage in efforts to encourage and recognize superior environmental protection efforts made by the owners or operators of commercial passenger vessels that exceed the requirements established by law.

Sec. 46.03.487. Exemption for vessels in innocent passage.

AS 46.03.460 - 46.03.490 do not apply to a commercial passenger vessel that operates in the marine waters of the state solely in innocent passage. For purposes of this section, a vessel is engaged in innocent passage if its operation in marine waters of the state, regardless of whether the vessel is a United States or foreign-flag vessel, would constitute innocent passage under the

(1) Convention on the Territorial Sea and the Contiguous Zone, April 29, 1958, 15 U.S.T. 1606; or

(2) United Nations Convention on the Law of the Sea 1982, December 10, 1982, United Nations Publication No. E.83.V.5, 21 I.L.M. 1261 (1982), were the vessel a foreign-flag vessel.

Sec. 46.03.488. Activities of the department.

The department may engage in the following activities relating to commercial passenger vessels operating in the marine waters of the state:

(1) direct in-water monitoring of discharges or releases of sewage, graywater, and other wastewater and direct monitoring of the opacity of air emissions from those vessels;

(2) monitoring and studying of direct or indirect environmental effects of those vessels; and

(3) researching ways to reduce effects of the vessels on marine waters and other coastal resources.

Sec. 46.03.490. Definitions.

In AS 46.03.460 - 46.03.490,

(1) "agent for service of process" means an agent upon whom process, notice, or demand required or permitted by law to be served upon the owner or operator may be served;

(2) "commercial passenger vessel" means a vessel that carries passengers for hire except that "commercial passenger vessel" does not include a vessel

(A) authorized to carry fewer than 50 passengers;

(B) that does not provide overnight accommodations for at least 50 passengers for hire, determined with reference to the number of lower berths; or

(C) operated by the United States or a foreign government;

(3) "discharge" means any release, however caused, from a commercial passenger vessel, and includes any escape, disposal, spilling, leaking, pumping, emitting, or emptying;

(4) "federal cruise ship legislation" means secs. 1401 - 1414 of H.R. 5666, as incorporated by reference into P.L. 106-554;

(5) "fund" means the commercial passenger vessel environmental compliance fund established under AS 46.03.482 ;

(6) "graywater" means galley, dishwasher, bath, and laundry wastewater;

(7) "large commercial passenger vessel" means a commercial passenger vessel that provides overnight accommodations for 250 or more passengers for hire, determined with reference to the number of lower berths;

(8) "marine waters of the state" means all waters within the boundaries of the state together with all of the waters of the Alexander Archipelago even if not within the boundaries of the state;

(9) "offloading" means the removal of a hazardous substance, hazardous waste, or nonhazardous solid waste from a commercial passenger vessel onto or into a controlled storage, processing, or disposal facility or treatment works;

(10) "other wastewater" means graywater or sewage that is stored in or transferred to a ballast tank or other holding area on the vessel that may not be customarily used for storing graywater or sewage;

(11) "passengers for hire" means vessel passengers for whom consideration is contributed as a condition of carriage on the vessel, whether directly or indirectly flowing to the owner, charterer, operator, agent, or any other person having an interest in the vessel;

(12) "sewage" means human body wastes and the wastes from toilets and other receptacles intended to receive or retain human body waste;

(13) "small commercial passenger vessel" means a commercial passenger vessel that provides overnight accommodations for 249 or fewer passengers for hire, determined with reference to the number of lower berths;

(14) "treated sewage" means sewage that meets all applicable effluent limitation standards and processing requirements of 33 U.S.C. 1251 - 1376 (Federal Water Pollution Control Act), as amended, the federal cruise ship legislation, and regulations adopted under 33 U.S.C. 1251 - 1376 or under the federal cruise ship legislation;

(15) "untreated sewage" means sewage that is not treated sewage;

(16) "vessel" means any form or manner of watercraft, other than a seaplane on the water, whether or not capable of self-propulsion;

(17) "voyage" means a vessel trip to or from one or more ports of call in the state with the majority of the passengers for hire completing the entire vessel trip; a vessel trip involving stops at more than one port of call is considered a single voyage so long as the majority of passengers for hire complete the entire trip;

(18) "waters of the Alexander Archipelago" means all waters under the sovereignty of the United States within or near Southeast Alaska, beginning at a point 58 degrees 11 minutes 41 seconds North, 136 degrees 39 minutes 25 seconds West (near Cape Spencer Light), thence southeasterly along a line three nautical miles seaward of the baseline from which the breadth of the territorial sea is measured in the Pacific Ocean and the Dixon Entrance, except where this line intersects geodesics connecting the following five pairs of points: (A) 58 degrees 05 minutes 17 seconds North, 136 degrees 33 minutes 49 seconds West and 58 degrees 11 minutes 41 seconds North, 136 degrees 39 minutes 25 seconds West (Cross Sound); (B) 56 degrees 09 minutes 40 seconds North, 134 degrees 40 minutes 00 seconds West and 55 degrees 49 minutes 15 seconds North, 134 degrees 17 minutes 40 seconds West (Chatham Strait); (C) 55 degrees 49 minutes 15 seconds North, 134 degrees 17 minutes 40 seconds West and 55 degrees 50 minutes 30 seconds North, 133 degrees 54 minutes 15 seconds West (Sumner Strait); (D) 54 degrees 41 minutes 30 seconds North, 132 degrees 01 minutes 00 seconds West and 54 degrees 51

minutes 30 seconds North, 131 degrees 20 minutes 45 seconds West (Clarence Strait); (E) 54 degrees 51 minutes 30 seconds North, 131 degrees 20 minutes 45 seconds West and 54 degrees 46 minutes 15 seconds North, 130 degrees 52 minutes 00 seconds West (Revillagigedo Channel); the portion of each such geodesic situated beyond three nautical miles from the baseline from which the breadth of the territorial sea is measured forms the outer limit of the waters of the Alexander Archipelago in those five locations.

Appendix C. Memorandum of Understanding – Hawaii and the Northwest Cruise Ship Association

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MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding is entered into this _____ day of __________ 2002 by and between the State of Hawaii and the North West CruiseShip Association, hereinafter referred to as NWCA, representing Carnival Cruise Lines, Celebrity Cruises, Crystal Cruises, Holland America Line, Norwegian Cruise Line, Princess Cruises, Royal Caribbean Cruise Line, World Explorer, Radisson Seven Seas and Seabourn, as representatives of the Cruise Industry in Hawaii.

Whereas the State of Hawaii is charged with the responsibility of protecting and conserving Hawaii's environmental resources in relation to the Cruise Industry's environmental practices in Hawaii; and

Whereas, the NWCA is a non-profit entity organized for the purpose of representing member cruise lines which operate in and about Hawaii, whose current membership is identified in ***Appendix i***; and

Whereas, the NWCA has adopted the "**Cruise Industry Waste Management Practices and Procedures"** as promulgated by the Cruise Industry's trade association, the International Council of Cruise Lines, herein referred to as ICCL, which practices and procedures are attached hereto as ***Appendix ii***; and

Whereas, NWCA cruise vessels operate in international waters and move passengers to destinations worldwide and, consequently, those cruise vessel waste management practices must take into account environmental laws and regulations in many jurisdictions and international treaties and conventions; and

Whereas, the NWCA and the State of Hawaii have met to develop waste management practices that preserve a clean and healthy environment and demonstrate the Cruise Industry's commitment to be a steward of the environment; and

Whereas, research is ongoing to establish the impact of ships' wastewater discharges on the ocean environment, and the results of this research will be taken into account in periodic review of the wastewater discharge practices described in this memorandum of understanding; and

Whereas, the cruise industry recognizes Hawaii's fragile marine environment and is committed to help protect this environment;

Now therefore, based upon mutual understanding, the parties enter into this Memorandum of Understanding to implement the following environmental goals, policies and practices:

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Definition of terms for the purpose of this agreement:

"air emissions" refers to the airborne releases associated with the operation of the vessel;

"blackwater" means waste from toilets, urinals, medical sinks and other similar facilities;

"cruise ship" means any vessel that is owned or operated by a member of the NWCA;

"garbage" means solid galley waste, paper, rags, plastics, glass, metal, bottles, crockery, junk or similar refuse;

"graywater" includes drainage from dishwasher, shower, laundry, bath and washbasin drains;

"Hawaii marine areas" means those waters between the shoreline of the Hawaiian Islands and any point 4 nautical miles beyond the 100 fathom contour line as illustrated in Appendix iii;

1. The State of Hawaii accepts the ICCL Industry Standard E-0l -01, titled ***Cruise Industry Waste Management Practices and Procedures (Appendix ii***) as ICCL member policy in the management of solid waste, hazardous wastes and wastewaters. In addition to the ICCL Practices, the members of NWCA operating in Hawaii agree to comply with the following unique practices among the Hawaiian Islands:

1.1 Wastewater Management

In recognition of the sensitive nature of Hawaii's marine environment, the NWCA agrees to prohibit the discharge of untreated black water, treated black water or gray water within the Hawaii marine area as defined above. (**Appendix iii**).

Exception from this prohibition is as follows:

If the effluent from an advanced wastewater treatment system on board a ship meets standards for continuous discharge as set under federal Law - Title XIV - Certain Alaskan Cruise Ship Operations, Section 1404 Limitations on Discharge of Treated Sewage or Graywater, Subsection (c) (1), (2), (3), (4) (**Appendix vii**), the effluent from such advanced wastewater treatment systems may be discharged in the Hawaii marine area while the ship maintains a minimum speed of six knots and while the ship is more than one nautical mile from shore.

Prior to the discharge of effluent by a ship utilizing an advanced treatment system in the situation described above, the cruise ship company must first provide to the State of Hawaii test results as are required under the above referenced federal law to verify that the system meets or exceeds the federal law standards as described.

The NWCA and the State of Hawaii will continue discussions to determine whether maintaining these restrictions on advanced wastewater treatment systems is consistent with best available scientific information on the environmental effects of the discharges.

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1.2 Solid Waste, Hazardous Waste Management:

The NWCA has adopted the ICCL policy guidelines as stipulated above. NWCA Ships sailing in Hawaiian waters will comply with these policies and best practices as presented in these standards. ***(Appendix ii)***

NWCA member ships operating in Hawaiian waters will eliminate, to the maximum extent possible, the disposal of wastes described under MARPOL Annex V into the marine environment through improved reuse and recycling opportunities. Where reuse and recycling are not feasible, waste will be discharged into the marine environment only if it has been properly processed and can be discharged in accordance with MARPOL, the ICCL best management practices, and other prevailing requirements. Whenever a member ship offloads solid waste in Hawaii, it shall ensure that such offloading be done in compliance with all state and local laws.

1.3 Air Emissions

1.3.1 NWCA members agree that their ships will not use their incinerators in any Hawaiian ports for the combustion of any waste materials.

1.3.2 NWCA members agree to limit visible emissions, excluding condensed water vapor, as follows:

Ships will not exceed 20% opacity for periods of time exceeding 6 minutes in any 60-minute period (Continuous emission monitor or EPA Method 9) except for the following:

a. When the ship is maneuvering to or from the dock or anchor,[1]
b. In the event of a navigational or safety concern on the ship,
c. When an equipment failure occurs[2]. In the case of an equipment failure, the cruise line will upon request, provide information to the State that describes the subject equipment, the malfunction, the corrective actions taken and the start and end times of the malfunctioning period.

Note:
Depending on current, wind and port congestion, it may be necessary to have full engine capacity on standby to assure safe port navigation or compensate for equipment failure. In such cases of full engine deployment and low engine loads, higher than normal particulate emissions can result.

Footnotes

1. *Maneuvering is defined for the purpose of this MOU as: On departure from the dock or anchorage, maneuvering will commence with the startup of the additional engines required for safe ship handling on its departure from the dock or anchor. It will cease once the ship has established its course and*

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speed towards the open sea and is clear of the last port navigational markers. On arrival, maneuvering will commence when the engine configuration for entering the port has been set by the Captain. It may cal for additional engines to assure adequate power to allow for safe ship handling during docking procedures, or anchoring, and will cease when the ship is safely secured to the dock, or at anchor, and the additional engines are shut down.

2. *Equipment failure (for example – boiler, engine injector or turbo failure) can cause periodic excess particulate matter. Some discretion from the visual emission standards is allowed if the failure has occurred on the current or previous voyage, as long as the repairs are waiting for either technical support or a critical spare part.*

1.3.3 NWCA ships will have opacity-metering and recording capability and will continuously monitor the stack's visible emissions while sailing in Hawaiian waters.

1.3.4 The State of Hawaii recognizes that, as of the execution of this memorandum, there are no Cruise Steamships plying the waters of Hawaii. Notwithstanding the foregoing, NWCA members agree that they shall not discharge soot within 1,000 yards of the Hawaii coastline. Cruise Steamships shall not cause or permit the discharge if it would have been practical to emit the discharge before or after leaving land or if an alternative method could have been employed.

1.3.5 The NWCA member ships generally take on fuel in California, British Columbia, and Hawaii ports. The sulfur content of the fuel currently available at these locations is less than 2.8% by weight. It is the intent of the member cruise lines to continue to bunker their ships in these ports with fuel with a sulfur content of less than 2.8% by weight. If such fuel becomes unavailable in those ports, or is unavailable for any NWCA ship coming to Hawaii from other ports, the ship will advise the State of Hawaii in writing.

2. The State of Hawaii acknowledges that the waste management practices and procedures referenced and/or contained in section 1 above meet or exceed the standards set forth in Hawaii laws and applicable Hawaii regulations as pertaining to ship operations.

3. The State of Hawaii and the NWCA understand that the U.S. Coast Guard (USCG) has Federal jurisdiction over environmental matters in navigable waterways in the United States and conducts passenger ship examinations that include review of environmental systems, Safety Management System (SMS) documentation and such MARPOL-mandated documents as the Oil Record Book and the Garbage Record Book. Additionally, NWCA member cruise vessels will integrate such industry standards into SMS documentation that ensure compliance through statutorily required internal and third party audits.

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4. The USCG has developed guidelines relating to the inspection of waste management practices and procedures, which have been adopted by the cruise industry. The State of Hawaii accepts the USCG Navigation and Vessel Inspection Circular and Environmental Systems Checklist (***Appendix iv)***, which will be incorporated into USCG 840 Guidebook as the procedure to conduct waste management inspections on board cruise vessels. To reduce administrative burden on the cruise ship industry, the State of Hawaii agrees to first request from the USCG any records for cruise vessels entering Hawaii territorial waters. Should records described above not be made available by the USCG, the cruise ship will provide them to the State.

5. The ICCL in consultation with NWCA is working with the Environmental Protection Agency (EPA) to develop a national practice for the assigning of an EPA Identification Number to the generator of hazardous wastes, which recognizes the multi-jurisdictional itineraries of a cruise vessel. Conceptually, the EPA has agreed that issuing a national identification number to cruise vessels operating in the U.S. is an acceptable procedure. EPA also proposes that the state where company offices are located may issue the national identification numbers provided the criteria and information submitted required for obtaining the number is standard for the United States. The State of Hawaii and NWCA agree to a uniform application procedure for the EPA national identification number in accordance with the Resource Conservation Recovery Act (RCRA) (***Appendix v***). The State of Hawaii shall have the right to inspect all such records upon written request to the cruise vessel operator. The State of Hawaii recognizes that in some cases EPA Identification Numbers may not be required under federal law because of the small amounts of waste generated.

6. The NWCA has adopted a uniform procedure for the application of RCRA to cruise vessels entering Hawaii (***Appendix vi***). The State of Hawaii accepts this procedure as the appropriate process for vendor selection and management of hazardous wastes in Hawaii. NWCA member lines agree to provide an annual report regarding the total hazardous waste offloaded in Hawaii by each cruise vessel.

7. The State of Hawaii and NWCA agree that all records required by RCRA for cruise vessels entering Hawaii territorial waters shall be available to the State of Hawaii upon written request to the cruise vessel operator.

8. The State of Hawaii recognizes that waste management practices are undergoing constant assessment and evaluation by cruise industry members. It is understood by the STATE OF HAWAII and the NWCA that the management of waste streams will be an on-going process, which has as its stated objectives both waste minimization and pollution prevention. Consequently, all parties agree to continue to work with each other in good faith to achieve the stated objectives. This may require additional meetings with federal regulators to discuss specific issues applicable to the cruise industry in the U.S.

9. The NWCA acknowledges that its operating practices are required to comply with the applicable provisions of the Marine Mammal Protection Act and the Invasive Species Act.

10. The State of Hawaii agrees that the performance required by the NWCA under the terms of this Memorandum of Understanding shall be directed only to its member cruise lines.

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The NWCA acknowledges that its members operate cruise vessels engaged in cruise itineraries greater than one day duration; and further that its members do not operate one-day attraction ships or casino gambling ships.

11. All parties acknowledge that ongoing discussions of environmental goals are recognized as a necessary component to the successful implementation of management practices for waste minimization and reduction.

12. All parties acknowledge that this MOU is not inclusive of all issues, rules or programs that may arise in the future. The State of Hawaii reserves the right to enter into additional MOU to address or refine such issues, or to pursue appropriate legislation. All parties agree to at least one annual meeting to review the effectiveness of the MOU. The State of Hawaii and NWCA reserve the right to cancel this MOU upon 90 days written notice.

IN RECOGNITION OF THE MUTUAL UNDERSTANDINGS DISCUSSED HEREIN; THE PARTIES HERETO AFFIX THEIR SIGNATURES ON THIS ______ DAY OF _______________ 2002.

____
BENJAMIN J. CAYETANO
Governor, State of Hawaii

____
JOHN HANSEN
President, North West CruiseShip Association

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APPENDICES
MEMORANDUM OF UNDERSTANDING

Appendix i	List of NWCA Member Lines
Appendix ii	ICCL Standards
Appendix iii	Navigational Chart of Hawaiian Waters denoting 4 nm outside demarcation of the 100 fathom zone
Appendix iv	USCG Navigation & Vessel Inspection Circular and Environmental Systems Checklist
Appendix v	Uniform application procedure for EPA National ID Number as per Resource Conservation Recovery Act.
Appendix vi	Uniform procedure for the application of RCRA to cruise vessels entering Hawaii
Appendix vii	Title XIV – Certain Alaskan Cruise Ship Operations, Section 1404 Limitations on Discharge of Treated Sewage or Graywater, Subsection (c) (1), (2), (3), (4)

Appendix D. Memorandum of Understanding – Florida, the Florida-Caribbean Cruise Ship Association, and ICCL

MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding is entered into this ____ day of ____, 2001 by and between the Florida Department of Environmental Protection, herein referred to as FDEP; the Florida-Caribbean Cruise Association and the International Council of Cruise Lines, as representatives of the cruise industry in Florida, hereinafter referred to as FCCA and ICCL.

Whereas, FDEP, is responsible for the protection of Florida's environment and for regulation of environmental laws in the State of Florida; and
Whereas, the FCCA and ICCL are non-profit entities organized for the purpose of representing member cruise lines which operate in Florida; whose current membership is identified in Appendix 1; and
Whereas, the FCCA and ICCL have developed and agreed to cruise industry policies with regard to waste minimization, waste reuse and recycling and waste management practices and procedures; and
Whereas, the United States Coast Guard, herein referred to as USCG, has Federal jurisdiction over environmental matters in navigable waterways in the United States; and
Whereas, the cruise industry through its trade associations----FCCA and ICCL----have been engaged with the FDEP and the USCG in an active discussion involving a number of environmental management policy goals based upon The Memorandum of Understanding executed by the parties dated March 14, 2000; and
Whereas, the FDEP recognizes that cruise vessels operate in international waters and move passengers to destinations worldwide and, consequently, that cruise vessel waste management practices must take into account environmental laws and regulations in many jurisdictions; and
Whereas, the Memorandum of Understanding dated on March 14, 2000 provided for certain environmental policy goal attainments relating to waste management practices; and
Whereas, the FCCA and ICCL have acted in "good faith" working with the FDEP and the USCG to develop waste management practices which preserve a clean and healthy environment and which demonstrate the cruise industry's commitment to be a steward of the environment and set policies that make the industry a leader in environmental performance; and
Whereas, the FDEP recognizes that when a cruise vessel seeks to dispose hazardous wastes in Florida then waste management becomes a Florida activity subject to Florida regulations; and
Whereas, the cruise industry recognizes Florida's fragile maritime environment and the cruise industry is committed to help protect this environment; now

therefore, FDEP, FCCA and ICCL enter into this Memorandum of Understanding based upon mutual understandings on the following environmental policy goal attainments:

1. FDEP accepts the ICCL Industry standard E-01-01, titled Cruise Industry Waste Management Practices and Procedures (Exhibit A), as ICCL member policy in the management of solid waste, hazardous wastes and wastewaters. FDEP acknowledges that FCCA and ICCL members agree to discharge wastewaters outside of Florida territorial waters. FDEP also acknowledges that such waste management practices and procedures meet or exceed the standards set forth in Florida laws and applicable Florida regulations.
2. FDEP and the FCCA/ICCL understand that the USCG has Federal jurisdiction over environmental matters in navigable waterways in the United States and conducts passenger ship examinations that include review of environmental systems, Safety Management System (SMS) documentation and such MARPOL-mandated documents as the Oil Record Book and the Garbage Record Book. FDEP agrees that the USCG is the proper U.S. agency to provide reasonable assurances that the cruise vessel is following management practices and industry standards as contained in Exhibit A. Additionally, FCCA/ICCL member Cruise Vessels will integrate such industry standards into SMS which ensure compliance through statutorily required internal and third party audits.
3. USCG has developed guidelines relating to the inspection of waste management practices and procedures which have been adopted by the cruise industry. FDEP accepts the USCG Navigation and Vessel Inspection Circular and Environmental Systems Checklist (Exhibit B) which will be incorporated into USCG 840 Guidebook as the procedure to conduct waste management inspections on board cruise vessels. FDEP may request, from the USCG, and inspect all records for cruise vessels entering Florida territorial waters.
4. FDEP in consultation with FCCA/ICCL is working with the Environmental Protection Agency (EPA) to develop a national practice for the assigning of an EPA Identification Number to the generator of hazardous wastes which recognizes the multi-jurisdictional itineraries of a cruise vessel. Conceptually, the EPA has agreed that issuing a national identification number to cruise vessels operating in the U.S. is an acceptable procedure. EPA also proposes that the state where company offices are located may issue the national identification numbers provided the criteria and information submitted required for obtaining the number is standard for the United States. FDEP and FCCA/ICCL agree to a uniform application procedure (Exhibit C) for the EPA national identification number in accordance with the Resource Conservation

Recovery Act (RCRA). FDEP shall have the right to inspect all such records upon written request to the cruise vessel operator.

5. FCCA and ICCL have adopted a uniform procedure (Exhibit D) for the application of RCRA to cruise vessels entering Florida. FDEP accepts this procedure as the appropriate process for vendor selection and management of hazardous wastes in Florida. FCCA/ICCL member lines agree to provide an annual report regarding the total hazardous waste offloaded in the United States by each cruise vessel.
6. FDEP and FCCA/ICCL agree that all records required by RCRA for cruise vessels entering Florida territorial waters shall be available to FDEP upon written request to the cruise vessel operator.
7. The FDEP recognizes that waste management practices are undergoing constant assessment and evaluation by cruise industry members. It is understood by the FDEP, the FCCA and the ICCL that the management of wastestreams will be an on-going process which has as its stated objectives both waste minimization and pollution prevention. Consequently, all parties agree to continue to work with each other in "good faith" to achieve the stated objectives. This may require additional meetings with federal regulators to discuss specific issues applicable to the cruise industry in the U.S.
8. The FDEP agrees that the performance required by the FCCA and ICCL under the terms of this Memorandum of Understanding only shall be directed to its member cruise lines. The FCCA and ICCL acknowledge that its members operate cruise vessels engaged in cruise itineraries greater than one day duration; and further that its members do not operate one-day attraction ships or casino gambling ships.
9. Attached as Appendix II is a discussion of future environmental goals which the FDEP, USCG and FCCA/ICCL have established as part of the ongoing, good faith, discussion amongst the parties. Additional meetings to discuss environmental goals are recognized as a necessary component to the successful implementation of management practices for waste minimization and reduction.

IN RECOGNITION OF THE MUTURAL UNDERSTANDINGS DISCUSSED HEREIN; THE PARTIES HERETO AFFIX THEIR SIGNATURES ON THIS ____ DAY OF ________ 2001.

____

Florida Department of Environmental Protection
By its Secretary, David Struhs

____

Florida-Caribbean Cruise Association
By its President, Michele M. Paige, on behalf
of its members which have approved the provisions
of this Memorandum.

____

International Council of Cruise Lines
By its President, J. Michael Crye, on behalf
of its members which have approved the provisions
of this Memorandum.

Appendix E. ICCL Cruise Industry Waste Management Practices and Procedures

INTERNATIONAL COUNCIL OF CRUISE LINES

ICCL INDUSTRY STANDARD E-01-01 (Revision 1)

CRUISE INDUSTRY WASTE MANAGEMENT PRACTICES AND PROCEDURES

The members of the International Council of Cruise Lines are dedicated to preserving the marine environment and in particular the pristine condition of the oceans upon which our vessels sail. The environmental standards that apply to our industry are stringent and comprehensive. Through the International Maritime Organization, the United States and other maritime nations have developed consistent and uniform international standards that apply to all vessels engaged in international commerce. These standards are set forth in the International Convention for the Prevention of Pollution from Ships (MARPOL). In addition, the U.S. has jurisdiction over vessels that operate in U.S. waters where U.S. laws such as the Resource Conservation and Recovery Act and the Federal Water Pollution Control Act apply. The U.S. Coast Guard enforces both international conventions and domestic laws.

The cruise industry commitment to protecting the environment is demonstrated by the comprehensive spectrum of waste management technologies and procedures employed on its vessels.

ICCL members are committed to:

a. Designing, constructing and operating vessels, so as to minimize their impact on the environment;

b. Developing improved technologies to exceed current requirements for protection of the environment;

c. Implementing a policy goal of zero discharge of MARPOL, Annex V solid waste products by use of more comprehensive waste minimization procedures to significantly reduce shipboard generated waste;

d. Expanding waste reduction strategies to include reuse and recycling to the maximum extent possible so as to land ashore even smaller quantities of waste products;

e. Improving processes and procedures for collection and transfer of hazardous waste; and

f. Strengthening comprehensive programs for monitoring and auditing of onboard environmental practices and procedures in accordance with the International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code).

INDUSTRY WASTE MANAGEMENT STANDARDS: ICCL member cruise vessel operators have agreed to adopt the following standards for their waste stream management.

1. Photo Processing, Including X-Ray Development Fluid Waste: *Member lines have agreed to minimize the discharge of silver into the marine environment through the use of best available technology that will reduce the silver content of the waste stream below levels specified by prevailing regulations.*

2. Dry-cleaning waste fluids and contaminated materials: *Member lines have agreed to* prevent *the discharge of chlorinated dry-cleaning fluids, sludge, contaminated filter materials and other dry-cleaning waste byproducts into the environment*

3. Print Shop Waste Fluids: *Member lines have agreed to prevent the discharge of hazardous wastes from printing materials (inks) and cleaning chemicals into the environment.*

4. Photo Copying and Laser Printer Cartridges: *Member lines have agreed to initiate procedures so as to maximize the return of photo copying and laser printer cartridges for recycling. In any event, these cartridges will be landed ashore.*

5. Unused And Outdated Pharmaceuticals: *Member lines have agreed to ensure that unused and/or outdated pharmaceuticals are effectively and safely disposed of in accordance with legal and environmental requirements.*

6. Fluorescent And Mercury Vapor Lamp Bulbs: *Member lines have agreed to prevent the release of mercury into the environment from spent fluorescent and mercury vapor lamps by assuring proper recycling or by using other acceptable means of disposal.*

7. Batteries: *Member lines have agreed to prevent the discharge of spent batteries into the marine environment.*

8. Bilge and Oily Water Residues: *Member lines have agreed to meet and exceed the international requirements for removing oil from bilge and wastewater prior to discharge.*

9. Glass, Cardboard, Aluminum and Steel Cans: *Member lines have agreed to eliminate the maximum extent possible, the industry will eliminate the disposal of MARPOL Annex V wastes into the marine environment through improved reuse and recycling opportunities. They have further agreed that waste will be discharged into the marine environment unless it has been properly processed and can be discharged in accordance with MARPOL and other prevailing requirements.*

10. Incinerator Ash: *Member lines have agreed to reduce the production of incinerator ash by minimizing the generation of waste and maximizing recycling opportunities.*

11. Graywater: *Member lines have agreed that graywater will be discharged only while the ship is underway and proceeding at a speed of not less than 6 knots; that graywater will not be discharged in port and will not be discharged within 4 nautical miles from shore or such other distance as agreed to with authorities having jurisdiction or provided for by local law except in an emergency, or where*

geographically limited. Member lines have further agreed that the discharge of graywater will comply with all applicable laws and regulations.

12. Blackwater: *Member lines have agreed that blackwater will be discharged only while the ship is underway and proceeding at a speed of not less than 6 knots and in accordance with applicable regulations; and that treated Blackwater will not be discharged in port and will not be discharged within 4 nautical miles from shore or such other distance as agreed to with authorities having jurisdiction or provided for by local law, except in an emergency, or where geographically limited. Member lines have further agreed that the discharge of blackwater will comply with all applicable laws and regulations.*

To improve environmental performance, some member cruise lines are field-testing wastewater treatment systems that utilize advanced technologies. These onboard wastewater treatment systems are designed to result in effluent discharges that are of a high quality and purity; for example, meeting or surpassing secondary and tertiary effluents and reclaimed water. Effluents meeting these high standards would not be subjected to the strict discharge limitations previously discussed.

Each ICCL cruise vessel operator has agreed to utilize one or more of the practices and procedures contained in the attached "*Cruise Industry Waste Management Practices and Procedures*" in the management of their shipboard waste streams. Recognizing that technology is progressing at a rapid rate, any new equipment or management practices that are equivalent to or better than those described, and which are shown to meet or exceed international and federal environmental standards, will also be acceptable. Member lines have agreed to communicate to ICCL the use of equivalent or other acceptable practices and procedures. As appropriate, such practices and procedures shall be included as a revision to the attached document. As an example, when improved systems for treating blackwater and graywater are perfected and shown to meet the requirements for MSDs and accepted by appropriate authorities, the new systems and associated technology will be included in the attachment as a revision.

ICCL and its Environmental Committee will work with the U.S. Coast Guard, the U.S. Environmental Protection Agency and other appropriate agencies to further implement the above commitments.

ATTACHMENT: *CRUISE INDUSTRY WASTE MANAGEMENT PRACTICES AND PROCEDURES* (Dated May 14,2001)

Adopted: June 11,2001
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Attachment to ICCL Standard E-1-01 (Revision 1)

CRUISE INDUSTRY WASTE MANAGEMENT PRACTICES AND PROCEDURES

(REVISED: December 1, 2001)

The cruise industry is dedicated to preserving the marine environment and oceans upon which our ships sail. As a stated industry standard, ICCL members have adopted aggressive programs of waste minimization, waste reuse and recycling, and waste stream management set forth in the following. In addition ICCL members are working in a number of areas to identify and implement new technologies in order to improve the environmental performance of their ships. ICCL member lines currently have agreed to utilize waste management practices and procedures, which meet or exceed the stringent standards as set forth in international treaties and applicable U.S. laws.

Introduction

The cruise industry is inextricably linked to the environment. Our business is to bring people to interesting places in the world, over the water. Recognizing the future of the industry depends on a clean and healthy environment, cruise industry senior management is committed to stewardship of the environment and establishing industry practices that will make ICCL member cruise ship operators leaders in environmental performance.

This document outlining member line practices has been developed under the auspice of the industry's professional organizations, the International Council of Cruise Lines (ICCL), the Florida Caribbean Cruise Association (FCCA), and the Northwest Cruise Ship Association (NWCA). The purpose of this document is to set forth agreed cruise industry practices and procedures for waste management that foster the above goals.

In the development of industry practices and procedures for waste management, the members of the International Council of Cruise Lines have endorsed policies and practices based upon the following fundamental principles:

- Full compliance with applicable laws and regulations
- Maintaining cooperative relationships with the regulatory community
- Designing, constructing and operating vessels, so as to minimize their impact on the environment
- Embracing new technology
- Conserving resources through purchasing strategies and product management
- Minimizing waste generated and maximize reuse and recycling
- Optimizing energy efficiency through conservation and management
- Managing water discharges
- Educating staff, guests and the community.

Discussion

Just as on shore, ship operations and passengers generate waste as part of many dail activities. On ships, waste is generated while underway and in port. Because ships move, th management of these wastes becomes more complicated than for land-based activities, as th facilities and laws change with the location of the ship. Facilities on the ships and managemen practices must be designed to take into account environmental laws and regulations around th world. Moreover, because waste management ultimately becomes a local activity, the local po infrastructure, service providers, and local waste disposal vendors are factors in the decision making processes.

On an international level, environmental processes are an important part of th International Maritime Organization's (IMO's) policies and procedures for the maritime industry ICCL member lines have agreed to incorporate environmental performance into Safet Management Systems (SMS) and MARPOL mandated Waste Management Manuals. Unde agreements and laws specific to many nations, these programs are routinely reviewed by Po States to ensure compliance. For example, in the United States, the US Coast Guard ha jurisdiction over environmental matters in ports and waterways and conducts passenger shi examinations that include review of environmental systems, SMS documentation and suc MARPOL-mandated documents as the Oil Record Book and the Garbage Record Book.

The industry effort to develop waste management practices and procedures has focuse on the traditional high volume wastes (garbage, graywater, blackwater, oily residues (sludge oi and bilge water), pollution prevention, and the small quantities of hazardous waste produce onboard. In the process, ICCL members have shared waste management strategies an technologies, while focusing on a common goal of waste reduction.

The process of waste reduction includes waste prevention, the purchasing of products th have recycled content or produce less waste (e.g. source reduction), and recycling or reuse o wastes that are generated. The ultimate goal is to have the waste management culture absorbe into every facet of cruise vessel operation. A fully integrated system beginning with the desig of the vessel should address environmental issues at every step.

Management practices for waste reduction should start before a product is selected. Ec purchasing and packaging are vital to the success of any environmental program, as are strategie to change packaging, processes and management to optimize the resources used.

The commitment of the industry to this cooperative effort has been quite successful, a companies have shared information and strategies.

Industry Standard Waste Handling Procedures

ICCL member lines have agreed that hazardous wastes and waste streams onboard cruis vessels will be identified and segregated for individual handling and management in accordanc with appropriate laws and regulations. They have further agreed, hazardous wastes will not b discharged overboard, nor be commingled or mixed with other waste streams.

A. **<u>Photo Processing, Including X-Ray Development Fluid Waste</u>:** *ICCL member lines have agreed to minimize the discharge of silver into the marine environment through the use of best available technology that will reduce the silver content of the waste stream below levels specified by prevailing regulations or by treating all photo processing and x-ray development fluid waste (treated or untreated) as a hazardous waste and landing ashore in accordance with RCRA requirements.*

There are several waste streams associated with photo processing operations that have the potential to be regulated under the Resource Conservation and Recovery Act (RCRA). These waste streams include spent fixer, spent cartridges, expired film and silver flake.

Photographic fixer removes the unexposed silver compounds from the film during the developing process. The spent fixer can have as much as 2000-3000 parts per million (ppm) of silver. Silver bearing waste is regulated by RCRA as a hazardous waste if the level of silver exceeds 5 ppm as determined by the Toxic ity Characteristic Leaching Procedure (TCLP) test.

Silver recovery units may be used to reclaim the silver from the used fixer waste stream. There are two types of recovery units. These are active (with electricity) and passive (without electricity) units. The active unit uses electricity to plate silver onto an electrode. The passive unit uses a chemical reaction between steel wool and silver to remove most of the silver from solution. Utilizing the best available technology, the equipment currently onboard ICCL member cruise ships is conservatively estimated to reduce the silver content of this effluent below 4 mg/l (milligrams/l or ppm)

The effluent from the silver recovery process must be tested before it can be discharged as a non-hazardous waste to be further diluted by addition to the ship's gray water. After the photographic and X-ray development fluids are treated for the removal of silver, the treated, non-hazardous effluent is then blended with the ship's graywater. In general, assuming that an entire week's photographic and X-ray development treated effluent stream is introduced into a single day's accumulation of graywater, the concentration of silver in the resulting mixture would be less than one-half of one part per billion (<0.5 micrograms/liter). Such mixing is not done on a weekly basis. Even at this assumed extreme however, it is expected that the silver concentration would only be approximately one fifth (1/5) the surface water quality standard for predominately marine waters specified in one state where cruise ships operate. When mixing is done on a daily basis it is evident that the resulting immediate concentration would be almost an order of magnitude less than this (1/50 of the current surface water quality standard). Additionally, it is evident that total mass of any discharges of silver would be negligible. Member lines have agreed that this discharge would be carried out only while their vessels are underway. Also, it should be noted that these estimates were carried out considering the largest cruise ships in service, which would produce the greatest amount of waste.

<u>Handling Method 1 Employed by Member Lines:</u>

Treat used photographic and x-ray development fluids to remove silver for recycling.

Verify that the effluent from the recovery unit is less than 5 parts per million (ppm) silver, as measured by EPA-approved methodology.

After treatment, the residual waste stream fluid is non-hazardous and landed ashore or discharged in accordance with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) and other prevailing regulations.

Handling Method 2 Employed by Member Lines:

Used photographic and x-ray development fluids, either treated or untreated, may be assumed to be a hazardous waste. In this event, they are landed ashore in accordance with the requirements of the Resource Conservation and Recovery Act (RCRA).

B. **Dry-cleaning waste fluids and contaminated materials**: *ICCL member lines have agreed to prevent the discharge of chlorinated dry-cleaning fluids, sludge, contaminated filter materials and other dry-cleaning waste byproducts into the environment.*

Shipboard dry cleaning facilities use a chlorinated solvent called perchlorethylene (also known as PERC or tetrachloroethylene) as a dry cleaning fluid. This is the approved dry cleaning solvent for these units. Operators must receive specific required training for the correct use of this chemical and its associated precautions. This solvent should be used in accordance with all safety procedures including appropriate personal protective equipment (PPE).

The dry cleaning units produce a small volume waste from condensate, the bottoms of the internal recovery stills, waste products from button and lint traps, spent perchloroethylene and filter media. This waste is comprised of dirt, oils, filter material, and spent solvent. Each ship utilizing these dry-cleaning units produces approximately two pounds of waste material weekly. However, the amounts may vary greatly by season and passenger load. This material is classified as hazardous waste under RCRA and must be handled accordingly.

Handling Method 1 Employed by Member Lines:

Perchloroethylene (PERC) and other chlorinated dry-cleaning fluids, contaminated sludge and filter materials are hazardous waste and landed ashore in accordance with the requirements of RCRA.

C. **Print Shop Waste Fluids**: *ICCL member lines have agreed to prevent the discharge of hazardous wastes from printing materials (inks) and cleaning chemicals into the environment.*

Print shop waste may contain hazardous waste. Printing solvents, inks and cleaners all may contain hydrocarbons, chlorinated hydrocarbons, and heavy metals that can be harmful to human and aquatic species. Recent advances in printing technology and substitution of chemicals that are less hazardous reduces the volume of print shop waste generated and reduces the impact of these waste products.

ICCL member lines have agreed to utilize, whenever possible, printing methods and printing process chemicals that produce both less volume of waste and less hazardous waste products, that shipboard printers will be trained in ways to minimize printing waste generated, and that alternative printing inks such as soy based, non-chlorinated hydrocarbon based ink products will be used whenever possible. The member lines have further agreed that all print shop waste including waste solvents, cleaners, and cleaning cloths will be treated as hazardous waste, if such waste contains chemical components that may be considered as hazardous by regulatory definitions, and that all other waste may be treated as non-hazardous.

Handling Method 1 Employed by Member Lines:

When using traditional or non-soy based inks and chlorinated solvents, all print shop waste is treated as hazardous, and discharged ashore in accordance with RCRA.

Handling Method 2 Employed by Member Lines:

Shipboard printing processes use non-toxic based printing ink such as soy based, non-chlorinated solvents, and other non-hazardous products to eliminate hazardous waste products.

D. **Photo Copying and Laser Printer Cartridges**: *ICCL member lines have agreed to initiate procedures so as to maximize the return of photocopying and laser printer cartridges for recycling, and in any event, have agreed that these cartridges will be landed ashore.*

Increased use of laser and photo copying equipment on shore as well as onboard ship results in the generation of increased volumes of waste cartridges, inks, and toner materials. ICCL member lines have agreed to use only such inks, toners and printing/copying cartridges that contain non-hazardous chemical components, and that none of these cartridges or their components should be disposed of by discharge into the marine environment. In recognition of the member lines' goal of waste minimization, they have further agreed these cartridges should, whenever possible, be returned to the manufacturer for credit, recycling, or for refilling.

Handling Method Employed by Member Lines:

ICCL member lines have agreed that wherever possible, photo copying and laser printer cartridges will be collected, packaged and returned for recycling and when this is not possible, that these materials will not be discharged into the sea or other bodies of water but will be handled as other shipboard waste that is landed ashore for further disposal.

E. **Unused And Outdated Pharmaceuticals**: *ICCL member lines have agreed to ensure that unused and/or outdated pharmaceuticals are effectively and safely disposed in accordance with legal and environmental requirements.*

In general ships carry varying amounts of pharmaceuticals. The pharmaceuticals carried range from over-the-counter products such as anti-fungal creams to prescription drugs such as epinephrine. Each ship stocks an inventory based on its itinerary and the demographics of its passenger base. ICCL member lines have agreed that all pharmaceuticals will be managed to ensure that their efficacy is optimized and that disposal is done in an environmentally responsible manner.

ICCL member lines have further agreed that when disposing of pharmaceuticals, the method used will be consistent with established procedures, and that pharmaceuticals and medications which are off specification or which have exceeded their shelf-life, and stocks that are unused and out of date, cannot be used for patients and therefore will be removed from the ship. Further, each regulatory jurisdiction has a posting of listed pharmaceuticals that must be considered hazardous waste once the date has expired or the item is no longer considered good for patient use.

Through onboard management of the medical facility, ICCL member lines have agreed that stocks of such listed pharmaceuticals are returned to the vendor prior to date of expiration. Pharmaceuticals that are being returned and which have not reached their expiration date are shipped using ordinary practices for new products.

Safety and Health

ICCL member lines have agreed that all expired listed pharmaceuticals will be handled in accordance with established procedures and all personnel handling this waste will receive appropriate training in the handling of hazardous materials. As guidance, the US Environmental Protection Agency (EPA) has issued a report that clarifies the fact that residuals, such as epinephrine, found in syringes after injections are not considered an acutely hazardous waste by definition and may be disposed of appropriately in sharps containers. Member lines have agreed that all Universal Precautions will be adhered to when handling sharps.

Handling Method 1 Employed by Member Lines:

Establish a reverse distribution system for returning unexpired, unopened non-narcotic pharmaceuticals to the original vendor.

Handling Method 2 Employed by Member Lines:

Appropriately destroy narcotic pharmaceuticals onboard ship in a manner that is witnessed and recorded.

Handling Method 3 Employed by Member Lines:

Land listed pharmaceuticals in accordance with local regulations. Listed pharmaceuticals are a hazardous waste having chemical compositions which prevent them from being incinerated or disposed of through the ship's sewer system. Listing of such pharmaceuticals may vary from state to state.

Handing Method 4 Employed by Member Lines:

Dispose of other non-narcotic and non-listed pharmaceuticals through onboard incineration or landing ashore.

F. **Fluorescent And Mercury Vapor Lamp Bulbs**: *ICCL member lines have agreed to prevent the release of mercury into the environment from spent fluorescent and mercury vapor lamps by assuring proper recycling or by using other acceptable disposal.*

The recycling of fluorescent lights and high intensity discharge (HID) lamps is a proven technology capable of reliably recovering greater that 99 percent of the mercury in the spent lights. This is done by using a crush-and-sieve method. In this process, the spent tubes are first crushed and then sieved to separate the large particles from the mercury containing phosphor powder. The phosphor powder is collected and processed under intense heat and pressure. The mercury is volatized and then recovered by condensation. The glass particles are segregated and recycled into other products such as fiberglass. Aluminum components are also recycled separately.

Storage and handling of used lights pose no compatibility problems; nevertheless, storage and shipment of the glass tubes is best done keeping the glass tubes intact. These items are classified as "Universal Waste" when they are shipped to a properly permitted recycling facility; as such, testing is not required.

Safety and Health

Fluorescent and Mercury Vapor lamps contain small amounts of mercury that could potentially be harmful to human health and the environment. To prevent human exposure and contamination of the environment, ICCL member lines have agreed that these lamps will be handled in an environmentally safe manner. Recycling of mercury from lamps and other mercury containing devices is the preferred handling method and is encouraged by various states. The recycling of fluorescent lights and HID lamps keeps potentially hazardous materials out of landfills, saves landfill space and reduces raw materials production needs.

Handling Method Employed by Member Lines:

Fluorescent and mercury vapor lamps are collected and recycled or landed for recycling or disposal in accordance with prevailing laws and regulations.

G. **Batteries**: *ICCL member lines have agreed to prevent the discharge of spent batteries into the marine environment.*

If not properly disposed of, spent batteries may constitute a hazardous waste stream. Most of the large batteries are on tenders and standby generators. Small batteries used in flashlights and other equipment and by passengers, account for the rest. There are four basic types of batteries used.

Lead-acid batteries – These are used in tenders and standby generators. They are wet, rechargeable, and usually six-celled. They contain a sponge lead anode, lead dioxide cathode, and sulfuric acid electrolyte. The electrolyte is corrosive. These batteries require disposal as a hazardous waste, unless recycled or reclaimed.

Lead-acid batteries use sulfuric acid as an electrolyte. Battery acid is extremely corrosive, reactive and dangerous. Damaged batteries will be drained into an acid-proof container. A damaged and leaking battery is then placed in another acid-proof container, and both the electrolyte and the damaged battery placed in secure storage for proper disposal as a hazardous waste.

Nickel-cadmium (NiCad) batteries – These are usually rechargeable, and contain wet or dry potassium hydroxide as electrolyte. The potassium hydroxide is corrosive and the cadmium is a characteristic hazardous waste. Therefore, NiCad batteries will be disposed of as hazardous waste, unless recycled or reclaimed.

Lithium batteries – These are used as a power source for flashlights and portable electronic equipment. All lithium batteries will be disposed of as hazardous waste, or sent out for reclamation.

Alkaline batteries – These are common flashlight batteries and are also used in many camera flash attachments, cassette recorders, etc. They should be recycled, properly disposed or reclaimed.

Handling Method Employed by Member Lines:

Spent batteries are collected and returned for recycling and/or disposal in accordance with prevailing regulations. Discarded batteries are isolated from the refuse waste stream to prevent potentially toxic materials from inappropriate disposal. The wet-cell battery-recycling program is kept separate from the dry battery collection process. Intact wet-cell batteries are sent back to the supplier. Dry-cell batteries are manifested to a licensed firm for recycling.

H. Bilge and Oily Water Residues: *ICCL member lines have agreed to meet and exceed the international requirements for removing oil from bilge and wastewater prior to discharge.*

The area of the ship at the very bottom of the hull is known as the bilge. The bilge is the area where water collects from various operational sources such as water lubricated shaft seals, propulsion system cooling, evaporators, and other machinery. All engine and machinery spaces also collect oil that leaks from machinery fittings and engine maintenance activities. In order to maintain ship stability and eliminate potential hazardous conditions from oil vapors in engine and machinery spaces, the bilge spaces should be periodically pumped dry. In discharging bilge and oily water residues, both international regulations (MARPOL) and United States regulations require that the oil content of the discharged effluent be less than 15 parts per million and that it not leave a visible sheen on the surface of the water.

All ships are required to have equipment installed onboard that limits the discharge of oil into the oceans to 15 parts per million when a ship is en route and provided the ship is not in a special area where all discharge of oil is prohibited. Regulations also require that all oil or oil residues, which cannot be discharged in compliance with these regulations, be retained onboard or discharged to a reception facility. The equipment and processes implemented onboard cruise ships to comply with these requirements are complex and sophisticated.

The term "*en route*" as utilized in MARPOL (73/78) Regulation 9(b) is taken to mean while the vessel is underway. The U.S. Coast Guard has informed ICCL that it agrees with this meaning of "*en route.*"

In accordance with MARPOL (73/78) Regulation 20, ICCL member lines have agreed that every ship of 400 gross tons and above shall be provided with an oil record book which shall be completed on each occasion whenever any of numerous specified operations take place in the ship and that operations include:

a. Ballasting or cleaning of fuel oil tanks,
b. Discharge of dirty ballast or cleaning water from the fuel oil tanks above,
c. Disposal of oily residues,
d. And discharge of bilge water that accumulated in machinery spaces.

Requirements regarding the keeping of an Oil Record Book as well as the form of the Oil Record Book are also found in MARPOL and in U.S. Coast Guard regulations (33CFR151).

Handling Method Employed by Member Lines:

Bilge and oily water residue are processed prior to discharge to remove oil residues, such that oil content of the effluent is less than 15 ppm as specified by MARPOL Annex 1.

I. **Glass, Cardboard, Aluminum and Steel Cans**: *ICCL member lines have agreed to eliminate, to the maximum extent possible, the disposal of MARPOL Annex V wastes into the marine environment through improved reuse and recycling opportunities, and that no waste will be discharged into the marine environment unless it has been properly processed and can be discharged in accordance with MARPOL and other prevailing requirements.*

Management of shipboard generated waste is a challenging issue for all ships at sea. This is true for cruise vessels, other commercial vessels, military ships, fishing vessels and recreational boats. Waste products in earlier days were made from natural materials and were mostly biodegradable. Today's packaging of food and other products presents new challenges for waste management. A large cruise ship today can carry over three thousand passengers and crew. Each day, an average cruise passenger will generate two pounds of dry trash and dispose of two bottles and two cans.

A strategy of source reduction, waste minimization and recycling has allowed the cruise industry to significantly reduce shipboard generated waste. To attain this, ICCL member lines have agreed to adopt a multifaceted strategy that begins with waste minimization to decrease waste from provisions brought onboard. This means purchasing in bulk, encouraging suppliers to utilize more efficient packaging, reusable packaging, and packaging materials that are more environmentally friendly—those that can be more easily disposed of or recycled. In fact, through this comprehensive strategy of source reduction, total waste on passenger vessels has been reduced by nearly half over the past ten years.

Another important component of the industry's waste reduction strategy is product or packaging recycling. Glass, aluminum, other metals, paper, wood and cardboard are, in most cases, recycled.

Handling Method Employed by Member Lines:

MARPOL Annex V ship waste is minimized through purchasing practices, reuse and recycling programs, landing ashore and onboard incineration in approved shipboard incinerators. Any Annex V waste that is discharged at sea will be done in strict accordance with MARPOL and any other prevailing requirements.

J. **Incinerator Ash**: *ICCL member lines have agreed to reduce the production of incinerator ash by minimizing the generation of waste and maximizing recycling opportunities, and that the discharge of incinerator ash containing hazardous components will be prevented through a program of waste segregation and periodic ash testing.*

Incinerator ash is not normally a hazardous waste. Through relatively straightforward waste management strategies, items that would cause the ash to be hazardous are separated from the waste stream and handled according to accepted hazardous waste protocols. In general, source segregation for waste streams is foundational for onboard waste management and is incorporated into the waste management manual required by MARPOL. Waste management for onboard waste streams include the following: source reduction, minimization, recycling, collection, processing and discharge ashore. This allows the incinerator to be used primarily for food waste, contaminated cardboard, some plastics, trash and wood.

Member lines have agreed that incinerator ash will be tested at least once quarterly for the first year of operation to establish a baseline and that testing may then be conducted once a year. The member lines have further agreed that a recognized test procedure will be used to demonstrate that ash is not a hazardous waste. A recognized test procedure includes the following metals as indicators for toxicity - arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Special attention is placed on the removal of batteries from the incinerator waste stream. The use of incinerators saves landfill space and prevents the build up of material onboard that could become the breeding ground for insects, rodents and other vermin.

Handling Method Employed by Member Lines:

Proper hazardous waste management procedures are to be instituted onboard each ship to assure that waste products, which will result in a hazardous ash, are not introduced into the incinerator. Non-hazardous incinerator ash may be disposed of at sea in accordance with MARPOL Annex V. Ash identified as being hazardous is disposed of ashore in accordance with RCRA.

K. Wastewater reclamation

Because of the amounts of fresh water involved, and its restricted availability onboard ship (all fresh water must be either purchased or generated onboard), fresh water is a valuable commodity. Therefore, water management is extremely important and takes the form of both minimizing water usage and the potential reclamation and reuse of water for non-potable purposes. Many ICCL companies are researching new technology and piloting graywater treatment systems onboard their vessels. ICCL member operators also take numerous steps in onboard water management. Water management techniques include:

a. Use of technical water (for example: air conditioning condensate) where possible.
b. Use of water recovery systems (for example: filtering and reuse of laundry water – last rinse use for first wash).
c. Reclamation and reuse as technical water (flushing toilets, laundry, open deck washing) of properly treated and filtered wastewaters.
d. Active water conservation (for example: use of reduced flow showerheads, vacuum systems for toilets, vacuum food waste transportation and laundry equipment that utilizes less water).

L. **Graywater**: *ICCL member lines have agreed to discharge graywater only while the ship is underway and proceeding at a speed of not less than 6 knots; that graywater will not be discharged in port and will not be discharged within 4 nautical miles from shore or such other distance as agreed to with authorities having jurisdiction or provided for by local law except in an emergency, or where geographically limited. The member lines have further agreed that the discharge of graywater will comply with all applicable laws and regulations.*

The term graywater is used on ships to refer to wastewater that is generally incidental to the operation of the ship. The International Maritime Organization (IMO) defines graywater as including drainage from dishwasher, shower, laundry, bath and washbasin drains. The US Clean Water Act (formally know as the Federal Water Pollution Control Act) includes galley, bath and shower water in its definition of graywater. The US regulations implementing this act do not include a further definition of gray water. However, the regulations do include a provision that exempts all of the wastewater included in the IMO definition and other discharges incidental to the operation of a ship from the Clean Water Act's permitting program (formally known as the

National Pollution Discharge Elimination System (NPDES) program). Finally, the US Coast Guard regulations include provisions that essentially combine the two definitions from the IMO and the Clean Water Act. None of the definitions of graywater include blackwater (discussed below) or bilgewater from the machinery spaces. Recent U.S. Legislation places limits on the discharge of graywater in the Alaska Alexander Archipelago.

Handling Method Employed by Member Lines:

Graywater is discharged only while ships are underway and proceeding at a speed of not less than 6 knots, in recognition that dispersal of these discharges is desirable and that mixing of these waters, which are discharged approximately 10-14 feet below the surface, by the action of the propellers and the movement of the ship, provides the best dispersal available.

M. **Blackwater**: *ICCL member lines have agreed to discharge* blackwater *only while the ship is underway traveling at a speed of not less than 6 knots and in accordance with applicable regulation, and that blackwater will not be discharged in port and will not be discharged within 4 nautical miles from shore or such other distance as agreed to with authorities having jurisdiction or provided for by local law, except in an emergency, or where geographically limited. The member lines have further agreed that the discharge of blackwater will comply with all applicable laws and regulations.*

Waste from toilets, urinals, medical sinks and other similar facilities is called "blackwater." Most cruise ships separate blackwater from other wastewaters before processing and/or discharge.

Treated blackwater is processed using an approved "Marine Sanitation Device" (MSD) that is intended to prevent the discharge of untreated or inadequately treated blackwater. Marine Sanitation Devices use physical, chemical and/or biological processes to allow effluent from the process to be discharged with characteristics that are similar to effluents from conventional, shoreside wastewater treatment plants.

All MSDs are certified and approved by the US Coast Guard. The US Coast Guard consults with the Environmental Protection Agency in evaluating processes used to certify MSDs.

The US Coast Guard regularly inspects MSDs while onboard ships for proper operation during their Control Verification Examinations. If the Coast Guard has reason to believe that an MSD is not properly operating, it can require the vessel owner to have the effluent sampled and analyzed by a qualified wastewater laboratory, with the results reported to the Coast Guard.

Handling Method 1 Employed by Member Lines:

Blackwater is treated by a properly working, approved Marine Sanitation Device prior to discharge. As agreed with and required by the U.S. Coast Guard, MSDs are tested periodically to ensure continued operation in accordance with certification standards.

Handling Method 2 Employed by Member Lines:

Untreated blackwater is discharged into the ocean at a distance greater than 4 nautical miles from any land, coral reef or designated sensitive area in accordance with MARPOL or such other distance as agreed to with authorities having jurisdiction

N. Advanced Wastewater Treatment Systems:

To improve environmental performance, cruise lines are testing and installing wastewater treatment systems that utilize advanced technologies. These onboard wastewater treatment systems are designed to result in effluent discharges that are of a high quality and purity; for example, meeting or surpassing standards for secondary and tertiary effluents and reclaimed water. Effluents meeting these high standards would not be subjected to the strict discharge limitations previously discussed.

O. Training and Educational Materials

Training is an important and ongoing part of every position and tasking onboard cruise ships. Not only is training necessary for the safe and economical operation of a ship, it is required by numerous international conventions and flag state regulations. The International Convention on Standards of Training Certification and Watchkeeping (STCW) for example, sets forth requirements for knowledge, experience and demonstrated competency for licensed officers of the deck and engineering departments and for ratings forming part of a navigation or engineering watch. These detailed requirements address not only the navigation of the ship but also the proper operation of the shipboard machinery and knowledge of and ability to assure compliance with the environmental protection requirements of MARPOL and the safety regulations of The International Convention on Safety of Life at Sea (SOLAS). SOLAS also requires that the ship's training manual (which contents are prescribed by regulation) be placed in the crew messes and recreation rooms or in individual crew cabins.

ICCL member lines have developed programs that raise the level of environmental awareness on the part of both the passengers and the crew. Each ship's crew receives training regarding shipboard safety and environmental procedures. Advanced training in shipboard safety and environmental management procedures is provided for those directly involved in these areas. Those directly responsible for processing wastes are given specific instruction in their duties and responsibilities and in the operation of the various equipment and waste management systems. Specific actions that our member lines have taken to train employees and increase passenger awareness include:

a. Announcements over the public address system and notices in ship newsletters that caution against throwing any trash overboard,
b. Signage and colorful posters placed in crew and passenger areas encouraging environmental awareness and protection,
c. Safety and environmental information booklets in crew cabins and crew lounges,
d. Regular meetings of ship safety and environmental committees consisting of officers and crew from all departments to review methods of improving performance, including better and more effective environmental practices.

STCW, SOLAS and the International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code) require that training be fully documented. Individual training is documented in each crewmember's file. Ship training exercises, such as fire drills and emergency response exercises, are documented in the appropriate ship's logs. All of these training documents are required to be available for oversight examination by both the ship's flag state inspectors and by port state authorities such as the United States Coast Guard.

Placards warning of the prohibition of the discharge of oil are posted on all ships operating in the navigable waters of the United States as required by U.S. Coast Guard regulations (33CFR155.450). Additionally, as part of required shipboard waste management plans, both Coast Guard regulations (33CFR151.59) and MARPOL (Annex V Regulation 9) require the posting of placards that notify the passengers and the crew of the disposal requirements for garbage. These placards are to be written in the official language of the State whose flag the ship is entitled to fly and also in English or French if neither of these is the official language. Once again, oversight of compliance with these requirements is conducted by ISM audits and frequent inspections by flag states and the United States Coast Guard.

The Safety of Life at Sea Convention mandates compliance with the ISM Code. This comprehensive Code requires that each vessel operating company and each vessel participate in a very strictly defined management program, under both internal and external audit and regulatory oversight, that sets forth detailed procedures for assuring compliance with safety, environmental protection, emergency response and training mandates.

Equivalent equipment, practices and procedures

ICCL member lines have agreed that the use of equivalent or other acceptable practices and procedures shall be communicated to ICCL. As appropriate, such practices and procedures shall be included as a revision to this document. As an example, when improved systems for treating blackwater and graywater are perfected, shown to meet the requirements for MSDs and accepted by appropriate authorities for the treatment of graywater, the new systems and associated technology will be included together with their impact on the current standard of discharging graywater only while underway.

Appendix F. 2002 ADEC Cruise Ship Discharge Data Summary

Table A1. Large Ships Advanced Treatment Conventional Pollutant Results

Sample Name	Fecal coliform	Oil& Grease	Nitrate as N	TKN	pH	Phosphorous	TOC	Settleable	TSS
Units	MPN	mg/L	mg/L	mg/L		mg/L	mg/L	Mg/L	mg/L
MDL	2	1.7	0.095	0.1	0.1	0.22	0.3	0.1	0.1
Ryndam TWW	1	0.85	0.05	21	7.65	0.608	13	0.05	0.05
Ryndam TWW-B0	900	0.1	0.05	27	7.35	2.28	16	0.1	0.05
Statendam TWW	1	0.85	0.05	33	7.73	5	20	0.05	0.05
Veendam Zenon 71702-WW	1	0.85	0.05	18.9	7.36	2.31	247	0.05	0.05
Volendam TWW Port A	900	0.85	5.03	1.9	7.49	2.86	12	0.05	7.1
Volendam TWW Port F UV	1	0.85	3.44	1.5	7.54	2.66	12	0.05	0.05
Volendam TWW-1	1	8.4	0.05	26.6	7.48	8.47	25	0.05	0.05
Volendam TWW-2	1	12	0.05	27.8	7.54	7.64	28	0.05	0.05
Zaandam TWW	1	0.85	0.05	27.7	7.83	4.51	16	0.05	0.05
Zaandam TWW-A Discharge Line	1	12	0.05	39.3	7.78	5.59	19	0.05	0.05
Min	1.00	0.10	0.05	1.50	7.35	0.40	12	0.05	0.05
Max	2200	280	5.03	59.1	7.83	19.4	247	0.10	152
GeoMean	5	3	0.10	14	7.57	3.70	28	0.05	0.21

Table A2. 2002 Large Ship Advanced Treatment Metals Results Total Recoverable (T) and Dissolved (D)

Sample Name	Antimony-D	Antimony-T	Arsenic-D	Arsenic-T	Chromium-D	Chromium-T	Copper-D	Copper-T
Units	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
MDL	0.027	0.049	0.044	0.12	0.049	0.076	0.034	0.04
Ryndam TWW	0.014	0.202	0.576	0.729	7.35	0.641	5.16	5.5
Statendam TWW	0.667	0.721	0.893	0.987	5.45	0.715	1.67	2.04
Veendam Zenon 71702-WW	0.181	0.255	1.26	1.45	3.36	0.856	5.9	6.49
Volendam TWW-1	0.106	0.255	0.552	0.82	5.72	0.972	7.52	7.9
Volendam TWW-2	0.014	0.255	0.569	0.801	5.83	1.42	7.91	7.66
Zaandam TWW	0.255	0.366	0.662	0.944	4.72	0.596	8.3	8.31
Min	0.01	0.20	0.55	0.73	2.27	0.60	1.67	2.04
Max	0.67	3.37	61.50	23.40	198.00	11.00	140.00	3970.00
GeoMean	0.08	0.41	1.52	1.62	7.45	1.26	12.10	19.35

Table A2. 2002 Large Ship Advanced Treatment Metals Results Total Recoverable (T) and Dissolved (D)

Sample Name	Lead-D	Lead-T	Nickel-D	Nickel-T	Selenium-D	Selenium-T	Zinc-D	Zinc-T
Units	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
MDL	0.03	0.047	0.05	0.036	0.14	0.16	0.084	0.094
Ryndam TWW	1.22	1.35	22.9	22.1	0.948	1.54	208	183
Statendam TWW	0.236	1.43	23.3	22.2	1.27	1.63	24.8	23.6
Veendam Zenon 71702-WW	0.358	0.323	15.7	17.1	0.936	1.37	196	201
Volendam TWW-1	0.975	2.09	8.96	9.82	0.755	1.87	195	176
Volendam TWW-2	0.963	2.48	9.4	9.73	0.764	1.43	194	174
Zaandam TWW	2.09	3.3	7.36	7.19	0.915	1.95	195	152
Min	0.24	0.32	7.36	7.19	0.76	1.37	24.80	23.60
Max	4.66	62.40	112.00	94.80	231.00	90.70	2470.00	7660.00
GeoMean	1.10	2.76	17.85	17.75	2.45	3.29	232.66	246.89

Table A3. 2002 Large Ship Sample Results for Advanced Treatment Ships for all Priority Pollutants except Metals

Sample_Name	1,2,4-Trimethylbenzene	2-Butanone	Acetone	Bis(2-Ethylhexyl)Phthalate	Chloroform	Di-n-Butyl phthalate	M&p Xylenes	Tetrachloroethene	Toluene
	Ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
MDL	0.29	1	2.5	0.67	1.3	1.4	0.15	0.12	0.25
Statendam TWW	0.15	0.5	11	0.335	1.3	2.4	0.075	3.4	0.53
Veendam Zenon 71702-WW	0.15	0.5	21	0.335	1.3	3.4	0.075	0.06	0.92
Volendam TWW-1	0.15	2.8	25	0.335	1.2	1.8	0.075	0.06	1.1
Volendam TWW-2	0.15	3.1	26	0.335	1.2	3.1	0.075	0.06	0.96
Zaandam TWW	0.15	0.86	6.1	0.335	1.1	0.7	0.075	0.06	0.125
Min	0.15	0.50	1.25	0.34	0.65	0.70	0.08	0.06	0.13
Max	2.20	3.10	26.00	5.20	3.10	3.40	3.00	3.40	1.20
GeoMean	0.22	0.77	6.61	0.72	1.21	1.39	0.14	0.09	0.43

Table A4. 2002 Large Ship Graywater Conventional Pollutant ALL Results

Sample Name	Conductivity	Fecal coliform
Units	Umhos/cm	MPN
MDL	1	2
Dawn Princess GW-11 Galley	3270	60000
Dawn Princess GW-A-15	1920	1600000
Dawn Princess GW-A-4 Dom/Laundry	36500	300000
Dawn Princess GW-A-4 Domestic	15100	2400000
Dawn Princess GW-A-8 Domestic	29600	130000
Dawn Princess GW-A-8 Domestic	14600	220000
Dawn Princess GW-D-11 Galley	13800	30000
Norwegian Wind GW-1 C Laundry	646	110000
Norwegian Wind GW-2 Mixed GW	31100	3000000
Norwegian Wind GW-3 Mixed GW	32200	5000000
Norwegian Sky GW-A	3440	3000000
Norwegian Sky GW-B	344	3000000
Star Princess GW-C DB#8 Graywater	8100	1700000
Star Princess GW-D DB#10 Galley	1190	300
Norwegian Sky GW-A Mixed	558	2090
Norwegian Sky GW-B Mixed	606	2910
Norwegian Wind GW-2 Mixed GW	22700	1600
Norwegian Wind GW-3 Mixed GW	23200	1600
Regal Princess GW-AD Overboard	4660	800000
Regal Princess GW-ADC Overboard	808	800000
Regal Princess GW-AFT Mixed	509	110000
Regal Princess GW-FWD Mixed	1060	500000
Sea Princess GW-A-11 Galley	2000	8000
Sea Princess GW-D-6 Domestic	834	500000
Sea Princess GW-D-8 Domestic	6100	110000
Sea Princess GW-D-9 Domestic	820	800000
Star Princess GW-C (accom)	392	240
Star Princess GW-D (galley & laundry)	1250	198000

Sun Princess GW-A2 accomodations	4080	130000
Sun Princess GW-A3 accomodations	7270	500
Sun Princess GW-A4 accomodations	1060	30000
Sun Princess GW-C galley	1680	900
Min	188	1
Max	36500	5000000
GeoMean	2627.33	32833.62

Table A9. 2002 Large Ship Graywater Metal Results

	Antimony-D	Antimony-T	Arsenic-D	Arsenic-T	Chromium-D	Chromium-T	Copper-D	Copper-T	Lead-D	Lead-T
Units	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
MDL	0.027	0.049	0.044	0.12	0.049	0.076	0.034	0.04	0.03	0.047
Dawn Princess GW-A-4	0.0135	0.025	3.12	0.06	4.5	5.81	46.3	144	11.7	18
Dawn Princess GW-A-8	4.13	0.025	59.5	39.8	3.3	0.038	11.4	73.6	6.17	15.8
Norwegian Sky GW-A	0.923	4.49	0.54	2.54	2.25	10.6	5.61	318	17	60
Norwegian Sky GW-B	3.93	3.69	1.61	1.74	6.58	10.7	2.59	195	14.5	26.5
Norwegian Wind GW-2	0.0135	0.025	43.6	44.8	4.15	7.15	9.31	77.4	12.8	22.9
Norwegian Wind GW-3	0.0135	0.025	39.1	50	7.52	6.44	9.81	84.3	23.6	24.3
Regal Princess GW-AFT	0.189	0.025	1.22	1.03	4.24	6.99	302	71.2	0.567	5.31
Regal Princess GW-FWD	0.122	0.128	1.62	1.41	3.05	4.65	114	294	0.672	4.5
Star Princess GW-C	0.518	0.549	0.459	0.388	1.5	1.86	61.4	143	2.07	6.48
Star Princess GW-D	0.378	0.025	3.3	5.48	30.5	47.3	17	1980	0.777	21.3
Sun Princess GW-A4	0.271	0.272	0.878	0.979	2.35	3.7	58.1	76.9	2.18	3.84
Sun Princess GW-C galley	0.176	0.199	2.43	2.58	17.1	15.8	53.7	74.5	0.937	5.49
Min	0.01	0.03	0.21	0.06	0.785	0.038	2.59	55.1	0.567	2.81
Max	4.13	4.49	59.50	50.00	30.5	47.3	302	1980	23.6	60
GeoMean	0.16	0.11	2.86	2.37	4.69	5.49	22.17	130.21	2.84	11.51

Table A9. 2002 Large Ship Graywater Metal Results

Sample Name	Nickel-D	Nickel-T	Selenium-D	Selenium-T	Silver-D	Silver-T	Zinc-D	Zinc-T
Units	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
MDL	0.05	0.036	0.14	0.16	0.028	0.031	0.084	0.094
Dawn Princess GW-A-4	5.19	6.12	13.6	14	0.014	0.0155	78.3	303
Dawn Princess GW-A-8	12.8	11	108	70.9	3.96	0.0155	60.6	71.1
Norwegian Sky GW-A	4.7	19.8	0.538	2.16	0.014	0.381	522	1740
Norwegian Sky GW-B	11.3	12.6	1.24	1.36	0.014	0.153	766	794
Norwegian Wind GW-2	33.8	25.5	74.9	88.6	0.014	0.0155	54.5	145
Norwegian Wind GW-3	29.6	32.8	91.2	83.6	0.014	0.0155	463	185
Regal Princess GW-AFT	17	14.8	1.66	0.538	0.205	0.75	251	30.5
Regal Princess GW-FWD	12.6	14.4	3.74	3.45	0.197	0.297	221	306
Star Princess GW-C	15.4	16.6	0.914	0.537	0.014	0.174	599	742
Star Princess GW-D	53	64.5	4.65	9.34	0.014	4.08	1170	1390
Sun Princess GW-A4	7.59	8.61	2.12	2.42	0.373	0.147	484	418
Sun Princess GW-C galley	20	15.2	2.98	4.24	0.014	1.59	259	280
Min	4.7	6.12	0.52	0.537	0.014	0.0155	55	31
Max	53	64.5	108	88.6	3.96	4.08	1170	1740
GeoMean	13.18	14.99	5.68	6.63	0.04	0.21	266	295

Table A10. 2002 Large Ship Bases, Neutral and Acids Graywater Results

Sample Name	Benzoic Acid	Benzyl Alcohol	3&4-Methyl phenol	Bis(2-Ethylhexyl)Phthalate	Butyl benzyl phthalate	Diethyl phthalate	Di-n-Butyl phthalate	Phenol
Units	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
MDL	23	0.55	1.2	0.66	0.36	0.52	1.4	0.85
Dawn Princess GW-A-4	190	8.5	11	11	1.9	13	4.8	2.5
Dawn Princess GW-A-8	46	2.9	6.3	2.8	0.18	3.9	5.3	0.4
Norwegian Sky GW-A	240	20	21	51	0.18	3.8	0.7	0.4
Norwegian Sky GW-B	310	25	26	48	0.18	3.8	0.7	0.4
Norwegian Wind GW-2	45	4.1	2	56	0.18	3	9.6	0.4
Norwegian Wind GW-3	54	3.4	2.3	13	0.18	2.7	3.9	0.4
Regal Princess GW-AFT	40	23	31	13	5.4	2.2	0.7	4.3
Regal Princess GW-FWD	28	28	3.9	5.3	0.18	17	4.4	1.9
Star Princess GW-C (acc)	410	24	18	15	2.6	18	0.7	3.2
Star Princess GW-D (G&L)	840	46	9.8	31	7.7	6.8	0.7	0.4
Sun Princess GW-A4	76	0.28	5.9	18	6.4	21	9.5	0.4
Sun Princess GW-C galley	350	0.28	140	36	12	3.5	7.7	0.4
Min	28	0.28	0.6	2.8	0.18	2.2	0.7	0.4
Max	900	46	140	56	12	21	9.6	4.3
GeoMean	169	9.21	9	13	0.63	6.5	2	0.84

Table A11. 2002 Large Ship Graywater Volatile Organic Compounds Results

Sample Name	Acetone	1,2,4-Trimethyl benzene	2-Butanone	4-Isopropyl toluene	4-Methyl-2-Pentanone	Bromo dichloro methane	Bromoform	Butyl benzyl phthalate
Units	Ug/L	ug/L	ug/L	Ug/L	ug/L	Ug/L	ug/L	Ug/L
MDL	2.5	0.15	0.51	0.11	0.15	0.23	0.32	0.36
Dawn Princess GW-A-4	72	0.08	4.2	0.055	0.08	0.48	0.16	1.9
Dawn Princess GW-A-8	38	0.08	2.9	0.055	0.08	0.12	1.8	0.18
Norwegian Sky GW-A	34	0.08	16	0.82	0.67	0.77	0.7	0.18
Norwegian Sky GW-B	35	0.08	13	0.87	1.7	0.89	0.94	0.18
Norwegian Wind GW-2	29	0.08	0.25	0.055	0.08	0.85	0.16	0.18
Norwegian Wind GW-3	18	0.08	0.25	0.055	0.08	0.86	0.16	0.18
Regal Princess GW-AFT	1.75	8.8	390	16	0.08	20	10	5.4
Regal Princess GW-FWD	970	42	56	5.2	0.08	27	9.4	0.18
Star Princess GW-C (acc)	55	0.08	5.3	0.055	5.1	0.88	0.16	2.6
Star Princess GW-D (G&L)	130	0.08	0.25	0.055	0.08	7.6	2	7.7
Sun Princess GW-A4	93	0.08	8.9	0.055	0.08	7	0.16	6.4
Sun Princess GW-C galley	220	0.08	0.25	3.4	0.08	6.1	0.16	12
Min	1.75	0.08	0.25	0.055	0.08	0.12	0.16	0.18
Max	970	42	390	16	5.1	27	10	12
GeoMean	59	0.16	3.36	0.32	0.14	2.5	0.61	0.63

Appendix G. Solution to Bacterial Load Model

C_O = initial concentration
C_y = concentration of bacteria at distance y
v = velocity of current and/or ship
y = distance from ship
L= total distance from point of discharge to shore
r = decay constant
D = eddy diffusivity

a. $D\frac{\partial^2 C}{\partial y^2} - v\frac{\partial C}{\partial y} - rC = 0$

let $C_y = ae^{ky}$
Source for this assumption: (Arya and Larnder, 1979)

b. $ak^2De^{ky} + vake^{ky} - rae^{ky} = 0$

c. $Dk^2 + vk - r = 0$

This is a quadratic equation, thus: d. $k = \frac{-v \pm \sqrt{v^2 + 4Dr}}{2D} = k_1 \;\&\; k_2$

Therefore:

e. $C_y = a_1 e^{k_1 y} + a_2 e^{k_2 y}$

at y=0: $C = C_0 = a_1 + a_2$

f. $\frac{\partial C}{\partial y} = k_1 a_1 e^{k_1 y} + k_2 a_2 e^{k_2 y}$

at y=L: $\frac{\partial C}{\partial y} = 0$; The function is at a minimum when y=L

g. $0 = k_1 a_1 e^{k_1 L} + k_2 a_2 e^{k_2 L}$

This equation is solved for a_1 and a_2

h. $a_1 = -\frac{k_2 a_2}{k_1}$ therefore $C_o = \frac{-k_2 a_2}{k_1} + a_2$

i. $a_2 = \frac{k_1 C_o}{k_1 - k_2}$

The determined values of a_1 and a_2 are inserted back into equation e to find the values of C_y

HOW ARE WE DOING?

[Park #]

[Park Name]

Date of Visit ___________

Is your stay: ❑ Day Use ❑ Overnight (002)

Please respond to each question by circling one of the numbers under "Importance" and one under "Satisfaction." For example:

(5) 4 3 2 1 N/A 5 (4) 3 2 1 N/A

We are listening. Please take a moment to tell us . . .

How *important* is it to you and how *satisfied* are you with the:

	Importance: Most Important	Very Important	Important	Fairly Important	Unimportant	Do Not Know or Not Applicable	Satisfaction: Totally Satisfied	Very Satisfied	Satisfied	Barely Satisfied	Not Satisfied	Do Not Use or Do Not Know
• Efforts to preserve the natural or historic resources here? (101)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Role which the park's natural resources played in the quality of your experience? (102)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Role which the park's cultural setting played in the quality of your experience? (103)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Role which the park's historic setting played in the quality of your experience? (104)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Level of protection of historic areas from inappropriate use? (105)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Level of protection of natural areas from inappropriate use? (106)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Level of protection of cultural areas from inappropriate use? (107)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Level to which historic buildings are protected from deterioration? (108)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Level to which cultural sites are protected from deterioration? (109)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of museum objects on exhibit? (110)	5	4	3	2	1	N/A	5	4	3	2	1	N/A

Comments on Park Resources: (199) ____________________________

	Importance: Most Important	Very Important	Important	Fairly Important	Unimportant	Do Not Know or Not Applicable	Satisfaction: Totally Satisfied	Very Satisfied	Satisfied	Barely Satisfied	Not Satisfied	Do Not Use or Do Not Know
• Feeling of safety and security during this visit? (202)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Fairness of rules and regulations? (203)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Enforcement of rules and regulations? (204)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of Lifeguards? (205)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of State Park Rangers? (206)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of staff to address safety problems? (207)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Feeling of safety and security from wildlife? (208)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Feeling of safety and security from uncontrolled domestic animals? (209)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Feeling of safety and security from natural hazards (poison oak, cliffs, rip currents, etc.)? (210)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Feeling of safety and security from criminal activity? (211)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of information on hazards? (212)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Posting of prohibited areas? (213)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of law enforcement services? (214)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of emergency services? (215)	5	4	3	2	1	N/A	5	4	3	2	1	N/A

HOW ARE WE DOING?

How *important* is it to you and how *satisfied* are you with the:

Please respond to each question by circling one of the numbers under "Importance" and one under "Satisfaction." For example: (5) 4 3 2 1 N/A 5 (4) 3 2 1 N/A

	Importance: Most Important	Very Important	Important	Fairly Important	Unimportant	Do Not Know or Not Applicable	Satisfaction: Totally Satisfied	Very Satisfied	Satisfied	Barely Satisfied	Not Satisfied	Do Not Use or Do Not Know
• Availability of a phone and emergency phone numbers? (216)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of directions (map) to nearest medical facility? (217)	5	4	3	2	1	N/A	5	4	3	2	1	N/A

Comments on Safety: (299) ______

• Overall condition of facilities? (302)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Cleanliness of restrooms? (303)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of roads? (304)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of boat ramps? (305)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of parking areas? (306)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of trails? (307)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of camping areas? (308)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of picnic areas? (309)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of swim areas? (310)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of restrooms? (311)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of showers? (312)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of dump stations? (313)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of the concessions (park store, boat rental, restaurant/snack bar, etc.)? (314)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of boat docks? (315)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of marina? (316)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of entrance area? (317)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Conditions of grounds/gardens? (318)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition of museum/historic buildings? (319)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Frequency of trash pick-up? (320)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Time of day restrooms are closed for cleaning? (321)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Number and availability of restrooms? (322)	5	4	3	2	1	N/A	5	4	3	2	1	N/A

Comments on Park Facilities: (399) ______

• Opportunities offered to help you learn about the area's history and natural environment? (402)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of services to help you understand and appreciate the park? (403)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of Junior Ranger programs? (404)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of Junior Ranger programs? (405)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of campfire programs? (406)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of campfire programs? (407)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of tours and other guided activities? (408)	5	4	3	2	1	N/A	5	4	3	2	1	N/A

HOW ARE WE DOING?

How *important* is it to you and how *satisfied* are you with the:

Please respond to each question by circling one of the numbers under "Importance" and one under "Satisfaction." For example: **(5) 4 3 2 1 N/A 5 (4) 3 2 1 N/A**

	Importance: Most Important	Very Important	Important	Fairly Important	Unimportant	Do Not Know or Not Applicable	Satisfaction: Totally Satisfied	Very Satisfied	Satisfied	Barely Satisfied	Not Satisfied	Do Not Use or Do Not Know
• Availability of tours and other guided activities? (409)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of information on history? (410)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of information on history? (411)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of information on natural features? (412)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of information on natural features (plants, animals, geology, etc.)? (413)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of information on recreational opportunities? (414)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of information on recreational opportunities? (415)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of information on park facilities? (416)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of information on park facilities (trails, restrooms, roads)? (417)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of information on park activities? (418)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of information on park activities? (419)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of publications? (420)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of publications? (421)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of audio-visual media? (422)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of audio-visual media? (423)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of outdoor exhibits or displays? (424)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of outdoor exhibits or displays? (425)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of recorded audio tours? (426)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of recorded audio tours? (427)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of park educational activities for children? (428)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of park educational activities for children? (429)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of "living history" programs? (430)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of "living history" programs? (431)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of other special events? (432)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of other special events? (433)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of visitor centers or museums? (434)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of visitor centers or museums? (435)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of information on cultures and traditions of the area? (436)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of information on cultures and traditions of the area? (437)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Opportunity to learn more, on your own, through exhibits, publications, or other methods? (438)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of museum objects on exhibit? (439)	5	4	3	2	1	N/A	5	4	3	2	1	N/A

Comments on Education Programs: (499) ____________________

	Importance: Most Important	Very Important	Important	Fairly Important	Unimportant	Do Not Know or Not Applicable	Satisfaction: Totally Satisfied	Very Satisfied	Satisfied	Barely Satisfied	Not Satisfied	Do Not Use or Do Not Know
• Quality of recreational opportunities available here? (501)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Fees you paid compared to the value of your park experience? (502)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Courtesy and helpfulness of park staff? (503)	5	4	3	2	1	N/A	5	4	3	2	1	N/A

HOW ARE WE DOING?

How *important* is it to you and how *satisfied* are you with the:

Please respond to each question by circling one of the numbers under "Importance" and one under "Satisfaction." For example:

(5) 4 3 2 1 N/A 5 (4) 3 2 1 N/A

	Importance: Most Important	Very Important	Important	Fairly Important	Unimportant	Do Not Know or Not Applicable	Satisfaction: Totally Satisfied	Very Satisfied	Satisfied	Barely Satisfied	Not Satisfied	Do Not Use or Do Not Know
• Accessibility for visitors with disabilities? (504)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Courtesy of concession staff (park store, boat rental, restaurant/snack bar, etc.)? (505)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Quality of your concession purchase (park store, boat rental, restaurant/snack bar, etc.)? (506)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Prices at concessions (park store, boat rental, restaurant/snack bar, etc.)? (507)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Time it took to get through to the telephone reservation service? (508)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Accuracy of information received from the telephone reservation service? (509)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Telephone courtesy you received from the reservation service employees? (510)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Fairness of the reservation fee? (511)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Fairness of the cancellation fee? (512)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Hours of operation of entrance station? (513)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Time it took to check-in and register for overnight camping? (514)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Time it took to get through entrance station? (515)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Enforcement of quiet hours? (516)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Availability of staff to assist you? (517)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Hours of permitted operation of recreational vehicle generators? (518)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Variety of recreational opportunities? (519)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Adequacy of signs? (520)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Grooming and appearance of uniformed employees? (521)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Condition and appearance of park vehicles and equipment? (522)	5	4	3	2	1	N/A	5	4	3	2	1	N/A
• Clarity of instruction for self-registration and payment of fees? (523)	5	4	3	2	1	N/A	5	4	3	2	1	N/A

Comments: (599) ______________________________

Optional: California State Parks are for *everyone*. Please tell us about yourself

Your ZIP code (or country if outside USA) (001) ______________

PLEASE CHECK ONE IN EACH CATEGORY

Your Education: ☐ Some High School ☐ H.S./Grad/GED ☐ Some College ☐ College Grad (003)

Are You: ☐ Male ☐ Female (004)

Your Age: ☐ Under 18 ☐ 18-24 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55-64 ☐ 64+ (005)

Your Annual Household Income: ☐ Under $15,000 ☐ $15,000-$29,999 ☐ $30,000-$44,999 ☐ $45,000-$59,999 ☐ $60,000-$75,000 ☐ Over $75,000 (006)

HOW ARE WE DOING?

	Importance						Satisfaction					
	Most Important	Very Important	Important	Fairly Important	Unimportant	Do Not Know or Not Applicable	Totally Satisfied	Very Satisfied	Satisfied	Barely Satisfied	Not Satisfied	Do Not Use or Do Not Know

How *important* is it to you and how *satisfied* are you with the:

Please respond to each question by circling one of the numbers under "Importance" and one under "Satisfaction." For example:

(5) 4 3 2 1 N/A 5 (4) 3 2 1 N/A

Your Ethnicity: ❑ Asian ❑ American Indian ❑ Black ❑ Filipino ❑ Hispanic ❑ Pacific Islander ❑ White ❑ Other
(007)

If you would like free California State Parks information, please provide your name and address below. (699)

____

____

Thank you for visiting your California State Parks

Please return this survey to a park employee, or mail to:

California Department of Parks and Recreation
Attn: Mary Veliquette
Field Services Division
Visitor Services Section
P.O. Box 942896
Sacramento, CA 94296-0001

Source: California State Parks Visitor Services Department

Appendix I. Beach Water Quality Data Contacts

San Diego:
Clay Clifton
San Diego County Department of Environmental Health
Telephone: 619-338-2386

Long Beach:
Jackie Hampton
City of Long Beach Health Department
Telephone: 562-570-4144

San Mateo
Steve Hartsell/ Carol-Ann Towe
San Mateo County Environmental Health
Telephone: 650-363-4798

Santa Cruz
Steven Peters
County of Santa Cruz Health Services-Environmental Health Services
Telephone: 831-454-5010

Orange County:
Michael Fennessy
Orange County Environmental Health Division
Telephone: 714-667-3755

Los Angeles:
Jerrick Torres
L.A. County Environmental Health, Recreational Health Program
Telephone: 626-430-5360

Appendix J. Travel Cost Temperature Data

Beach	Months						Year
	April	May	June	July	August	September	
San Gregorio	no data	62.29	64.80	67.13	69.65	69.63	1998
Pomponio	no data	no data	64.80	no data	no data	no data	1998
Pescadero	no data	62.29	64.80	67.375 (average)	no data	no data	1998 & 2000
Half Moon Bay	63.43	no data	no data	67.375 (average)	no data	no data	1998 & 2000
Montara	no data	no data	no data	67.375 (average)	no data	no data	2000
Sunset	61.03	59.77	61.67	62.19	64.48	66.4	1994
	59.53	59.77	61.33	66.61	65.61	66.83	1995
	59.6	56.94	60.17	62.97	65.45	65.5	1999
	61.43	61.19	65.03	63.58	65.26	69.57	2000
Manresa	61.03	59.77	61.67	62.19	64.48	66.4	1994
	59.53	59.77	61.33	66.61	65.61	66.83	1995
	59.6	56.94	60.17	62.97	65.45	65.5	1999
	61.43	61.19	65.03	63.58	65.26	69.57	2000
	57.03	66.12	64.88	63.74	65	64.77	2001
San Elijo	59.53	59.77	61.33	66.61	65.61	66.83	1995
	71.63	71.16	72.3	74.39	77.68	74.63	1996
	67.93	73.48	70.8	73.48	77.68	81.23	1997
	65.43	62.29	64.80	67.13	69.65	69.63	1998
	59.6	56.94	60.17	62.97	65.45	65.5	1999
	61.43	61.19	65.03	63.58	65.26	69.57	2000
	57.03	66.12	64.88	63.74	65	64.77	2001
Torrey Pines	61.03	59.77	61.67	62.19	64.48	66.4	1994
	67.93	73.48	70.8	73.48	77.68	81.23	1997
	65.43	62.29	64.80	67.13	69.65	69.63	1998
	59.6	56.94	60.17	62.97	65.45	65.5	1999
	61.43	61.19	65.03	63.58	65.26	69.57	2000
	57.03	66.12	64.88	63.74	65	64.77	2001
San Onofre	59.6	56.94	60.17	62.97	65.45	65.5	1999
	61.43	61.19	65.03	63.58	65.26	69.57	2000
	57.03	66.12	64.88	63.74	65	64.77	2001
	63.67	66.06	68.67	71.81	73.35	75.47	2002
Silver Strand	59.53	59.77	61.33	66.61	65.61	66.83	1995
	71.63	71.16	72.3	74.39	77.68	74.63	1996
	67.93	73.48	70.8	73.48	77.68	81.23	1997
	65.43	62.29	64.80	67.13	69.65	69.63	1998
	59.6	56.94	60.17	62.97	65.45	65.5	1999

South Carlsbad	67.93	73.48	70.8	73.48	77.68	81.23	1997
	65.43	62.29	64.80	67.13	69.65	69.63	1998
	59.6	56.94	60.17	62.97	65.45	65.5	1999
	61.43	61.19	65.03	63.58	65.26	69.57	2000
	57.03	66.12	64.88	63.74	65	64.77	2001
	63.67	66.06	68.67	71.81	73.35	75.47	2002
Bolsa Chica	65.2	69	70.27	75.45	73.81	72.9	1999
	67.1	70.29	73.8	74.45	76.39	76.57	2000
	63.2	69.35	73.47	73.45	74.06	73.57	2001
	64.8	67.71	70.9	73.81	73.1	74.03	2002
	65.33	67.29	69.8	77.39	77.55	73.13	2003

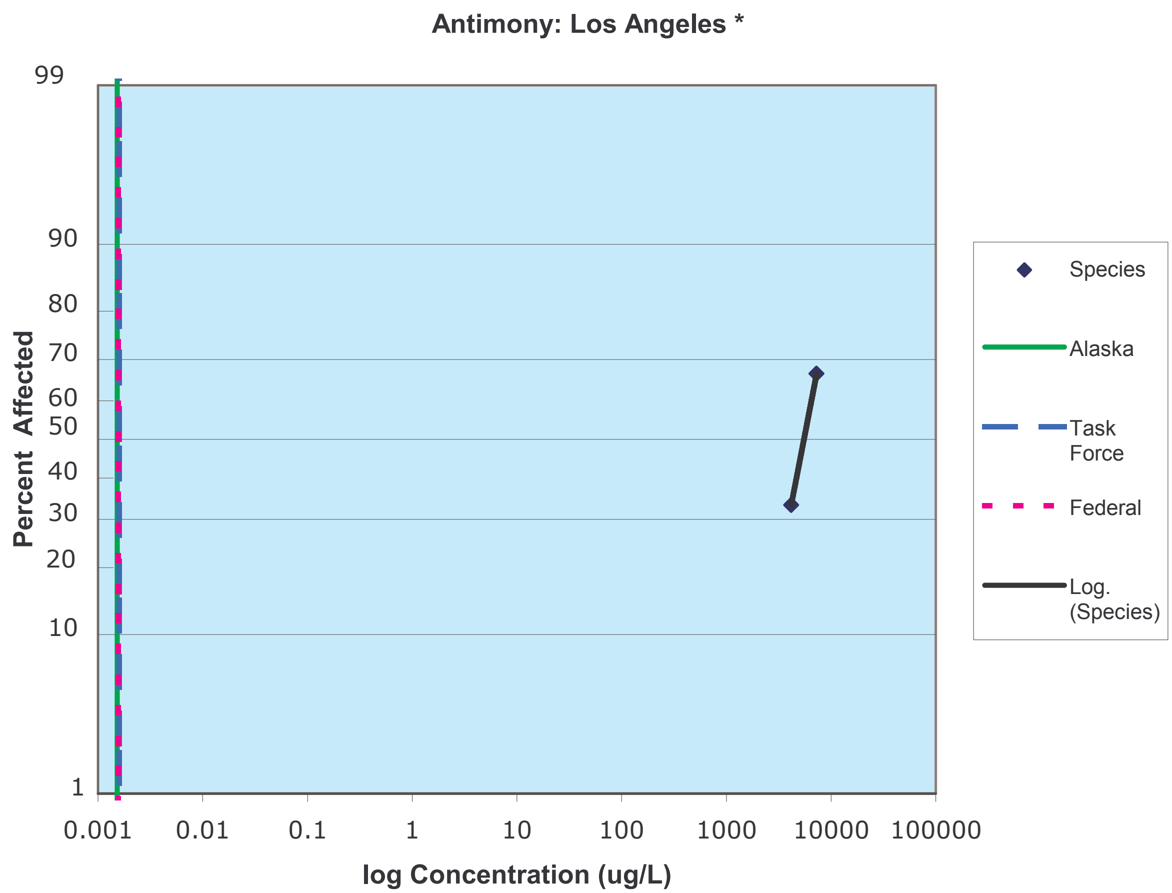
Source: Western Regional Climate Center

Appendix K. Consumer Price Index Calculation and Results

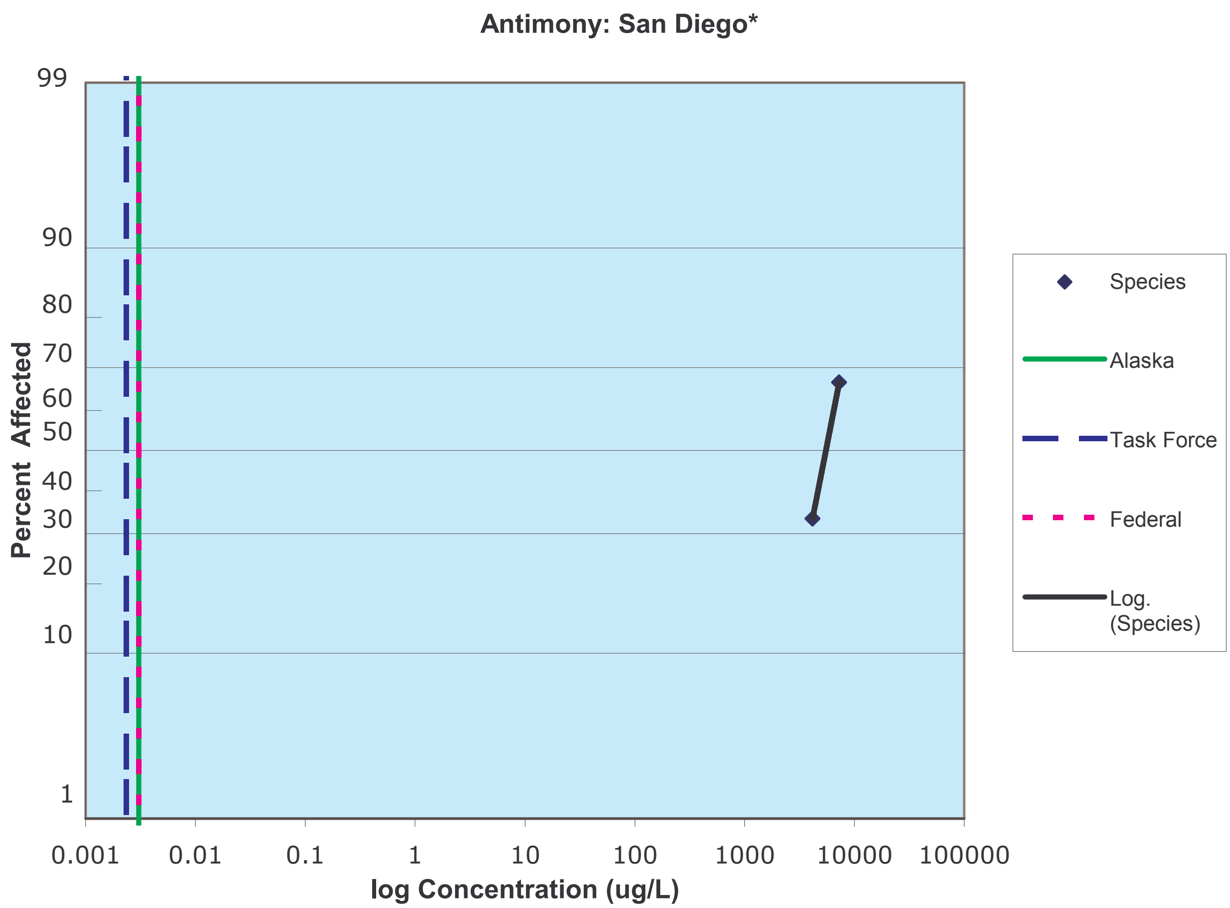
Year	CPI	Calculation Steps:	Year	Results:
1994	148.2	CPI for current period	1994	121.39%
1995	152.4	Less CPI for previous period	1995	118.04%
1996	156.9	Equals index point change	1996	114.66%
1997	160.5	Divided by previous period CPI	1997	112.09%
1998	163	Equals	1998	110.37%
1999	166.6	Result multiplied by 100	1999	107.98%
2000	172.2	Equals percent change	2000	104.47%
2001	177.1		2001	101.58%
2002	179.9		2002	100.00%
2003	184		2003	97.72%

Source: Bureau of Labor Statistics

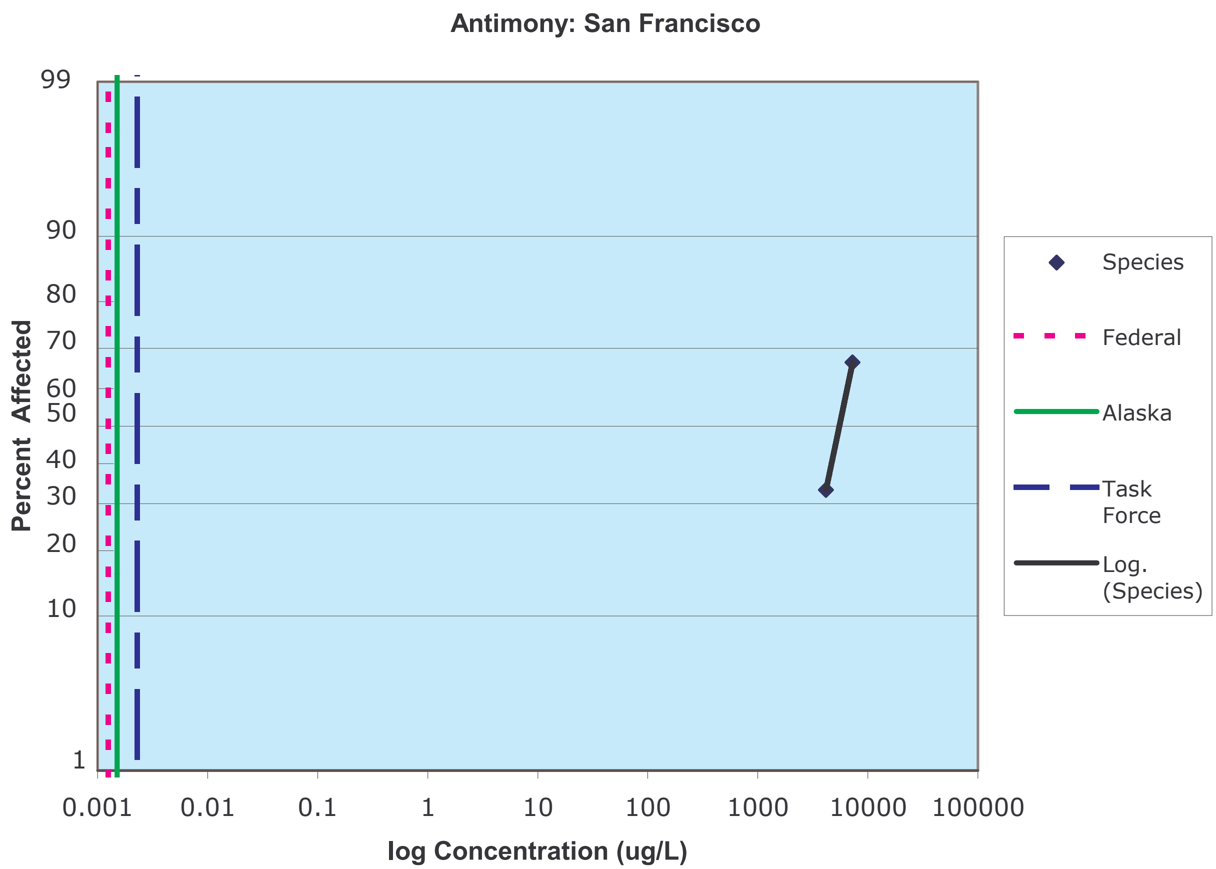
Appendix L. Species Sensitivity Distributions for Los Angeles, San Diego and San Francisco



* The calculated concentrations for all scenarios overlap for this port due to similar depths.

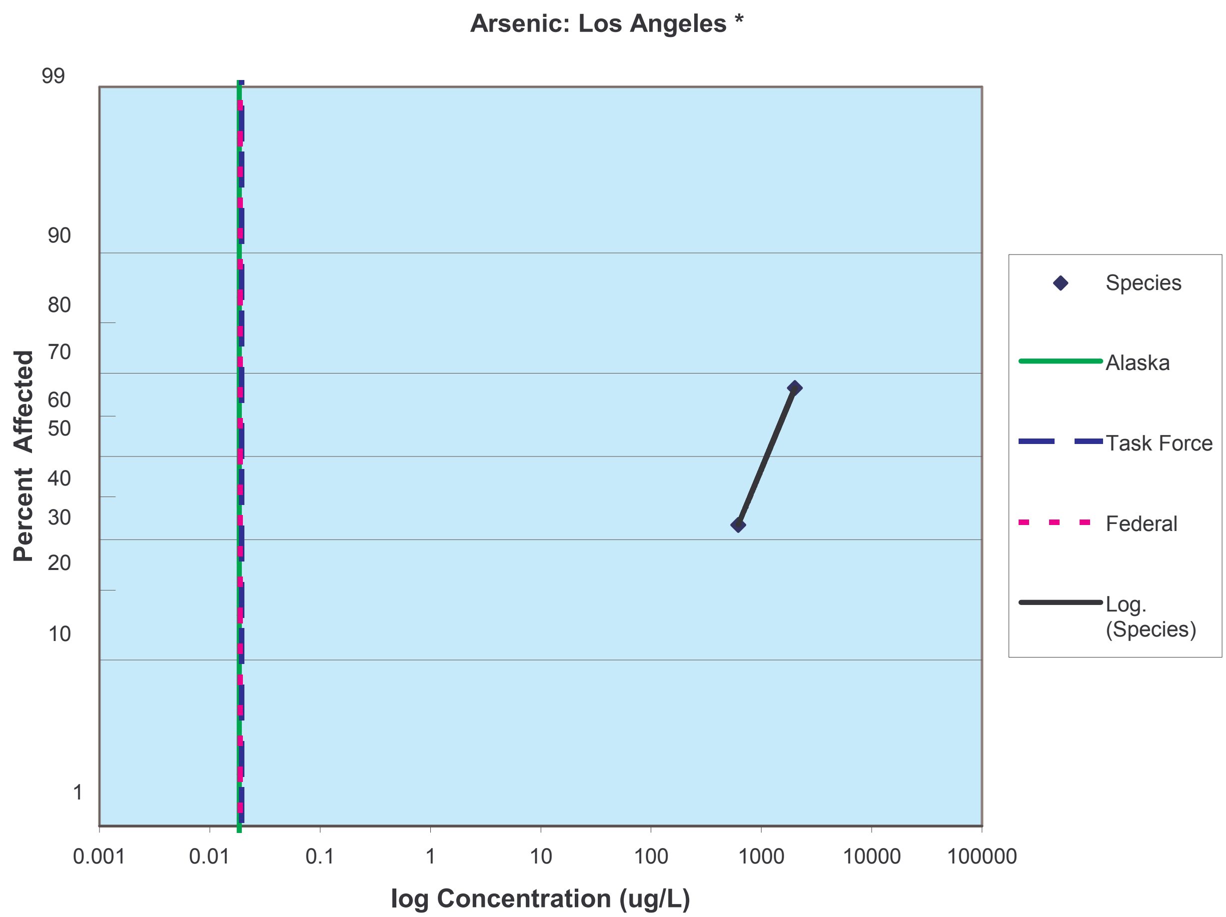


* The calculated concentrations for Alaska and Federal scenarios overlap for this port due to similar depths.

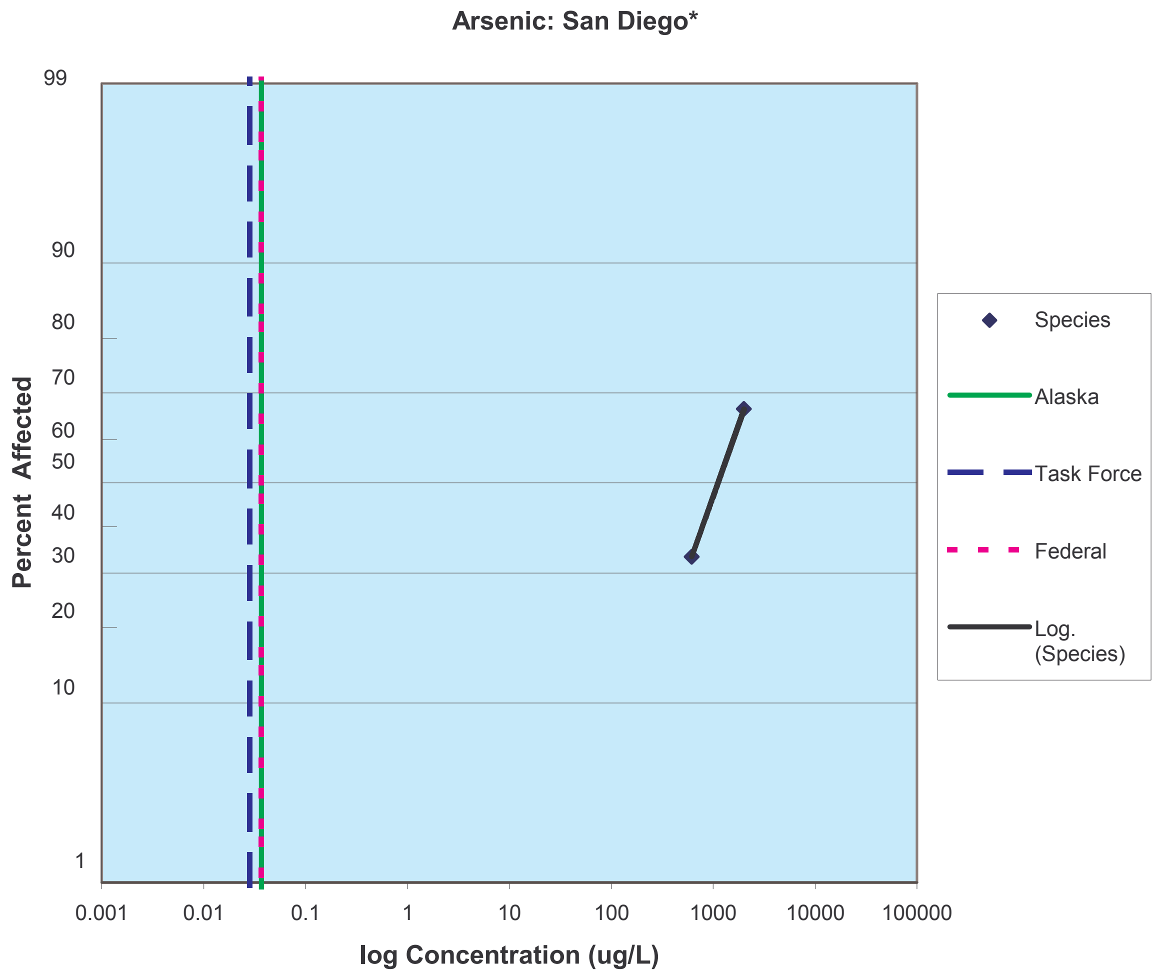


Species used as data points to create the species sensitivity distributions for Antimony:

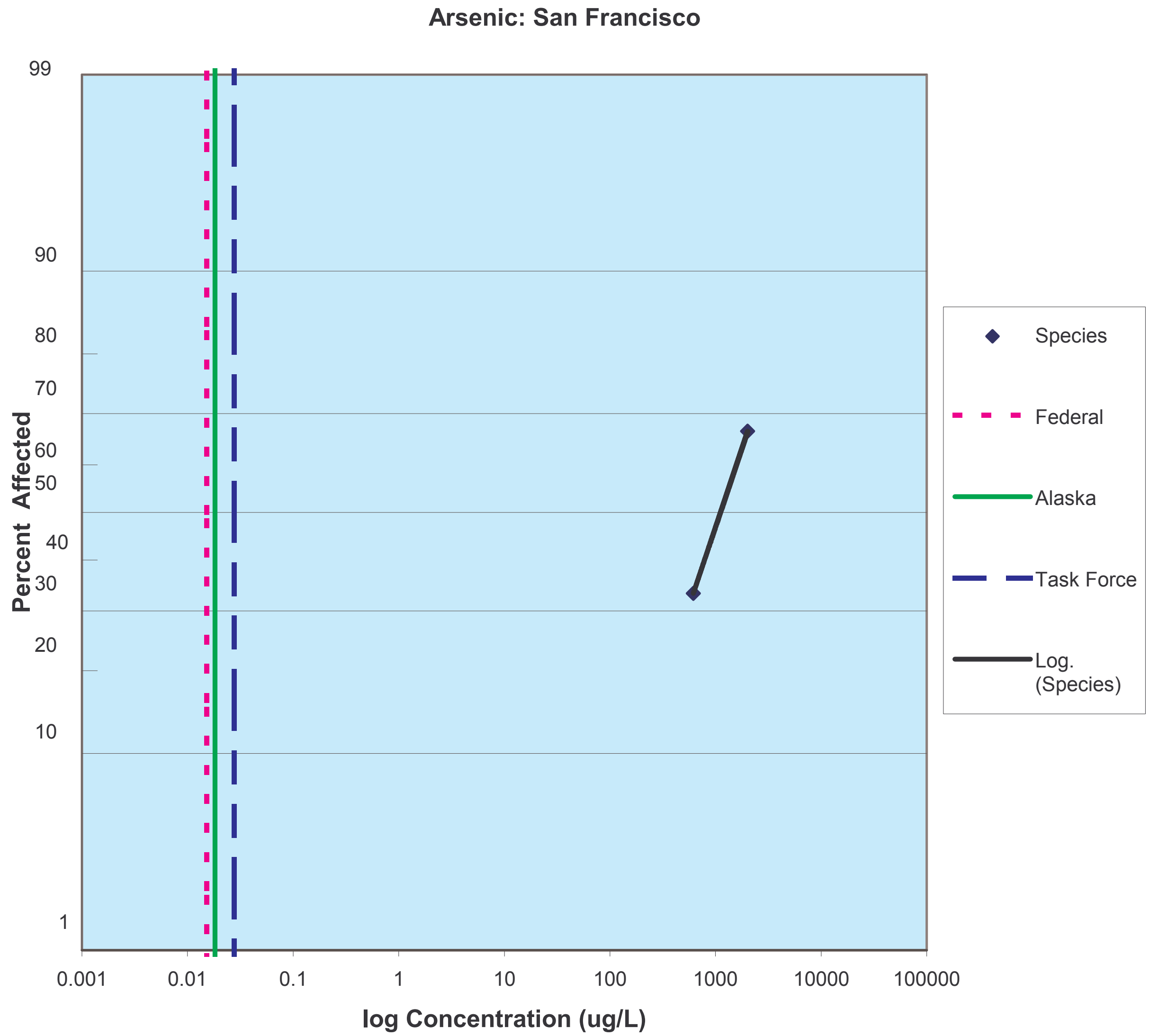
Species	LC50 Value (ug/L)	Source
Opossum shrimp (Americamysis bahia)	4150	(US Environmental Protection Agency, 1990)
Sheepshead minnow (Cyprinodon variegates)	7250	(Heitmuller, 1981)



* The calculated concentrations for all scenarios overlap for this port due to similar depths.

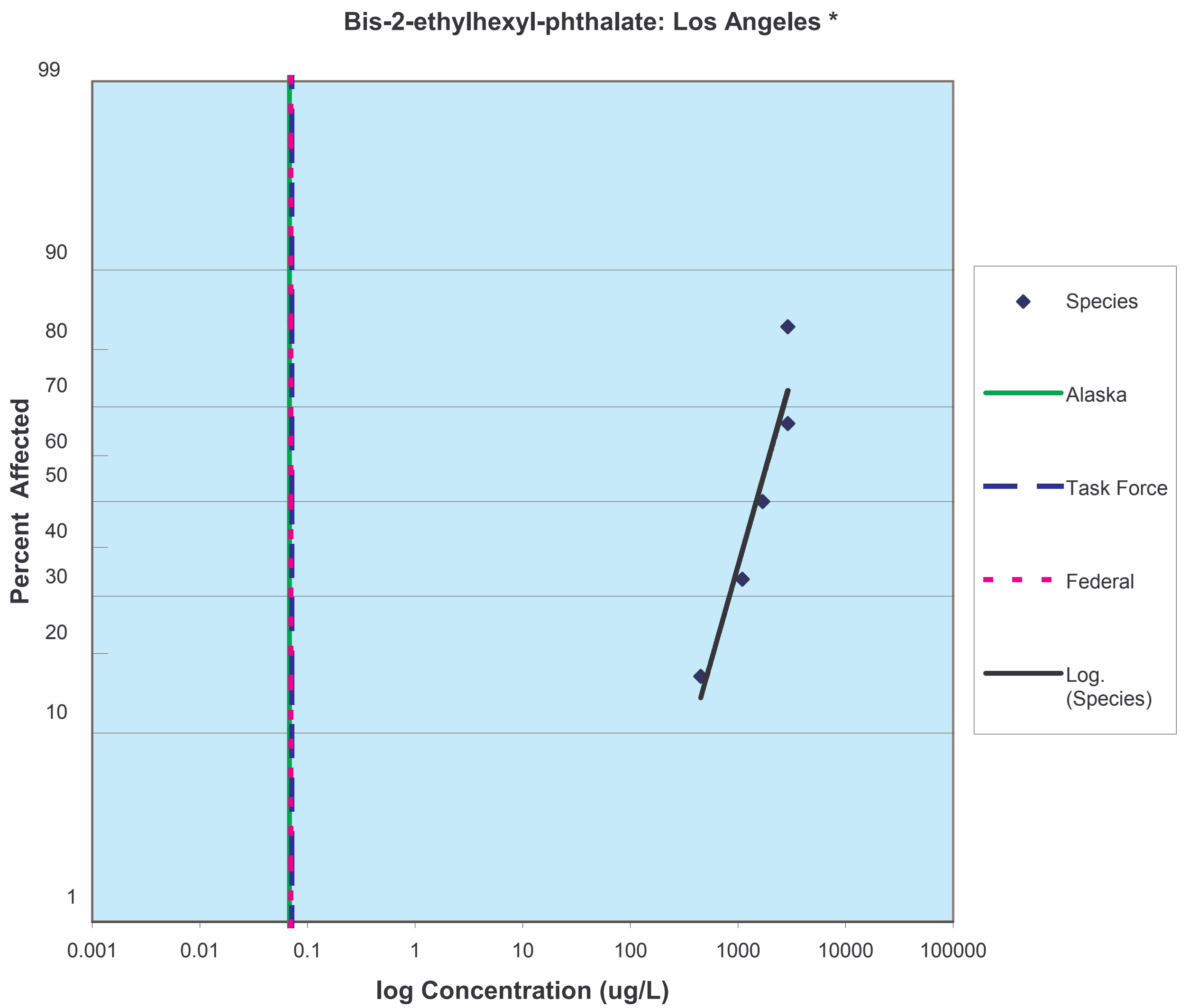


* The calculated concentrations for Alaska and Federal scenarios overlap for this port due to similar depths.

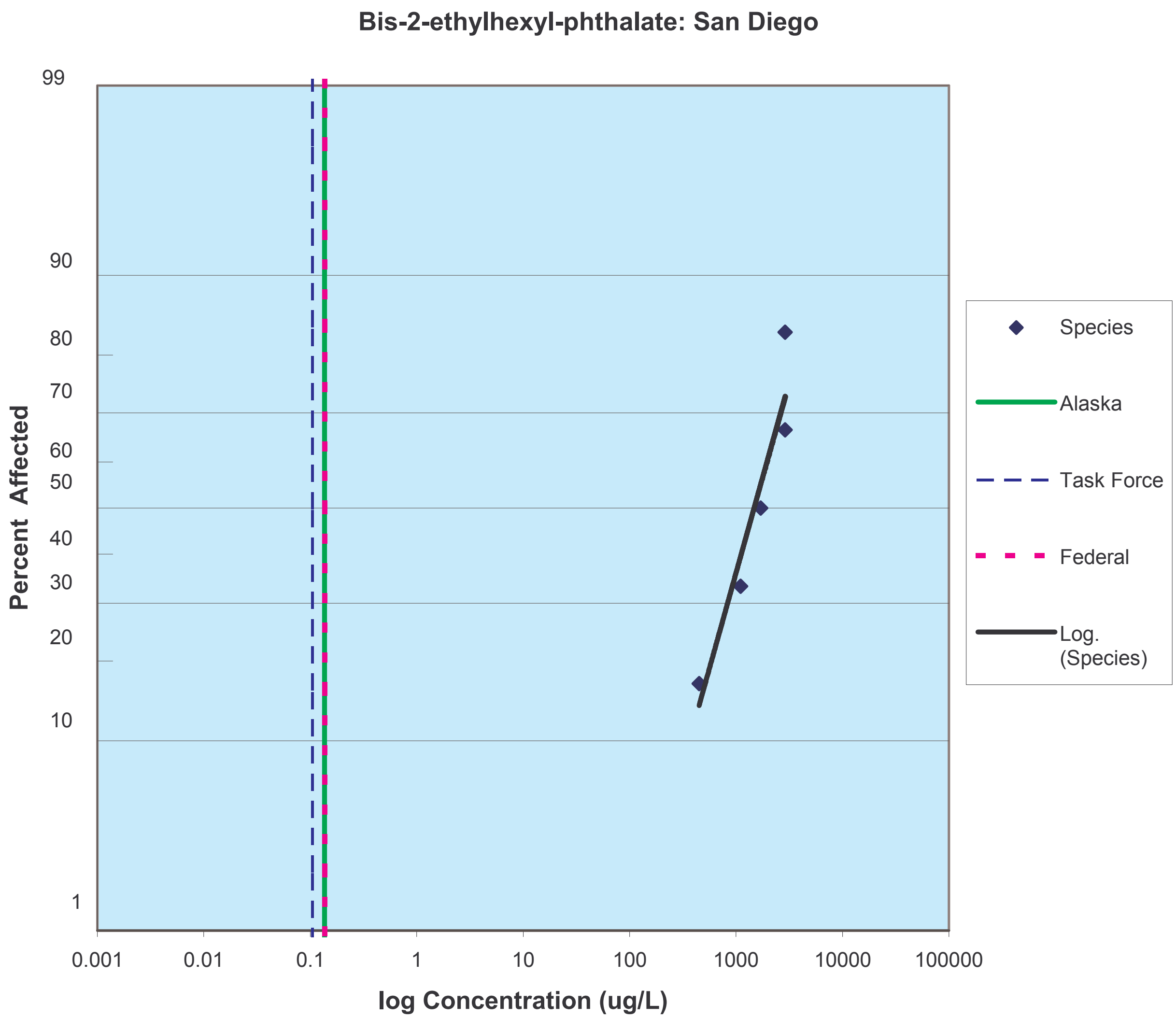


Species used as data points to create the species sensitivity distributions for arsenic:

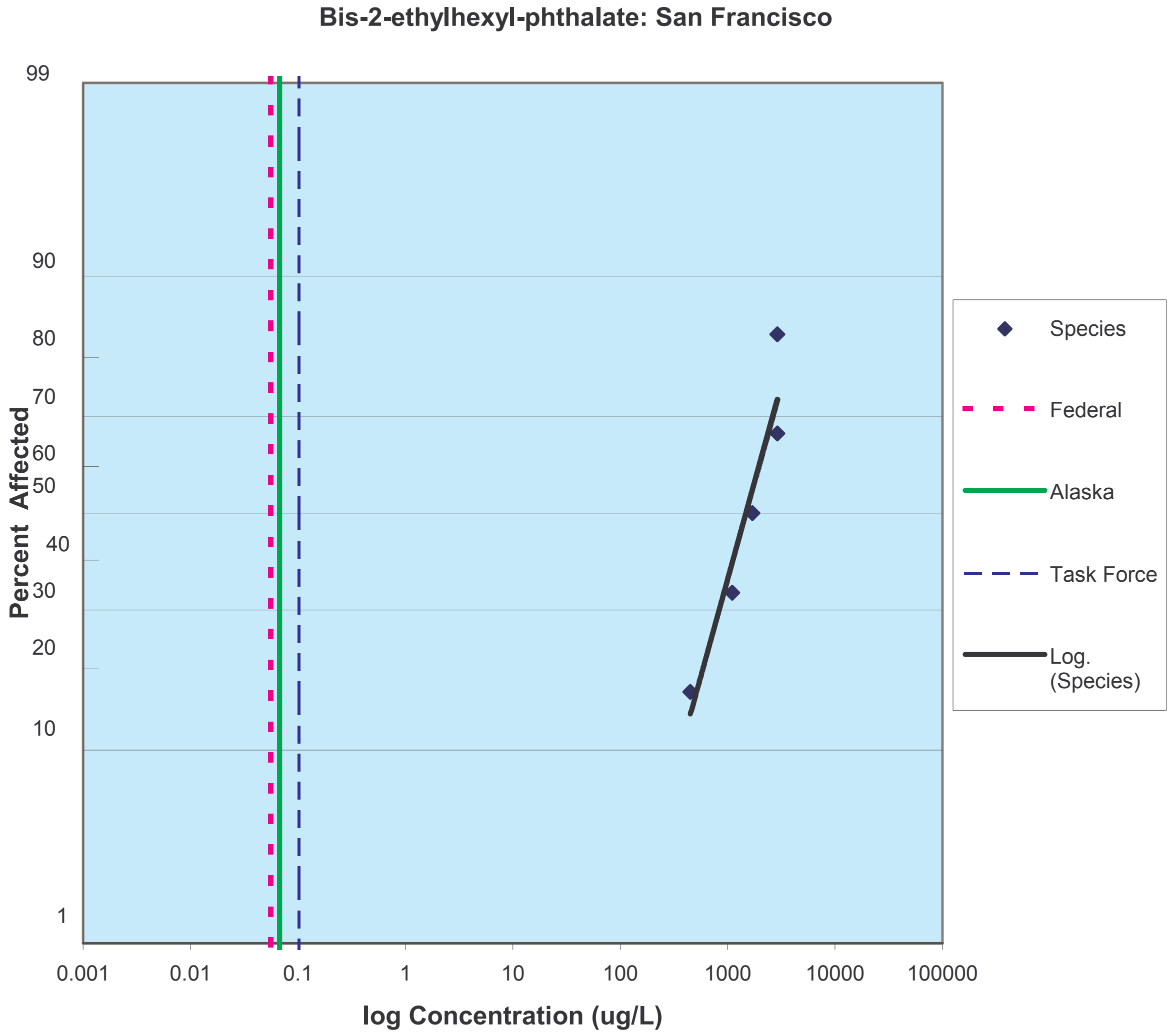
Species	LC50 Value	Source
Acartia clausi (Calenoid copepod)	616.28	(Lussier, 1985),(Cardin, 1980)
Americamysis bahia (Opposum shrimp)	2008.75	(Lussier, 1985), (Lussier, 1985)



* The calculated concentrations for all scenarios overlap for this port due to similar depths.

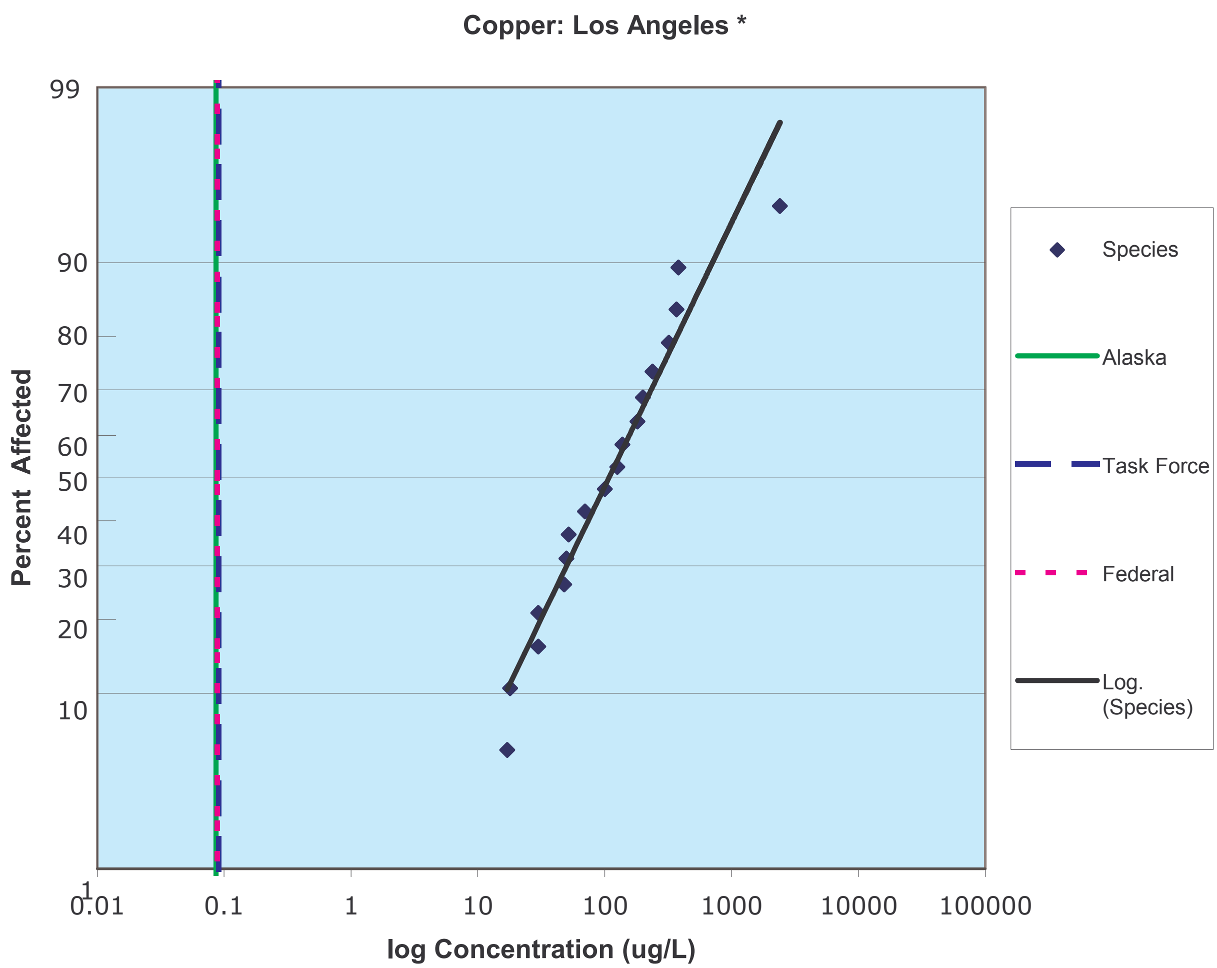


* The calculated concentrations for Alaska and Federal scenarios overlap for this port due to similar depths.

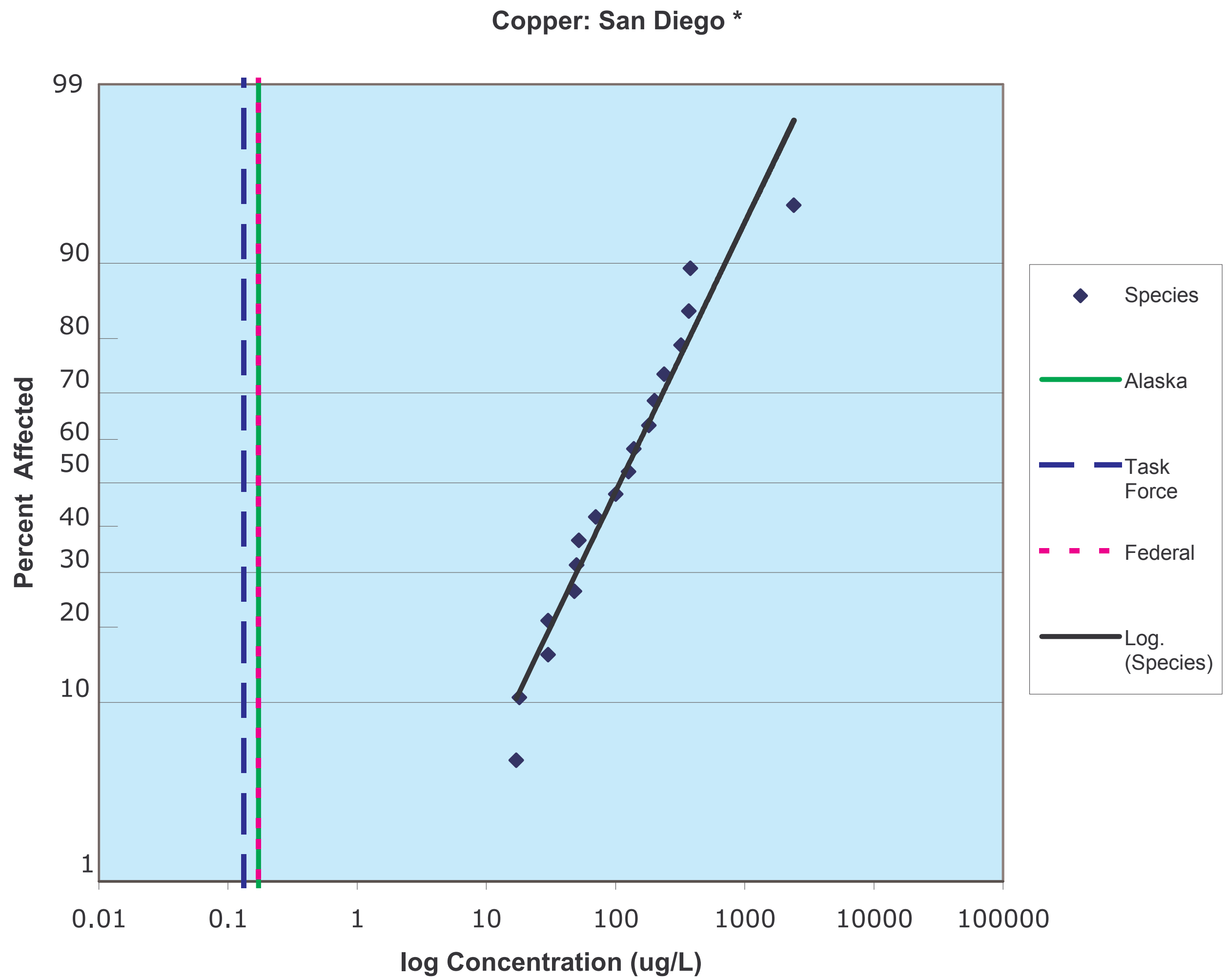


Species used as data points to create the species sensitivity distributions for Bis-2-ethylhexyl-phthalate:

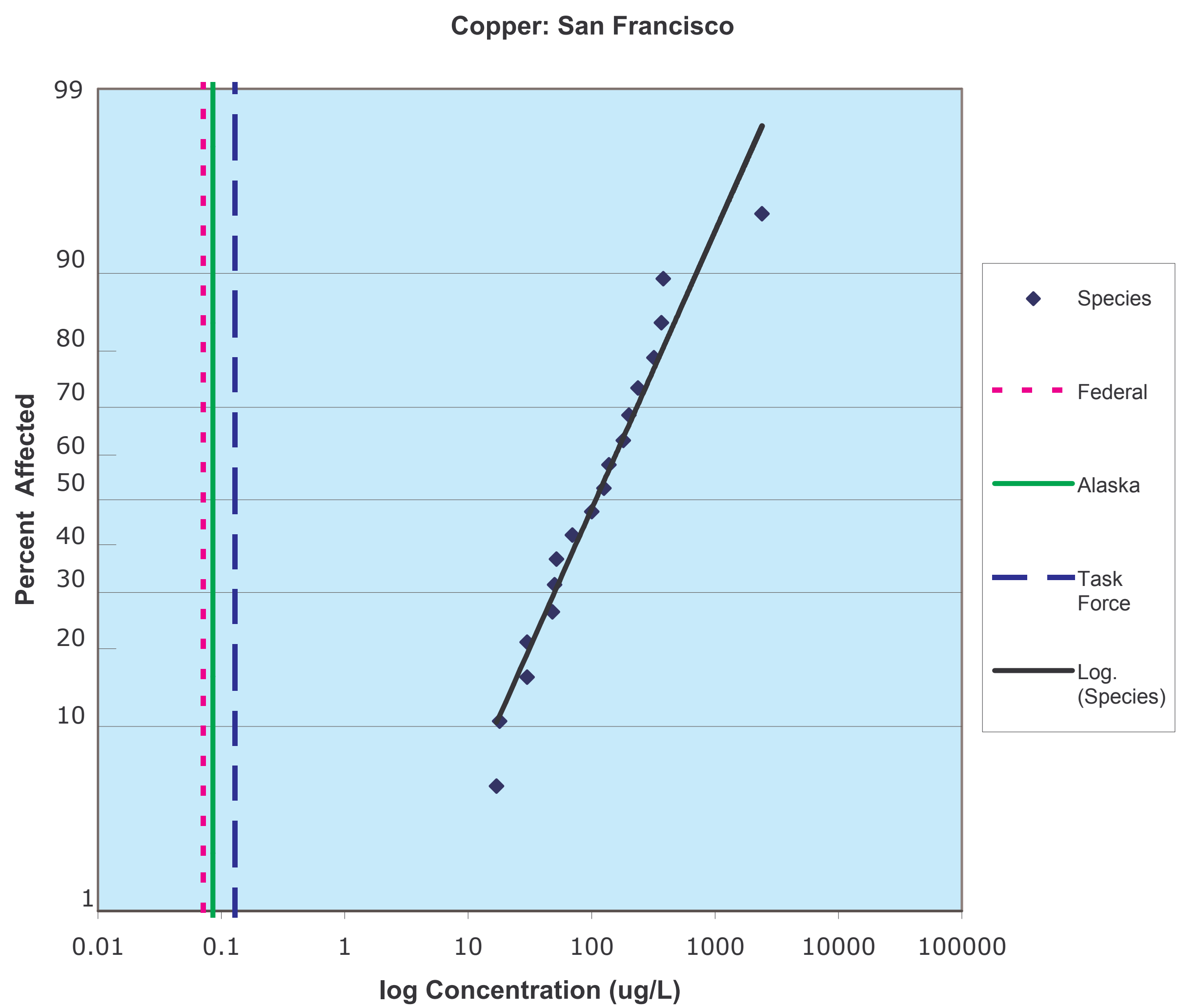
Species	LC50 Value (ug/L)	Source
Scud (Corophium acherusicum)	450	(Tagatz, 1990)
Morton's egg cockle (Laevicardium mortoni)	1100	(Tagatz, 1990)
Harpacticoid copepod (Nitocra spinipes)	1700	(Linden, 1990)
Polychaete or Opheliid worm (Armandia maculata)	2900	(Tagatz, 1990)
Sea cucumber (Leptosynapta inhaerens)	2900	(Tagatz, 1990)



* The calculated concentrations for all scenarios overlap for this port due to similar depths.

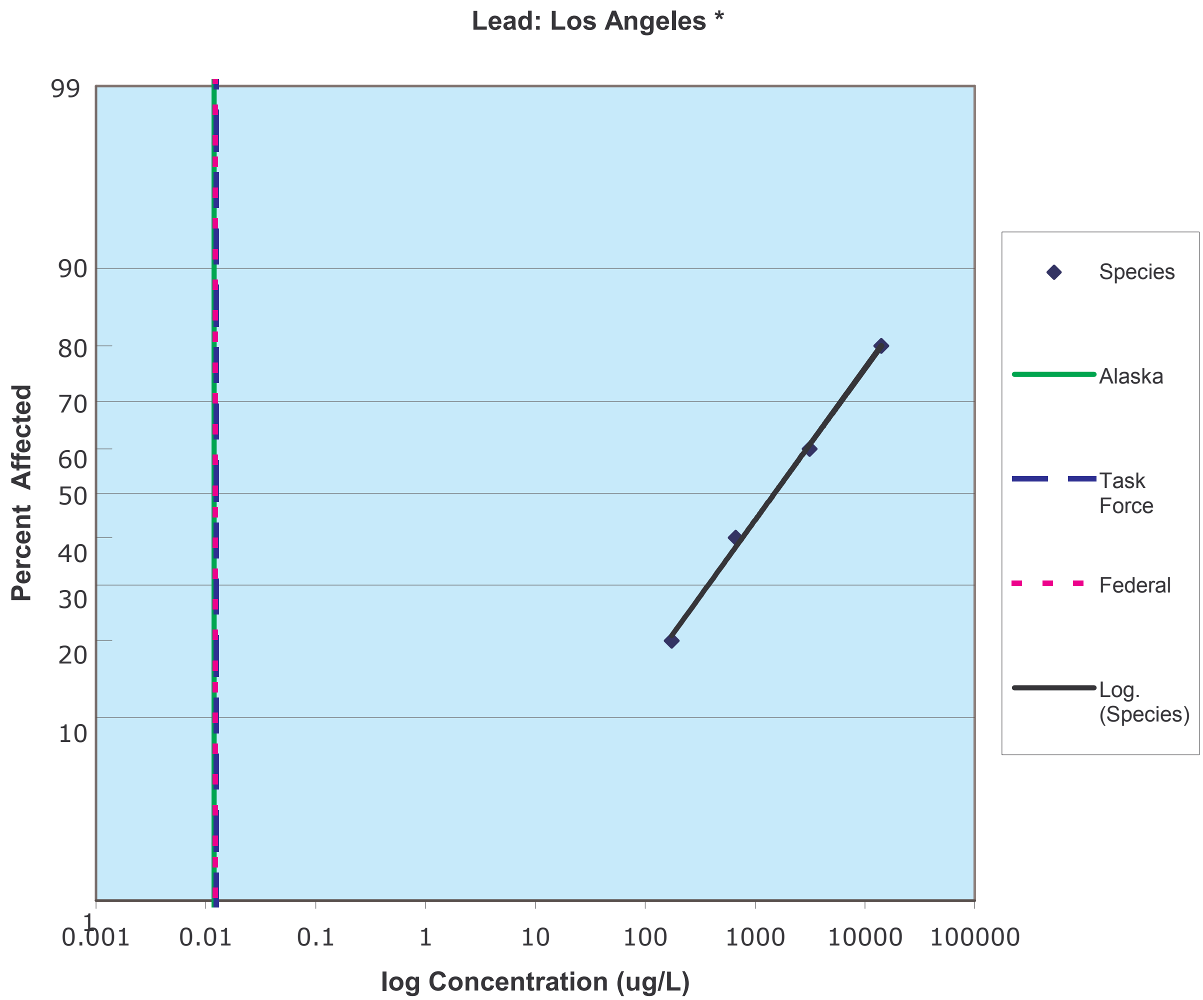


* The calculated concentrations for Alaska and Federal scenarios overlap for this port due to similar depths.

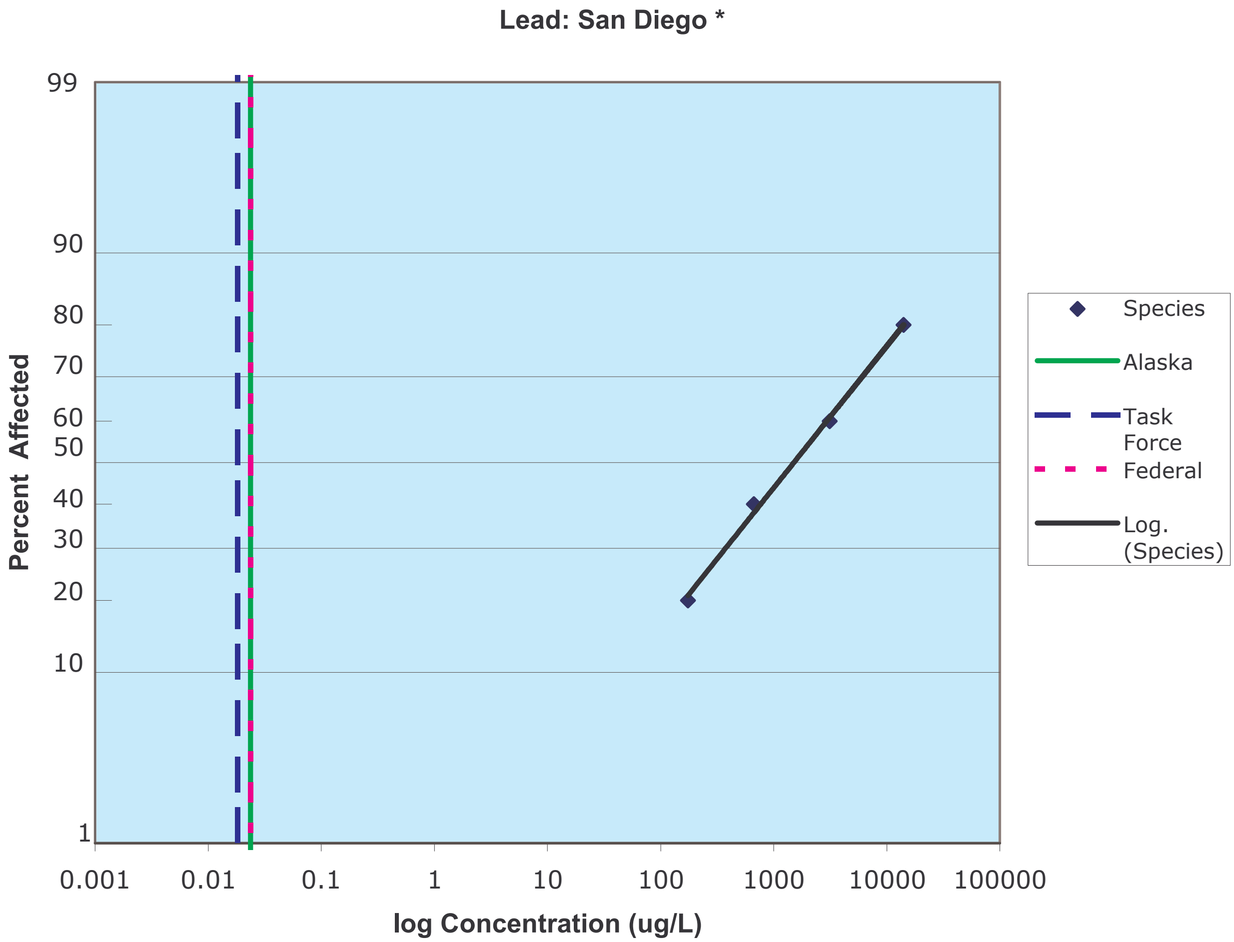

Copper: San Francisco
99
90
80
70
60
50
40
30
20
10
1
Percent Affected
0.01
0.1
1
10
100
1000
10000
100000
log Concentration (ug/L)
Species
Federal
Alaska
Task Force
Log. (Species)

Species used as data points to create the species sensitivity distributions for Copper:

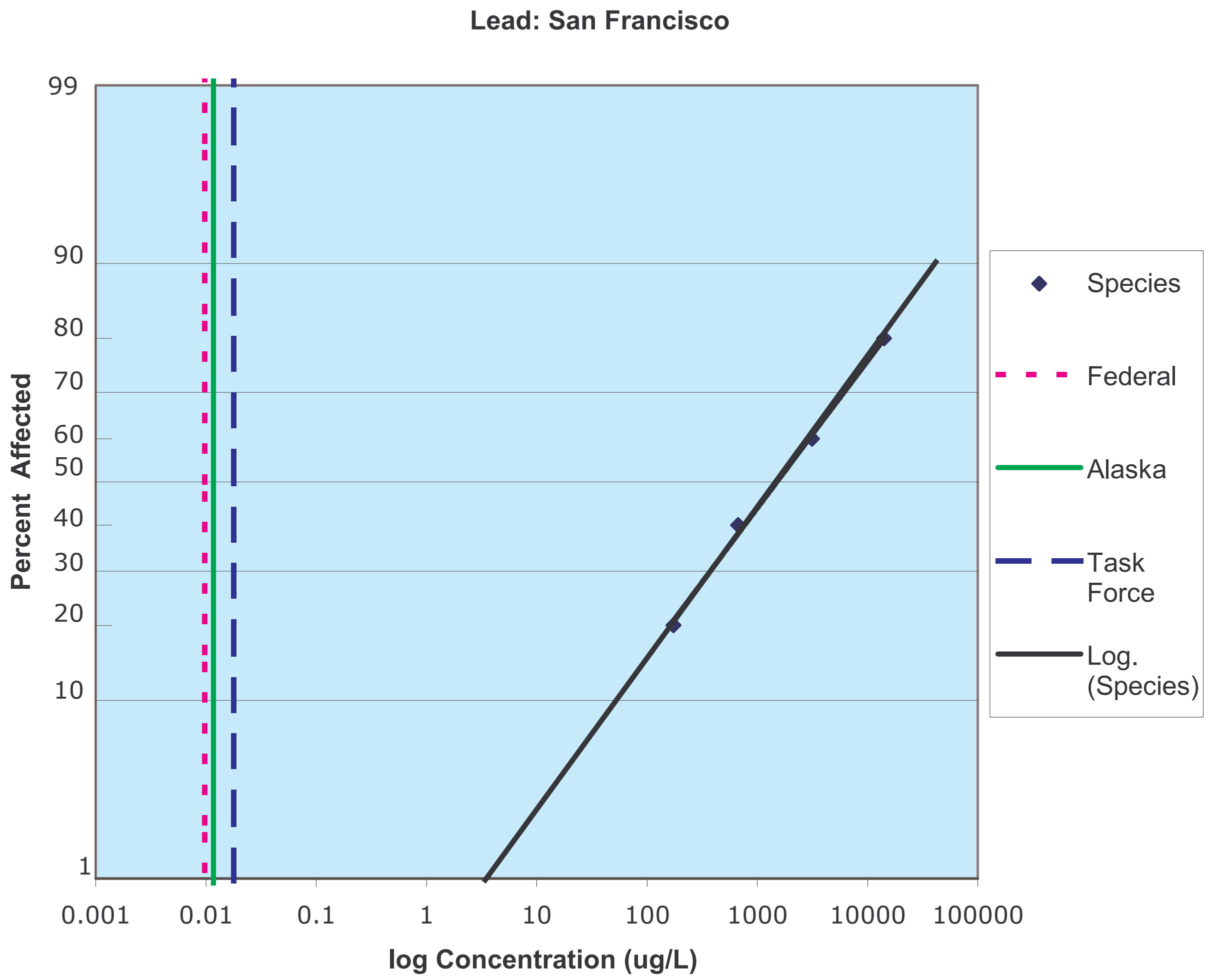
Species	LC50 Value	Source
Acartia clausi (Calanoid copepod)	52	(Gentile, 1982)
Acartia tonsi (Calanoid copepod)	17	(Sosnowski and Gentile, 1978), (Gentile, 1982)
Americamysis bahia (Opossum shrimp)	188	(Lussier, 1985)
Atherinops affinis (Topsmelt)	238	(Anderson, 1991)
Balanus improvisus (Barnacle)	100	(Koryakova, 1993)
Cyprinodon variegates (Sheepshead minnow)	368	(Hughes, 1989)
Eurytemora affinis (Calanoid copepod)	30	(Sullivan, 1983), (Gentile, 1982)
Haliotis (Abalone)	30	(Harrison, 1985)
Macrobrachium rosenbergii (Giant river prawn)	320	(Ismail, 1990)
Mytilus (Mussel)	200	(Harrison, 1985)
Pagrus major (Red Sea bream)	2400	(Hori, 1996)
Penaeus chinensis (Fleshy prawn)	18	(Liu, 1995)
Penaeus merguiensis (Banana prawn)	380	(Ahsanullah, 1995)
Pseudodiaptomus coronatus (Calanoid copepod)	138	(Gentile, 1982)
Sciaenops ocellatus (Red drum)	.5181	(Peppard, 1991)
Stichopus sp. (Sea cucumber)	70	(Shcheglov, 1990)
Strongylocentrotus intermedius (Sea urchin)	30	(Shcheglov, 1990)
Tigriopus californicus (Harpacticoid copepod)	1.20E-06	(O'Brien, 1988)



* The calculated concentrations for all scenarios overlap for this port due to similar depths.

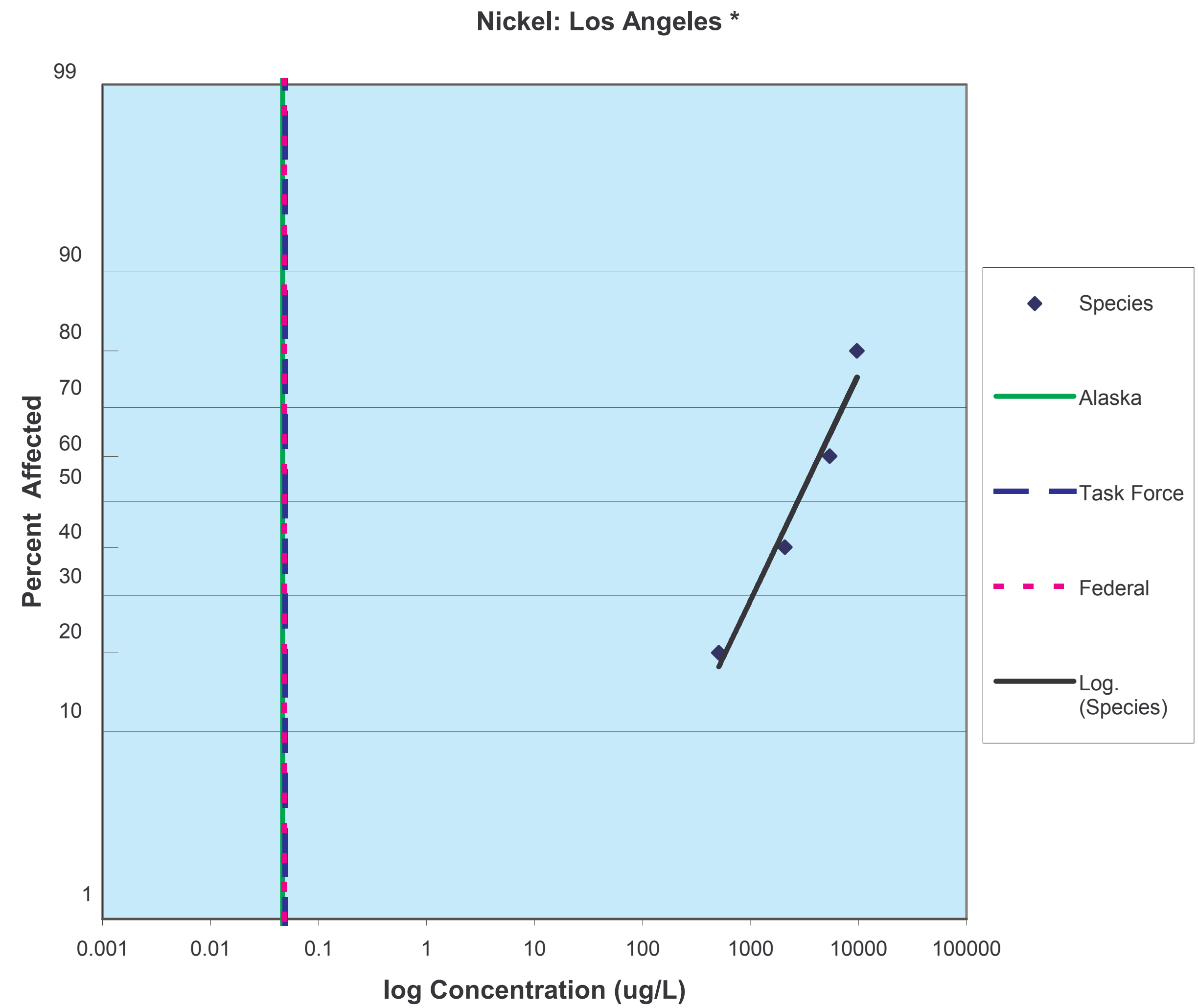


* The calculated concentrations for Alaska and Federal scenarios overlap for this port due to similar depths.

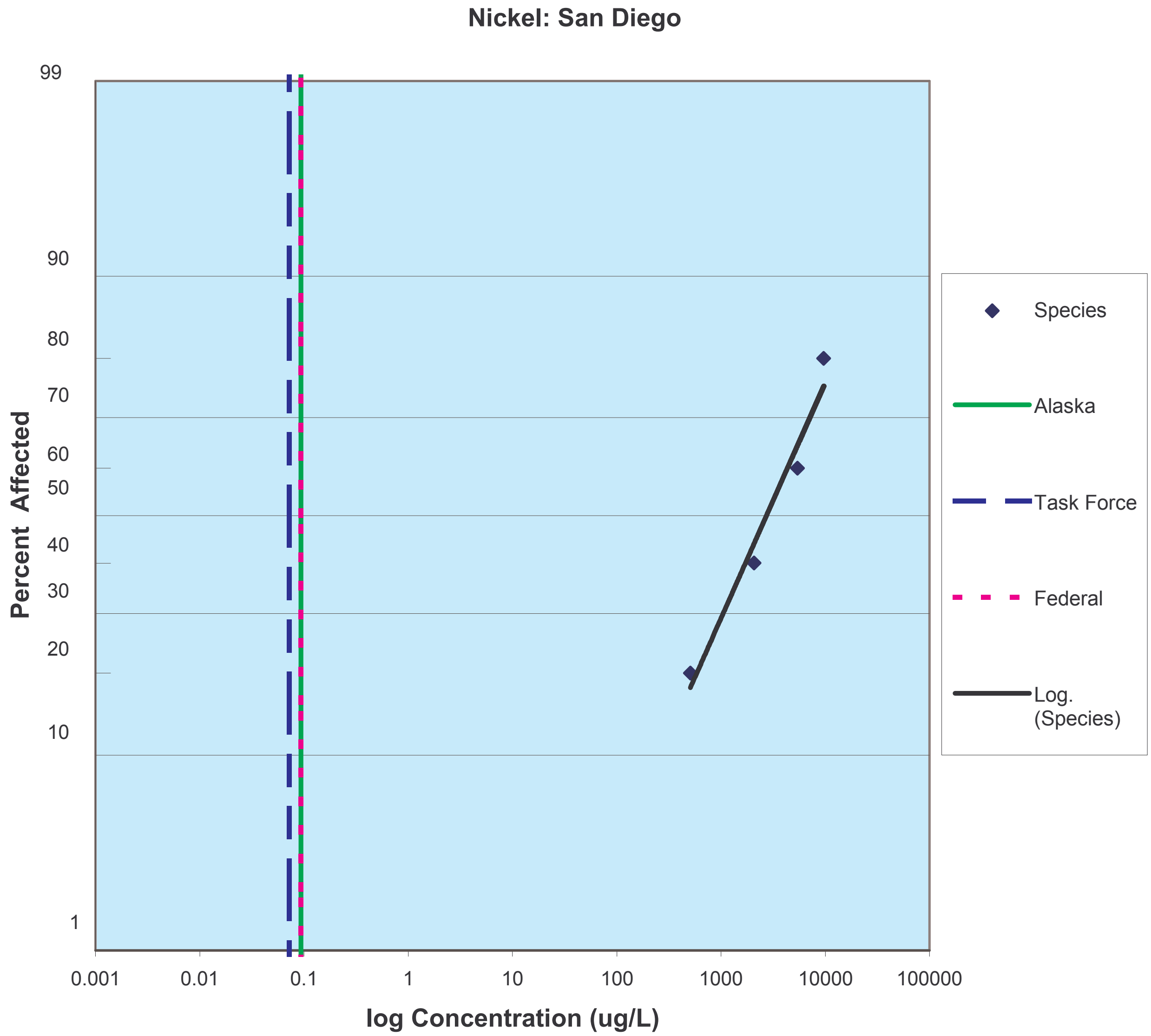


Species used as data points to create the species sensitivity distributions for lead:

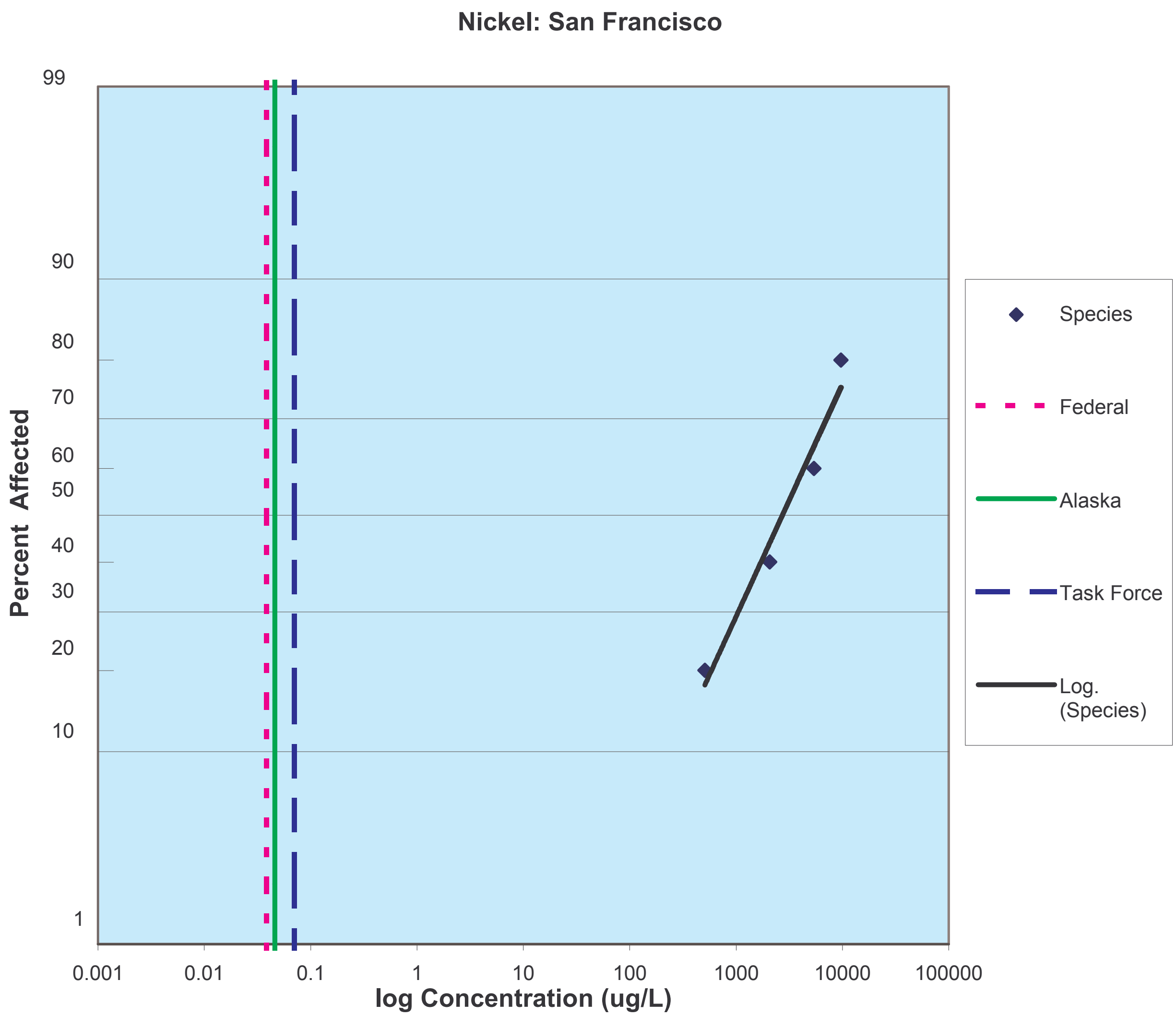
Species	LC50 Value	Source
Acartia clausi (Calanoid copepod)	668	(Cardin, 1980), (Lussier, 1985)
Americamysis bahia (Opossum shrimp)	3130	(Lussier, 1985)
Penaeus chinensis (Fleshy prawn)	174	(Liu, 1995)
Rhepoxynius abronius (Amphipod)	14100	(Chapman, 1992)



* The calculated concentrations for all scenarios overlap for this port due to similar depths.

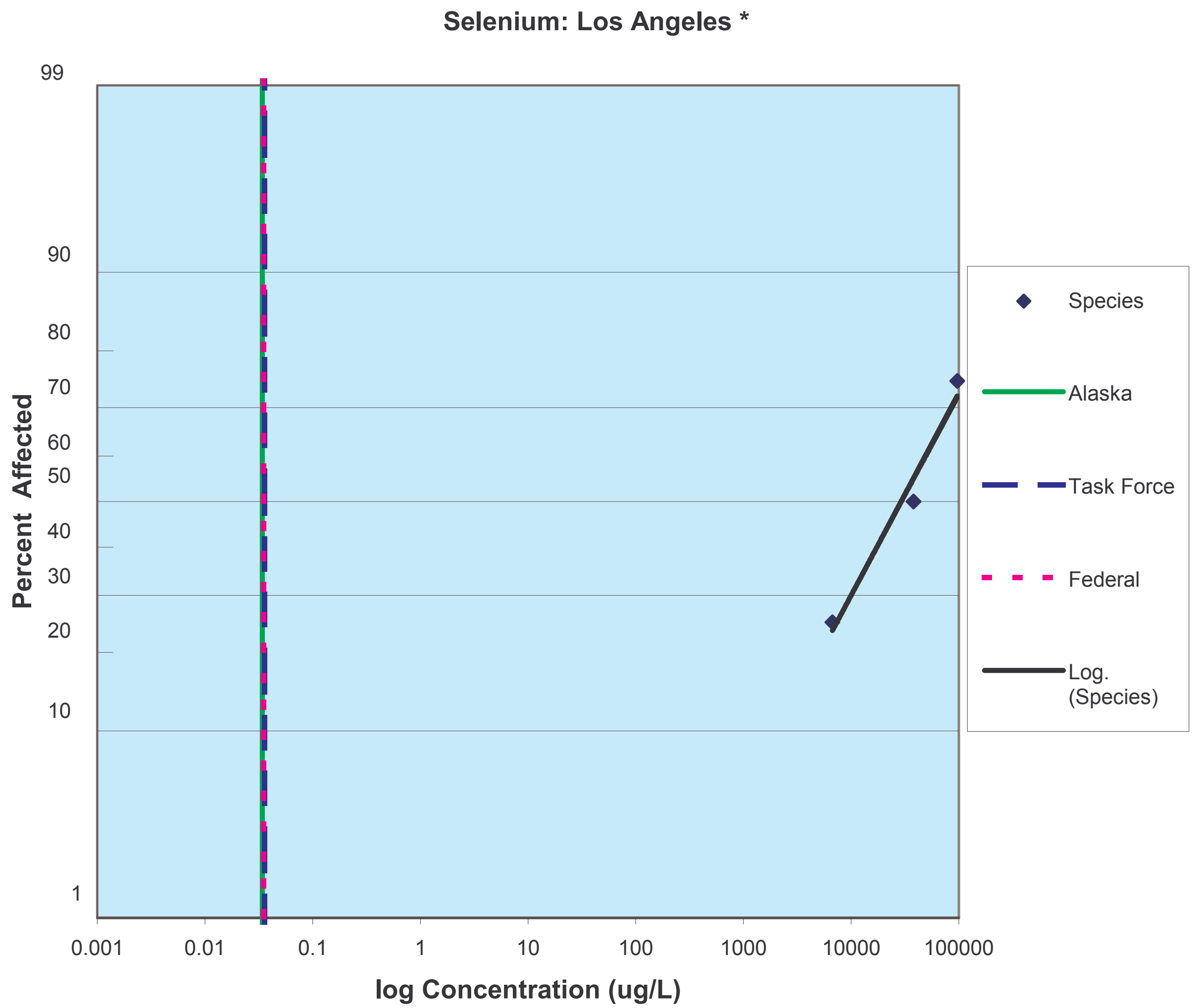


* The calculated concentrations for Alaska and Federal scenarios overlap for this port due to similar depths.

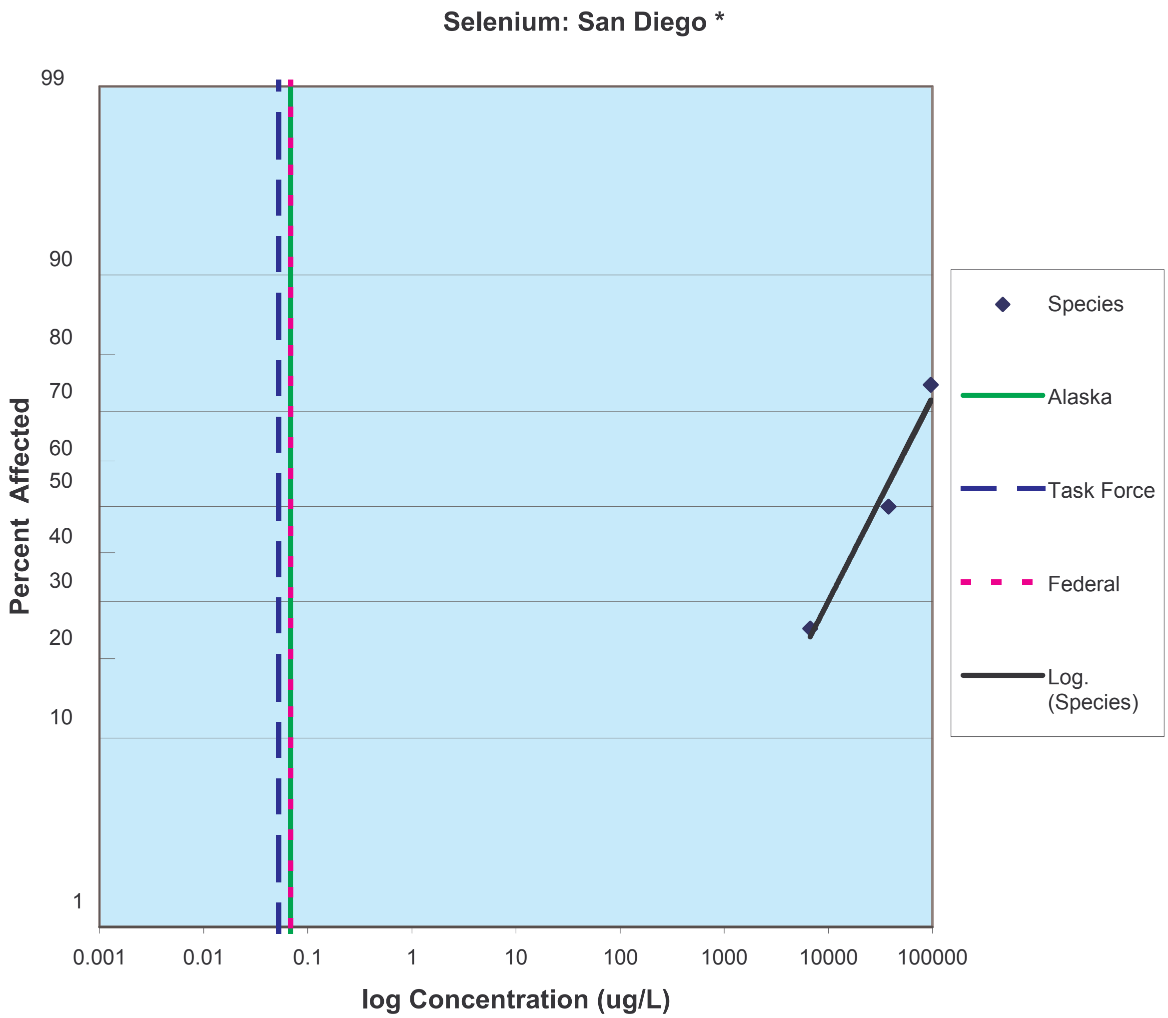


Species used as data points to create the species sensitivity distributions for nickel:

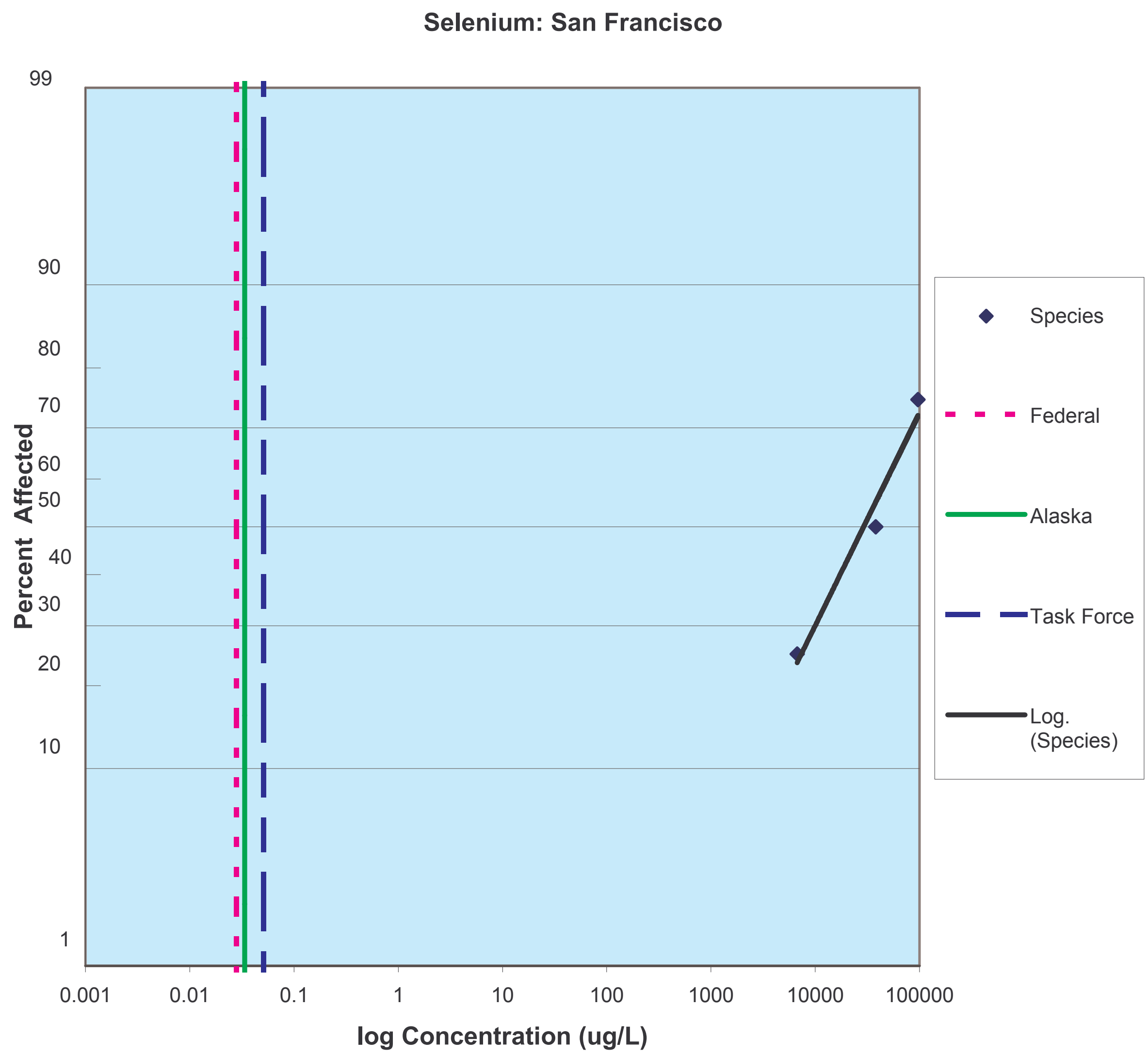
Species	LC50 Value	Source
Americamysis bahia (Opossum shrimp)	508	(Lussier, 1985)
Acartia clausi (Calanoid copepod)	2076	(Gentile, 1982)
Cyprinodon variegates (Sheepshead minnow)	5400	(Haley, 1993)
Eurytemora affinis (Calanoid copepod)	9670	(Gentile, 1982)



* The calculated concentrations for all scenarios overlap for this port due to similar depths.

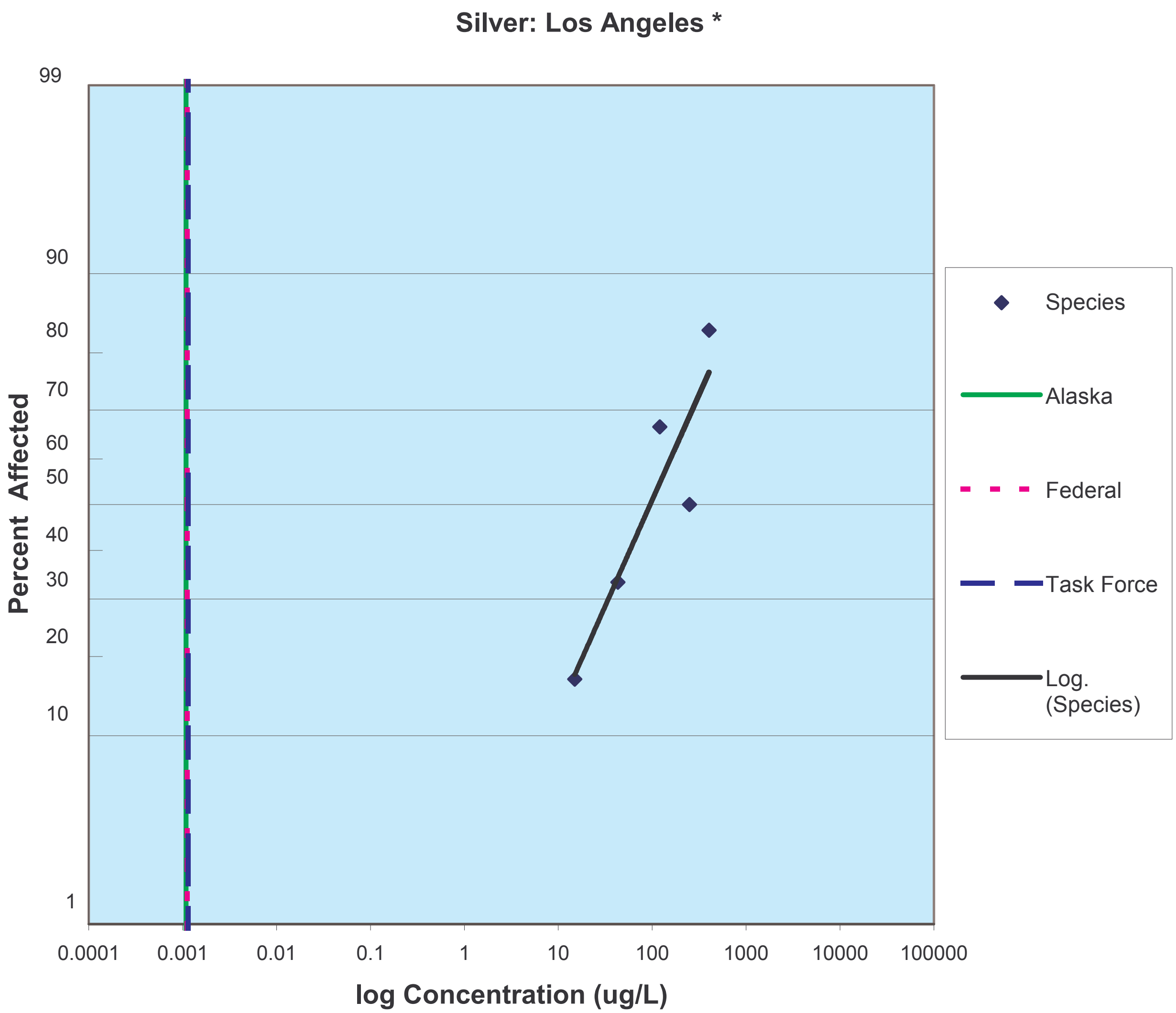


* The calculated concentrations for Alaska and Federal scenarios overlap for this port due to similar depths.



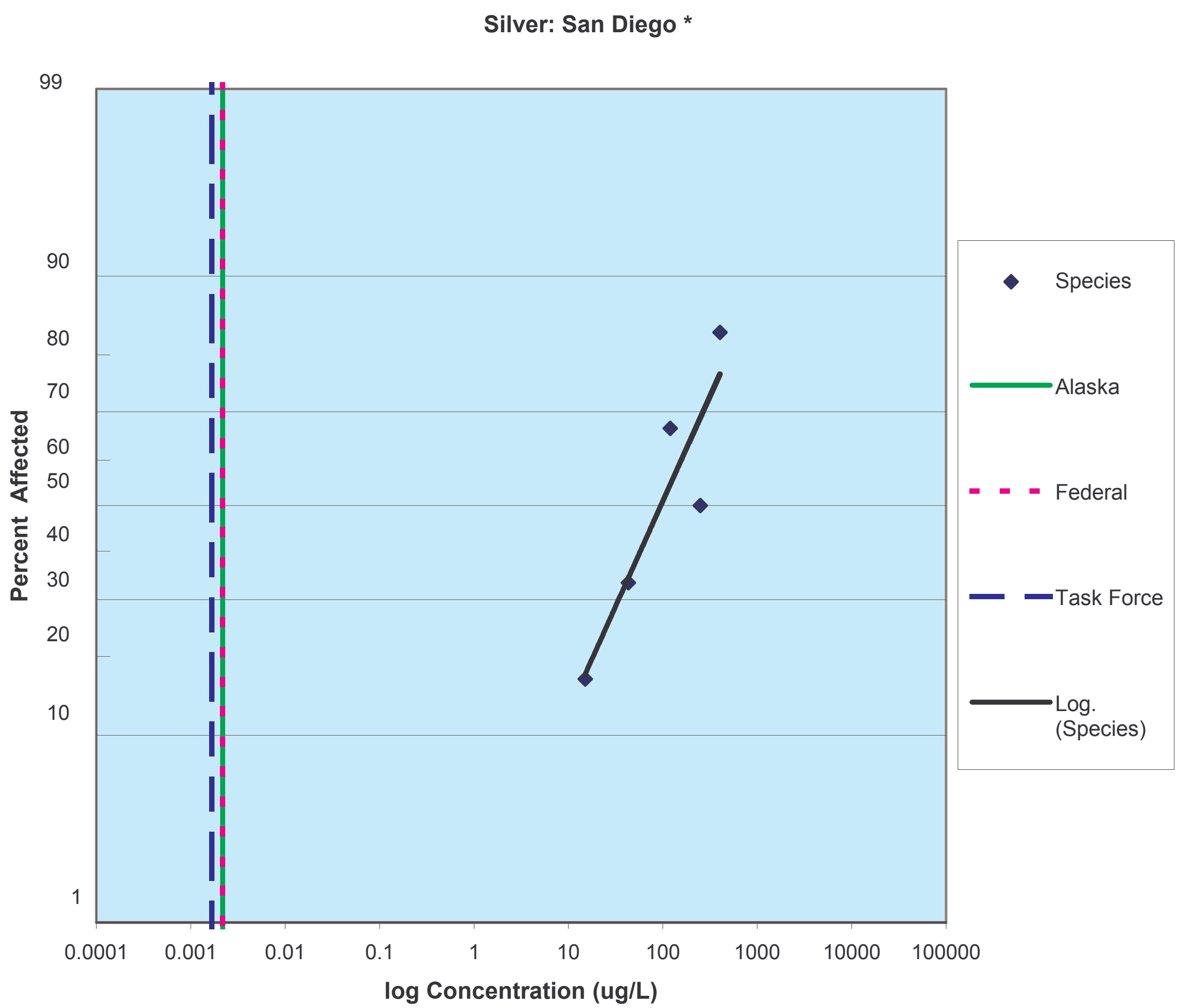
Species used as data points to create the species sensitivity distributions for selenium:

Species	LC50 Value	Source
Cyprinodon variegates (Sheepshead minnow)	6700	(Heitmuller, 1981)
Oncorhynchus kisutch (Coho salmon)	38000	(Hamilton, 1990)
Oncorhynchus tshawytscha (Chinook salmon)	96800	(Hamilton, 1990)

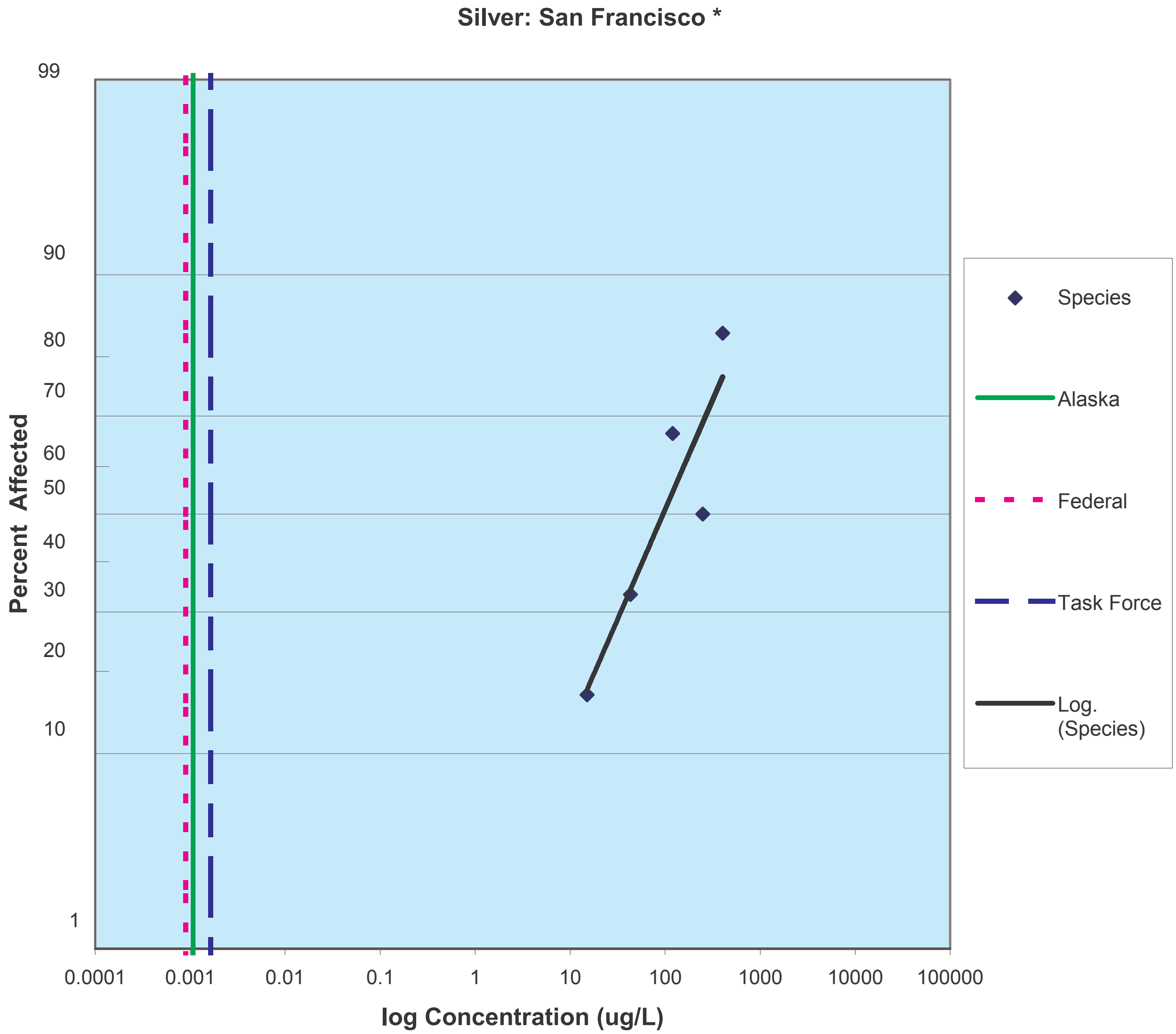


* The calculated concentrations for all scenarios overlap for this port due to similar depths.

Silver: San Diego *

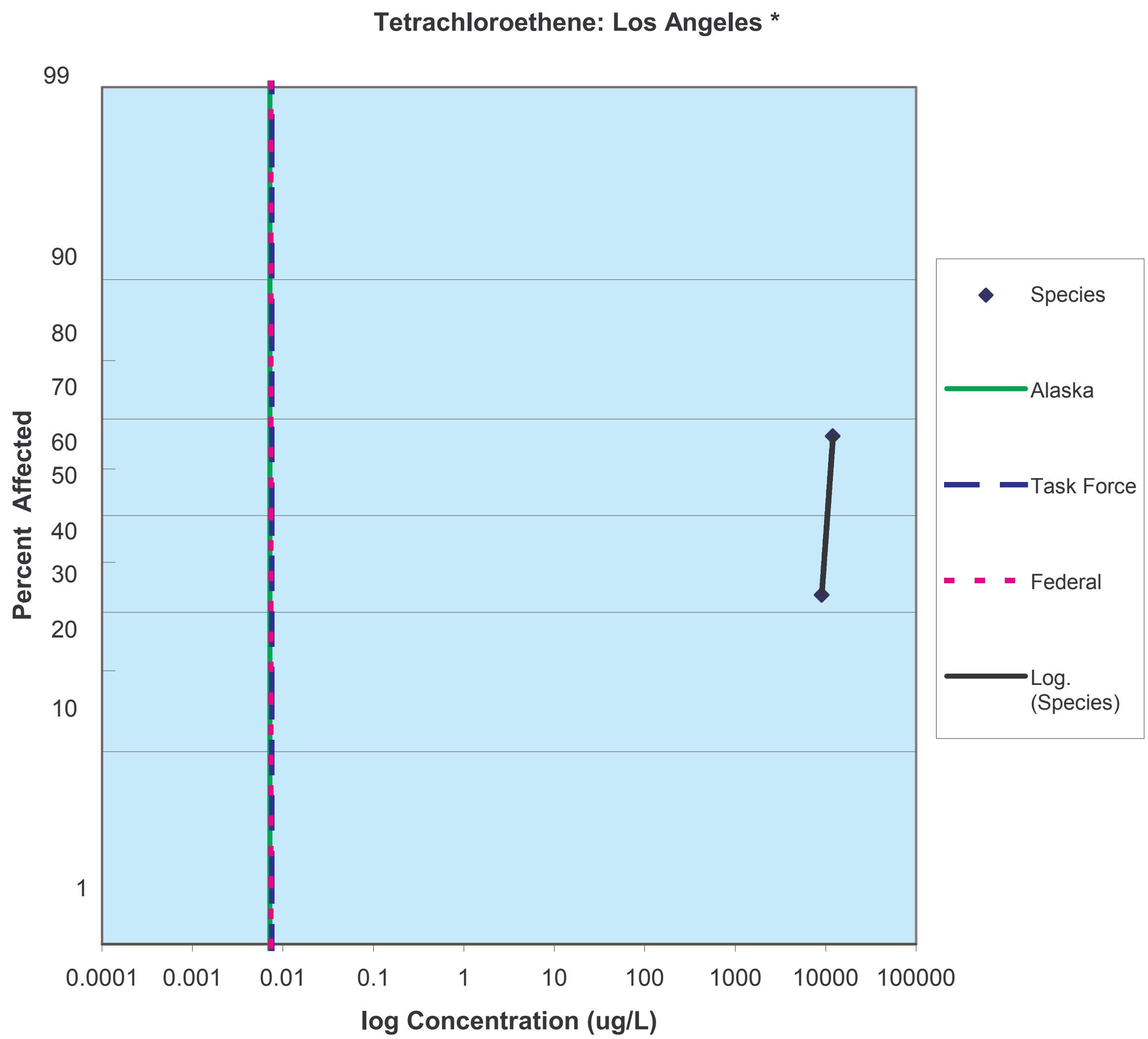


* The calculated concentrations for Alaska and Federal scenarios overlap for this port due to similar depths.

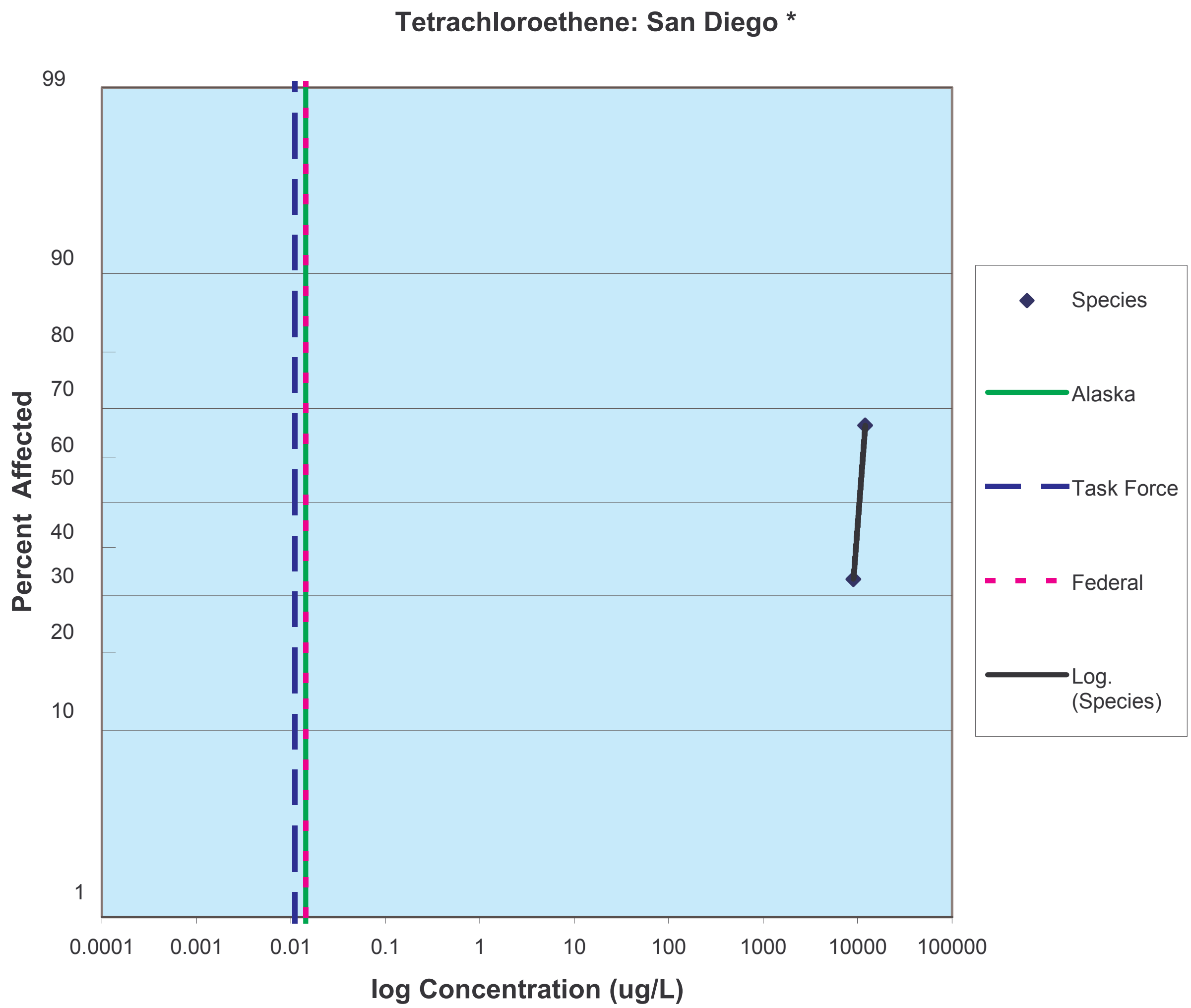

Silver: San Francisco *
Percent Affected
99
90
80
70
60
50
40
30
20
10
1
0.0001
0.001
0.01
0.1
1
10
100
1000
10000
100000
log Concentration (ug/L)
Species
Alaska
Federal
Task Force
Log. (Species)

Species used as data points to create the species sensitivity distributions for silver:

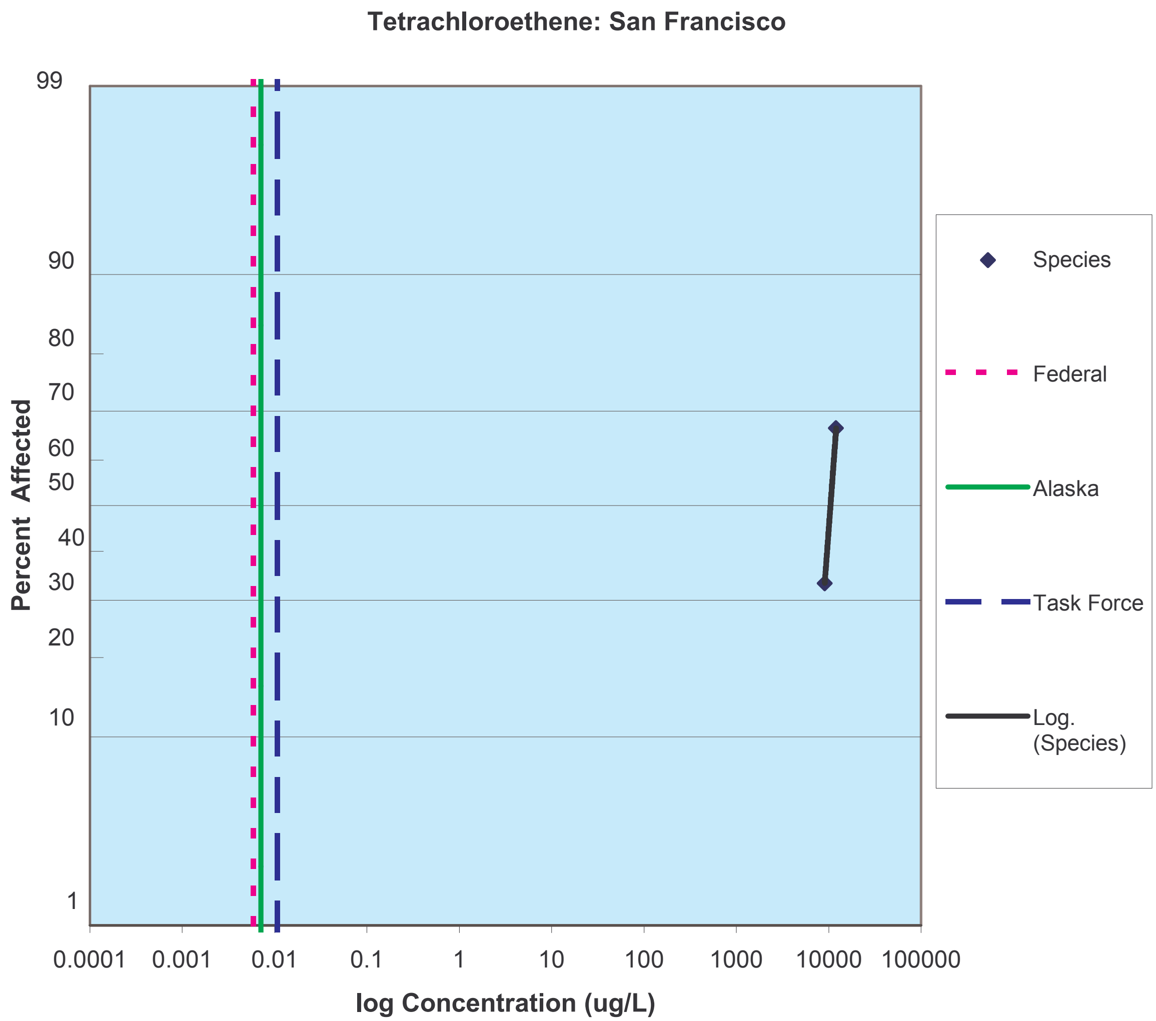
Species	LC50 Value	Source
Acartia clausi (Calanoid copepod)	15	(Cardin, 1980)
Acartia tonsa (Calanoid copepod)	43	(Cardin, 1980)
Americamysis bahia (Opossum shrimp)	249	(Lussier, 1985)
Brachionus plicatilis (Rotifer)	120	(Snell, 1981)
Cyprinodon variegates (Sheepshead minnow)		(Heitmuller, 1981)
Menidia menidia (Atlantic silverside)	110	(Office of Pesticide Programs, 2000)
Oligocottus maculosus (Tidepool sculpin)		(Ferguson, 1996)
Oncorhynchus mykiss (Rainbow trout)	401.5	(Ferguson, 1996)



* The calculated concentrations for all scenarios overlap for this port due to similar depths.

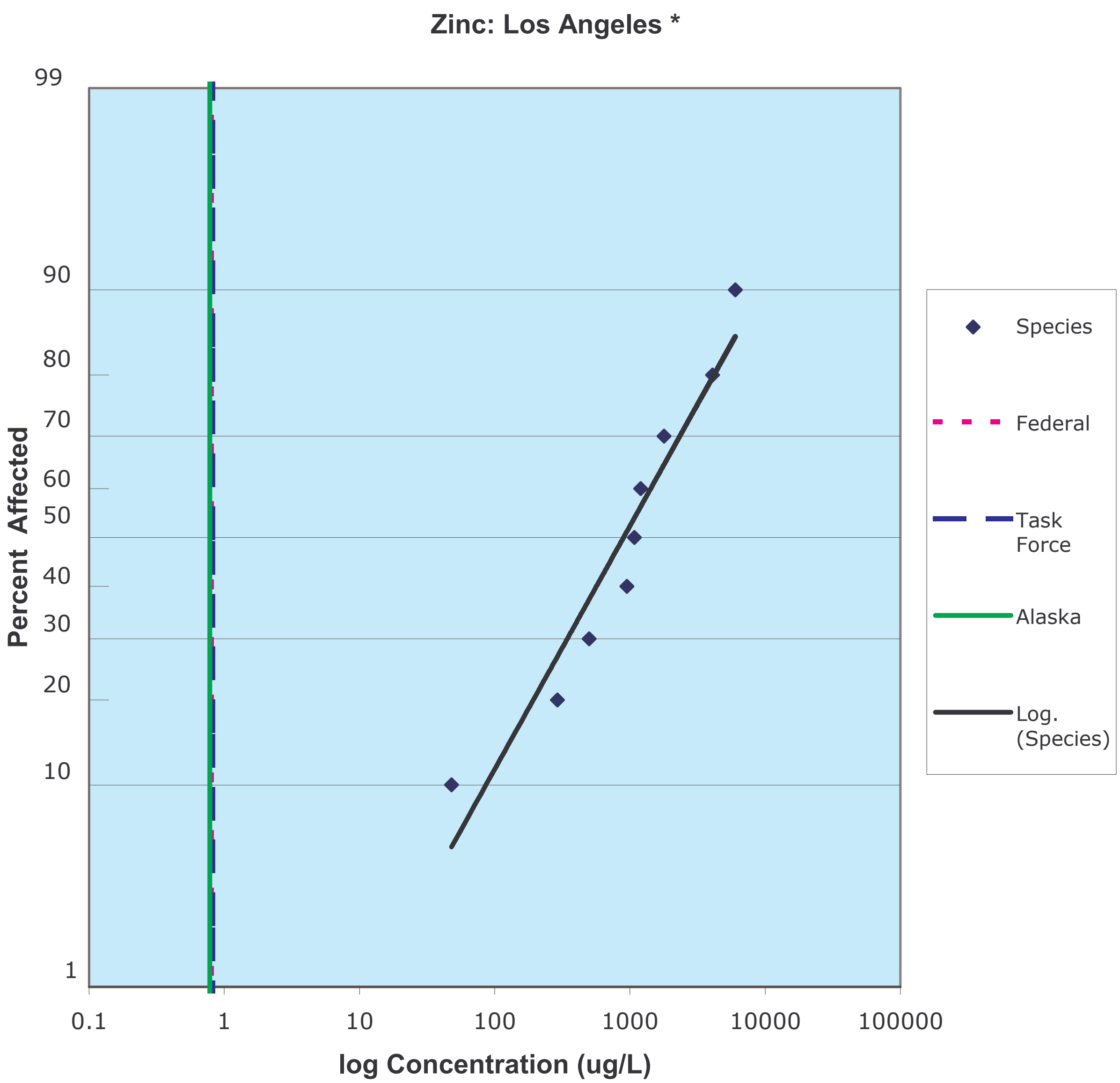


* The calculated concentrations for Alaska and Federal scenarios overlap for this port due to similar depths.

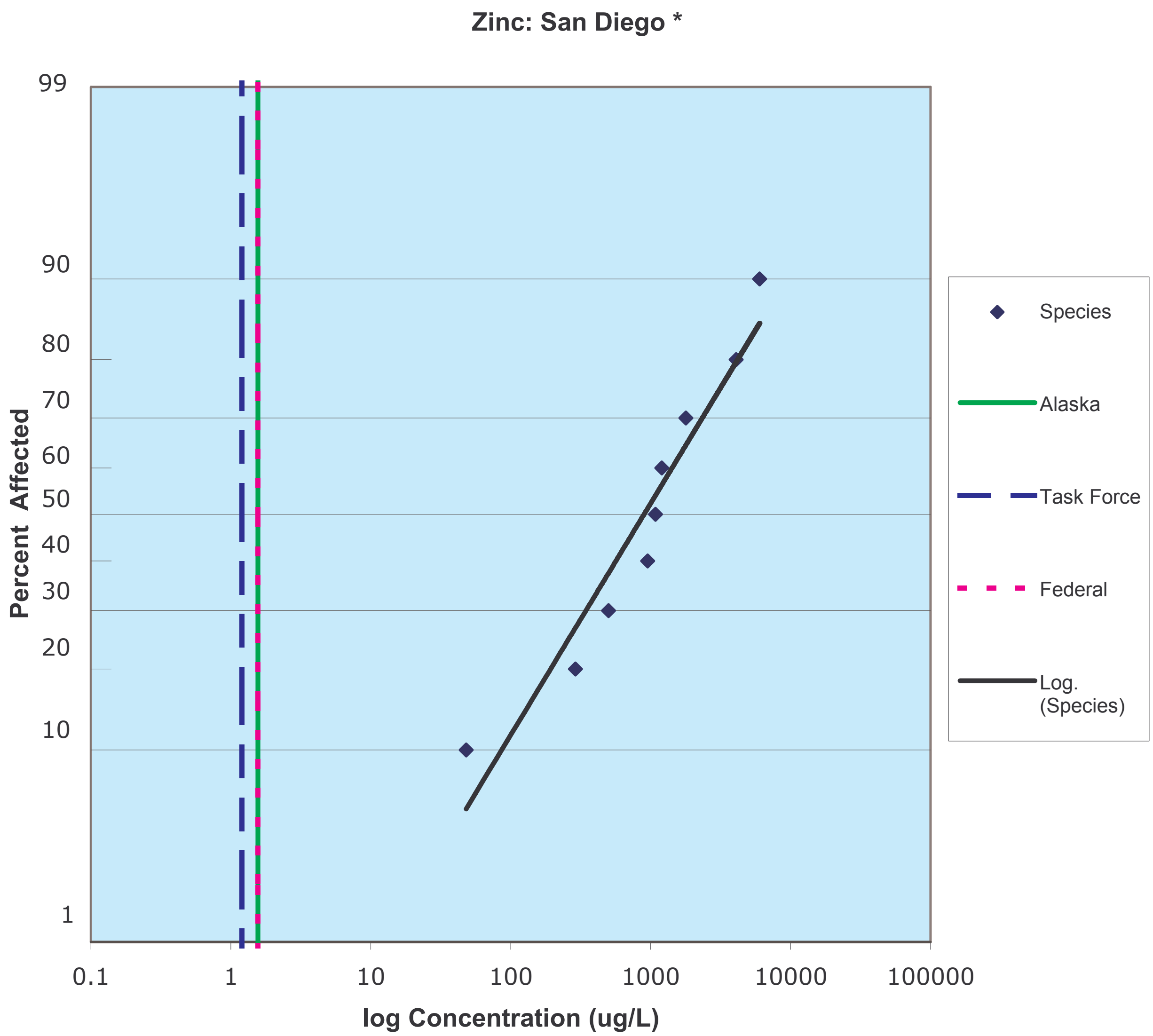


Species used as data points to create the species sensitivity distributions for Tetrachloroethene:

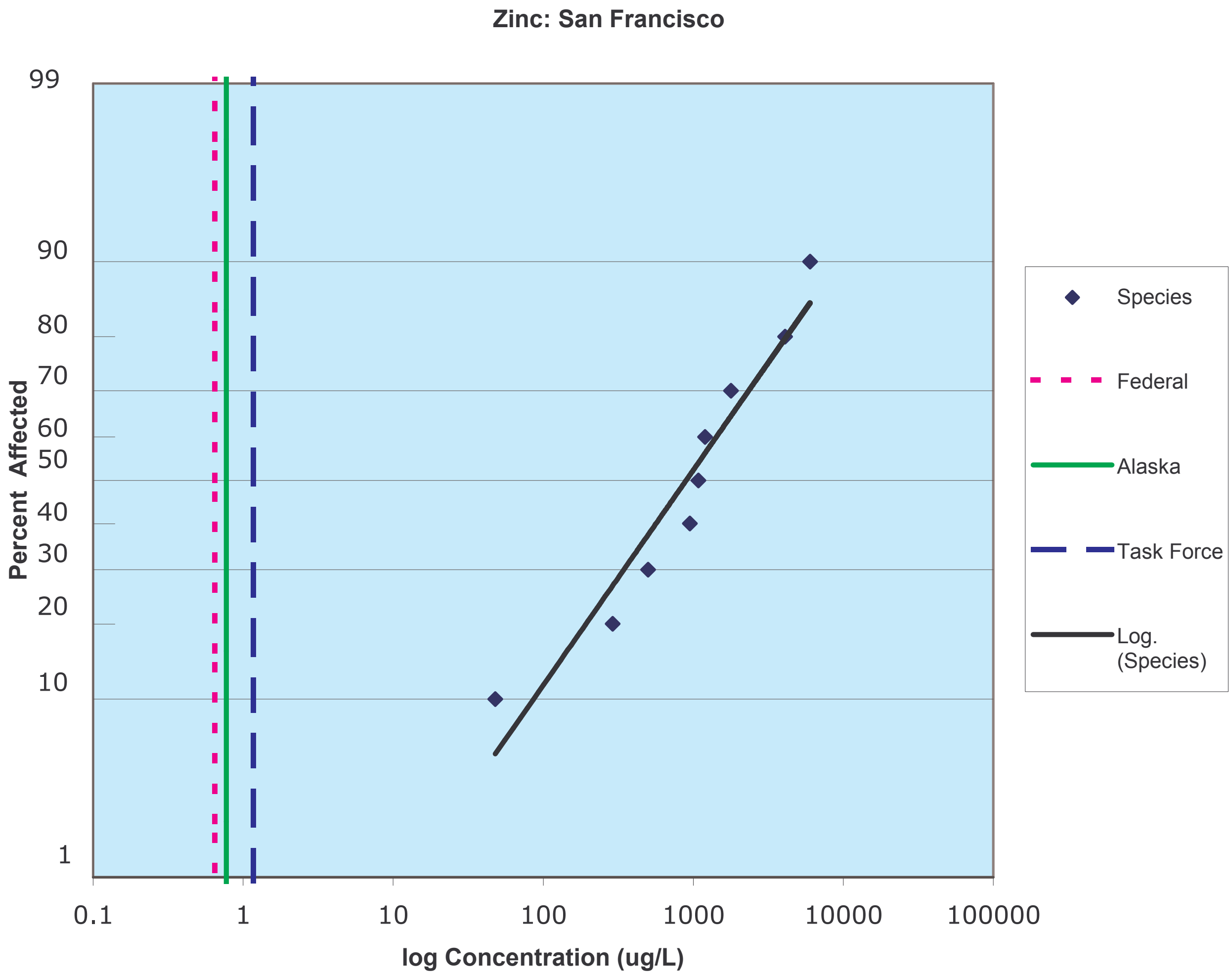
Species	LC50 Value (ug/L)	Source
Opossum shrimp (Americamysis bahia)	9020	(US Environmental Protection Agency, 1990)
Sheepshead minnow (Cyprinodon variegates)	12000	(Heitmuller, 1981)



* The calculated concentrations for all scenarios overlap for this port due to similar depths.



* The calculated concentrations for Alaska and Federal scenarios overlap for this port due to similar depths.



Species used as data points to create the species sensitivity distributions for zinc:

Species	LC50 Values	Source
Acartia clausi (Calanoid copepod)	950	(Gentile, 1982)
Acartia tonsa (Calanoid copepod)	290	(Gentile, 1982)
Americamysis bahia (Opossum shrimp)	499	(Lussier, 1985)
Eurytemora affinis (Calanoid copepod)	4090	(Gentile, 1982)
Nereis diversicolor (Polychaete worm)	6000	(Fernandez, 1990)
Penaeus chinensis (Fleshy prawn)	48	(Liu, 1995)
Pseudodiaptomus coronatus (Calanoid copepod)	1783	(Gentile, 1982)
Stichopus sp. (Sea cucumber)	1200	(Shcheglov, 1990)
Strongylocentrotus intermedius (Sea urchin)	1080	(Shcheglov, 1990)

Appendix M. Beach Visitor Survey Years for California State Beaches

Beach	Years Surveyed						
Bolsa Chica	1999	2000	2001	2002	2003		
Half Moon Bay	1998 & 2000						
Manresa	1994	1995	1999	2000	2001		
Montara	2000						
Pescadero	1998 & 2000						
Pomponio	1998						
S.Carlsbad	1997	1998	1999	2000	2001	2002	
San Elijo	1995	1996	1997	1998	1999	2000	2001
San Gregorio	1998						
San Onofre	1999	2000	2001	2002			
Silver Strand	1995	1996	1997	1998	1999		
Sunset	1994	1995	1999	2000			
Torrey Pines	1994	1997	1998	1999	2000	2001	

Source: California State Parks Visitors Department