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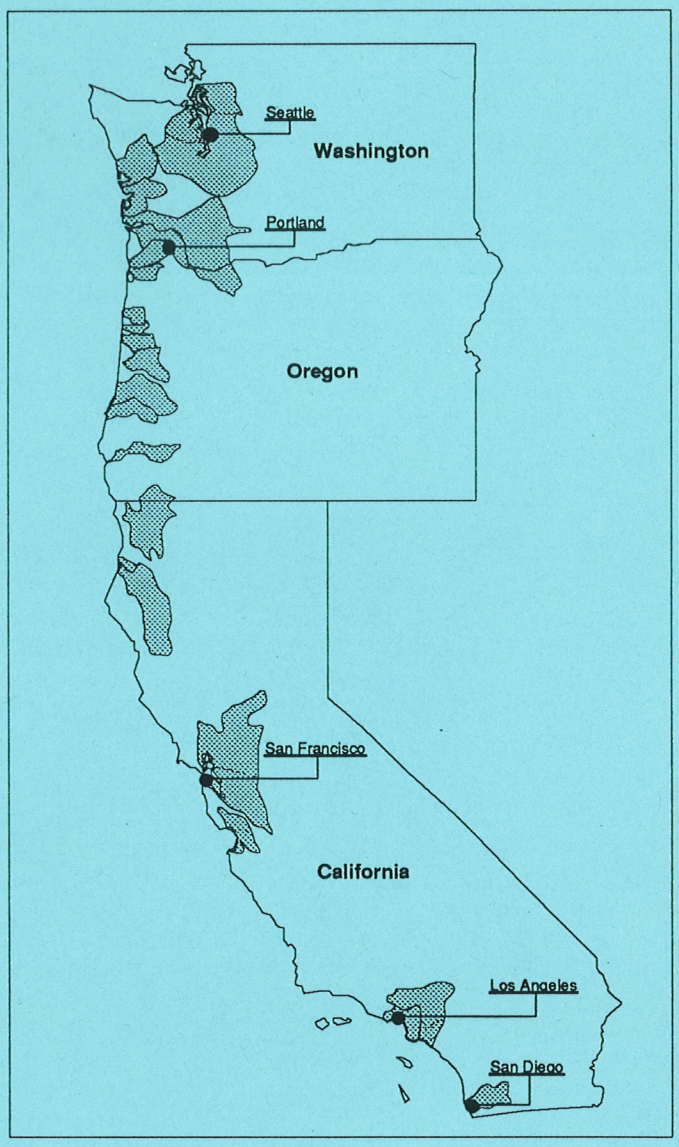
Strategic Assessment of Near Coastal Waters

Susceptibility and Status of West Coast Estuaries to Nutrient Discharges: San Diego Bay to Puget Sound

SUMMARY REPORT



NOAA/EPA
Team on Near Coastal Waters

October 1991

National Estuarine Inventory

The National Estuarine Inventory (NEI) is a series of related activities within the Strategic Environmental Assessments (SEA) Division, Office of Ocean Resources Conservation and Assessment (ORCA), National Oceanic and Atmospheric Administration (NOAA) designed to develop a national estuarine data base and assessment capability. The NEI was initiated in June 1983 as part of NOAA's strategic assessment of the Nation's coastal and oceanic resources.

The cornerstone of the NEI is the National Estuarine Inventory Data Atlas series. *Volume 1, Physical and Hydrologic Characteristics*, was completed in November 1985, and identifies 92 important estuarine and sub-estuarine systems within the contiguous U.S. Maps and tables are used to present specific estuarine characteristics, and to define estuarine drainage areas (EDAs), the commonly derived spatial unit for which all data are compiled. The estuaries listed in Volume 1 represent approximately 90 percent of the estuarine water surface area and freshwater inflow for the East Coast, West Coast, and Gulf of Mexico.

The NEI data base and assessment capabilities under development are part of an evolving process. Estuaries have recently been added to the inventory, most along the West Coast and Gulf of Mexico, and refinements are being made to the physical and hydrologic data. Estimates of other estuarine attributes, such as volume by salinity zone, flushing rates, and shoreline length and characteristics have been added to the data base.

Other volumes in the NEI data atlas series are: *Volume 2, Land Use Characteristics*; *Volume 3, Coastal Wetlands, New England Region*; and *Volume 4, Public Recreational Facilities in Coastal Areas*. Information from these atlases and other NOAA projects is being incorporated into a geographic information system and various desktop information systems for use by coastal resource managers. Other NOAA projects using strategic assessment data include the National Coastal Pollutant Discharge Inventory, the National Shellfish Register, and the Estuarine Living Marine Resources program.

National Coastal Pollutant Discharge Inventory Program

The National Coastal Pollutant Discharge Inventory (NCPDI) program is a series of data base development and analytical activities designed to assess the sources, magnitude, and impact of pollutant discharges within the Nation's coastal and estuarine areas. The cornerstone of the NCPDI is a comprehensive data base and computational framework containing pollutant estimates for all major categories of point, nonpoint, and riverine sources located in coastal counties or the 200-mile Exclusive Economic Zone (EEZ) that discharge to the estuarine, coastal, and oceanic waters of the contiguous U.S. (excluding the Great Lakes).

NCPDI pollutant-discharge estimates are made for the base year 1982, but approximate pollutant discharge conditions for 1980 to 1985. Estimates are made for 15 pollutants in eight major categories: 1) wastewater; 2) oxygen-demanding materials; 3) particulate material; 4) nutrients; 5) heavy metals; 6) petroleum hydrocarbons; 7) chlorinated hydrocarbons; and 8) pathogens. Pollutant estimates can be aggregated by county, hydrologic cataloging unit, or estuarine drainage area.

A series of projects is currently underway within the NCPDI Program to improve and refine the estimates for selected pollutant source categories and coastal areas. These improvements include: expanding study areas to include more inland estuarine drainage basins, updating the base year to 1987 (which has already been done for several Gulf of Mexico states), using improved methods to estimate discharge, and adding a number of toxic pollutants to the inventory. In addition, projects are planned to assess the impact of management practices on nonpoint discharges and to develop computer applications to allow easier access to data base information.

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PLEASE NOTE

The 22 estuaries in this report were identified in NOAA's National Estuarine Inventory Data Atlas, Volume 1: Physical and Hydrologic Characteristics, and Supplement 1 of the National Estuarine Inventory. Refinements have been made to estuary boundaries as well as to the physical and hydrologic data. The NEI has recently been expanded to included six additional estuaries in California. These systems, however, are not included in this report.

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Introduction

This report summarizes estimates of the relative susceptibility of twenty-two West Coast estuaries to nutrient-related pollution. It is the fourth and final report in a series intended to increase understanding of coastal environmental problems and to serve as a screening tool for coastal resource decisionmaking.

The initial NOAA/EPA report on estuarine susceptibility (1988) included information on eutrophication, dissolved concentration potentials, nutrient sources, discharge estimation methods, and nutrient loads. Three regional reports on nutrient susceptibility followed: two for estuaries on the East Coast (Passamaquoddy Bay to Chesapeake Bay and Albemarle/Pamlico Sounds to Biscayne Bay); and one for the Gulf of Mexico. This report assesses West Coast estuaries from San Diego Bay to Puget Sound. Each susceptibility report is based on data from NOAA's National Estuarine Inventory (NEI) and National Coastal Pollutant Discharge Inventory (NCPDI).

In this report, a one-page summary is included for each West Coast estuary. These summaries contain information on physical and hydrologic features, nutrient loading estimates, pollution susceptibility, nutrient concentration predictions, and interpretive text explaining the data.

Background

Eutrophication. Eutrophication is an over-abundance of nutrients, resulting from natural and/or man-made sources, that may induce massive algal blooms and (due to subsequent decay) may result in the emission of noxious odors, depletion of dissolved oxygen, and mass finfish and shellfish mortality. Important factors influencing eutrophication include the amount of nutrient loading and the physical and hydrologic characteristics affecting nutrient distribution and concentration.

Assessing Eutrophication Potential. Estimates of nutrient discharge and calculations of pollution susceptibility and nutrient concentration help indicate estuarine eutrophication potential. This report presents estimates of annual nitrogen and phosphorus loads entering West Coast estuaries, along with flushing and dilution characteristics based on flushing time and estuarine volume. From these estimates, average nutrient concentrations are predicted for each estuary. The data provide an indication of estuaries likely to experience high nutrient levels, therefore having greater eutrophication potential. The degree to which eutrophic conditions occur, however, is influenced by additional factors affecting nutrient concentration, not specifically quantified in this report. These factors include nutrient recycling, loading changes over time (e.g. reduced agricultural runoff), and hydrologic characteristics such as freshwater inflow fluctuation and periodic stratification.

The assessments in this report are based on estimated estuarine characteristics and nutrient loadings. They do not reflect actual nutrient concentration measurements or documented estuarine eutrophication symptoms. Standardized and quantitative long-term records of total nutrient discharges and concentrations do not exist for most estuaries. Assessments of relative susceptibility and estimated or predicted nutrient concentrations (volumetric loading) can provide resource managers with initial insight into existing and potential eutrophication problems on a regional and national scale. The characterization of actual estuarine eutrophication problems or symptoms is the next step in understanding the effects of nutrient-related pollution.

Organizing the Data by Estuary. Nutrient discharges are estimated based on estuarine drainage areas (EDAs). EDAs generally coincide with U.S. Geological Survey (USGS) hydrologic cataloging units. They extend from the head of tide to the seaward estuarine boundary. These are illustrated in NOAA's *National Estuarine Inventory Data Atlas Volume 1: Physical and Hydrologic Characteristics* (1985) and *NEI Supplement 1*. EDAs may fall completely within or extend beyond coastal counties. Estimates of nutrient loadings from point and nonpoint sources are made for the coastal county portion of the EDA and, for some estuaries, the coastal county portion of the fluvial drainage area (FDA). The FDA is the land and water portion of the entire watershed upstream of the EDA. Upstream sources account for discharges from portions of the EDA and FDA outside coastal counties. In this report, the percentage of EDA land within coastal counties is given for each estuary.

Nutrient Sources and Loadings

Nitrogen and phosphorus loads originate from natural and man-made sources. Specific sources of both nutrients include sediments, chemical fertilizers, feces, meat and milk processing wastes, and feedlots. Primary sources of nitrogen include urea and feces. Major phosphorus sources include synthetic laundry detergents and wastewater treatment plants. In this report,

nutrient sources are divided into three categories: point, nonpoint, and upstream.

Basis for Estimates. Nitrogen loading estimates represent total nitrogen (ammonia, nitrate, nitrite, and organic material). Estimates of total phosphorus include organic and inorganic forms. Data for nutrient loads are taken from the NCPDI data base, and are a combination of monitored and estimated data, with a base year of 1982. Exceptions include wastewater treatment plant (WWTP) and industrial facility discharge estimates, which have a base year of 1985 (Arnold et al., 1988). NCPDI methods used to estimate nutrient discharges are briefly summarized in *Susceptibility and Status of Northeast Estuaries to Nutrient Discharges* (NOAA/EPA, 1988) and are explained in detail in the NCPDI Methods Documents (NOAA, 1987a-e).

Streamflow and nutrient concentration data used to calculate NCPDI upstream source discharge were obtained from the USGS Water Resource Data Reports, the USGS National Stream Quality Accounting Network (NASQAN), and other USGS and State surface water monitoring programs (NOAA, 1987c). Where streamflow and/or concentration data were unavailable, nutrient discharge was estimated using data from nearby streams with similar flows and land use characteristics, or prorated using drainage area information (NOAA, 1987c).

Point Sources. Point sources are those wastewater treatment plants and industrial facilities that are land-based and discharge directly to surface waters within a coastal county portion of the EDA through a pipe, or similar conveyance, on a regular basis. On the West Coast, there are 988 industrial facilities, 35 power plant facilities, and 337 wastewater treatment plants (total 1,360). Of these facilities, 1,151 are considered to be minor and 209 major.

A major wastewater treatment plant discharges over one million gallons of treated water per day. The NCPDI estimates that over one trillion gallons of treated wastewater per year are discharged from publicly owned treatment plants and wastewater facilities (POTWs) to surface waters along the West Coast.

A major industrial facility discharges more than 0.5 million gallons per day to surface waters. Industrial facilities are estimated to discharge 261 billion gallons of process water per day to surface waters in coastal counties of the region.

Nonpoint Sources. Nonpoint discharge is the transport of dissolved and particulate materials to surface waters within the coastal county portion of the EDA via surface runoff from precipitation. There are four categories of nonpoint discharge: agriculture, forest, urban, and other (nonurban). Urban discharges represent nutrient input from urban areas with populations over 2,500. Discharges from sewer overflows are included in urban nutrient load estimates. Throughout the coastal counties of the West Coast region there are 677 urban areas. Other (nonurban) sources include rangeland and brushland. The extent of data coverage for nonpoint discharges within EDA coastal counties is given in the one-page summary for each estuary. Incomplete data coverage for nonpoint discharges is due to land areas from which no runoff data is available (principally barren lands and wetlands). Land use distribution shown in pie charts reflects only the coastal county portion of the EDA; wetlands and barren lands are not included in land use diagrams.

Upstream Sources. Upstream sources include all riverine sources with an average annual flow in excess of 500 cubic feet per second (cfs). However, some special exceptions have been made to include streams in Southern California. The upstream category accounts for estuarine pollutant loads originating from those EDA and FDA portions outside of coastal counties. Thirty-eight West Coast rivers and streams were included as upstream sources.

Limitations of Estimates. Susceptibility and nutrient loading estimates do not account for all possible input sources. Estimates are unavailable for nutrient input due to ocean influx, groundwater inflow, bottom sediments, wetlands, barren lands, and direct atmospheric deposition. In some cases, nutrient contributions from these sources may be substantial (Jaworski, 1981; Moshiri et al., 1981; Jones and Lee, 1981). Also, NCPDI estimates for point and nonpoint sources represent *end of pipe* and *edge of field* loadings. They do not account for transport phenomena, and thus portray a high estimate of the pollutant loads reaching estuaries from these sources. Nevertheless, NCPDI estimates do reflect the addition of nutrients from several important anthropogenic sources, and are useful in evaluating relative contributions from different sources.

Susceptibility to Pollution

Susceptibility. An estuary's susceptibility to pollution is defined as its relative ability to concentrate dissolved and particulate pollutants. Estuarine pollutants are either dissolved in the water or attached to waterborne or benthic particles. Susceptibility is based on an estuary's physical and hydrologic characteristics. That is, estu-

aries with a poor ability to dilute or flush are likely to trap sediments and associated toxic substances.

Susceptibility is quantified by two parameters: dissolved concentration potential (DCP) and particle retention efficiency (PRE). DCP estimates an estuary's relative ability to concentrate dissolved substances (e.g. total phosphorus and nitrogen). PRE estimates the relative ability to retain suspended particles and attached pollutants (chiefly toxic materials). This report focuses on estuarine DCP. Although PRE values are reported, discussion is abbreviated.

A susceptibility classification scheme relating DCP and PRE was developed to provide a relative estuarine ranking based on pollution susceptibility (including both dissolved and particulate pollutants). This classification scheme has been applied to estimates for the 102 U.S. estuaries identified in NOAA's NEI. Figure 1 illustrates the relative position of these estuaries in the classification scheme, and highlights susceptibility estimates for West Coast estuaries.

Dissolved Concentration Potential (DCP). Assuming average estuarine loading and well-mixed, steady-state conditions, DCP characterizes effects of flushing and dilution on the given load of dissolved pollutant. To allow for DCP comparison between estuaries, an equal pollutant load (10,000 tons/yr) is assumed for all estuaries. DCP is a relative measure of overall potential and does not reflect site-specific conditions. A high DCP suggests an estuary is likely to retain or concentrate a load of dissolved pollutant. A low DCP suggests an estuary has significant dilution ability (due to large estuarine volume) and/or flushing ability (due to rapid volume replacement).

DCP is based on the freshwater fraction method for predicting pollutant concentration (Ketchum, 1955). (Additional information on DCP is provided in Appendix E of NOAA/EPA, 1988; and Klein et al., 1988). The distribution of a dissolved conservative pollutant (in this case designated as the distribution of nutrients prior to biological uptake, recycling, and regeneration) is assumed to be affected by the physical forces of tide, freshwater inflow, and wind in the same manner that they affect estuarine freshwater distribution. Assuming a uniform pollutant loading rate, DCP is a function of flushing time and dilution:

$$DCP = L\,(V_{fw} / i_{fw})\,(1 / V_{tot})$$

where:
L=loading rate
V_{fw} =estuarine freshwater volume
i_{fw} = freshwater inflow
V_{tot} =total estuarine volume

Average annual conditions are used for freshwater inflow and estuarine volumes. The volume of freshwater in the estuary is determined by estimating and summing the freshwater fraction of the tidal fresh, mixing, and seawater portions of the estuary.

High, medium, and low DCP classes are based on order-of-magnitude differences in DCP values. The low DCP value range is 0.01 to 0.1 mg/l, the medium range is 0.1 to 1.0 mg/l, and the high range is 1.0 to 10.0 mg/l. This scheme is used for comparison, and is necessary because of discharge variability over time and accuracy limitations on current load-estimation techniques. (For discussion of accuracy of discharge estimates see NOAA/EPA, 1988.)

DCP does not characterize all estuaries equally well. For example, the method assumes a vertically homogenous, well-mixed system. DCP reliability increases with the degree of mixing in the estuary. DCP values are less useful in estuaries where salinity stratification persists for significant periods. Also, DCP assumes a recognizable freshwater-inflow component (as expressed in the resultant salinity regime) to infer pollutant distribution. For systems like San Diego Bay and Santa Monica Bay, which approach the salinity concentration of seawater, DCP is less reliable in predicting nutrient pollution susceptibility.

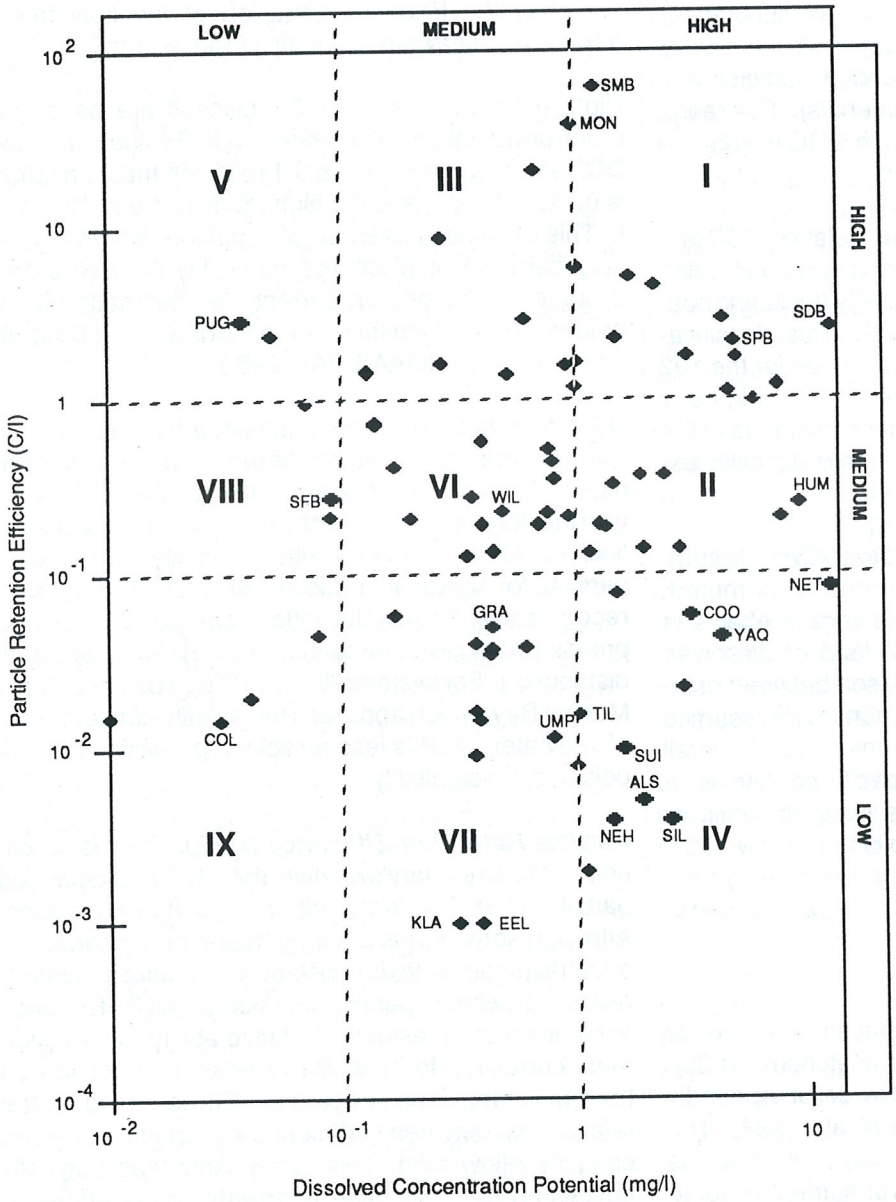
Particle Retention Efficiency (PRE). PRE is an estimation of an estuary's relative ability to trap suspended particles and pollutants adhering to those particles. Although some forms of nitrogen and phosphorus can attach to particles, toxic substances are more commonly associated with suspended sediments. The PRE method assumes that an estuary's relative ability to trap sediment correlates to its ability to retain any associated toxic pollutant. The concept of PRE is based on the relationship between sediment trapping efficiency and capacity/inflow ratio. This relationship was originally developed for man-made freshwater impoundments, and was found to be loosely applicable to some U.S. estuaries (Biggs and Howell, 1984). PRE is expressed by:

$$PRE = C/I$$

where:
C =estuarine volume (capacity)
I =annual freshwater inflow

The issue of estuarine toxic pollutants is beyond the scope of this report. Therefore, further discussion of sediment trapping efficiency is omitted here. PRE val-

Figure 1. Relative Susceptibility Classification for West Coast Estuaries



Estuary	Abbreviation
San Diego Bay	SDB
San Pedro Bay	SPB
Santa Monica Bay	SMB
Monterey Bay	MON
San Francisco Bay	SFB
Eel River	EEL
Humboldt Bay	HUM
Klamath River	KLA
Rogue River	ROG
Coos Bay	COO
Umpqua River	UMP
Siuslaw River	SIU
Alsea River	ALS
Yaquina Bay	YAQ
Siletz Bay	SIL
Netarts Bay	NET
Tillamook Bay	TIL
Nehalem River	NEH
Columbia River	COL
Willapa Bay	WIL
Grays Harbor	GRA
Puget Sound	PUG

C = volume of the estuary at mean sea level; I = total volume of freshwater inflow over an annual cycle; based upon a loading of 10,000 tons/year.

ues are provided for each estuary to characterize overall susceptibility to both dissolved and particulate pollutant inputs as expressed in Figure 1.

Nutrient Status: Concentration, Classification, and N:P Ratio

Nutrient Concentration and Classification. Nutrient pollution levels are predicted from estimated nitrogen and phosphorus concentrations, a classification of those concentrations, and an indication of how a change in nutrient load may affect an estuary's predicted nutrient concentration classification. All nutrient concentration predictions are based on annual load estimates. Predicted nutrient concentrations do not account for nutrient uptake by plants or for nutrient recycling, which may be substantial. Some studies suggest recycling may account for a greater percentage of ambient nutrient concentrations than new loads entering a system each year (Boynton, et al., 1982; Kemp, et al., 1982). Still, nutrient recycling rates, as well as peak and annual values of primary productivity, appear to be a function of long-term estuarine loading (Boynton et al., 1982; Kemp et al., 1982).

A relative indication of each estuary's ability to flush or concentrate pollutants was obtained by using a constant 10,000 ton/yr nutrient load for each estuary. To calculate predicted nutrient concentrations, however, each estuary's NCPDI-estimated nutrient load is utilized in the DCP formula. The estimated nitrogen and phosphorus concentrations for all estuaries identified in the NEI are plotted on Figures 2 and 3, respectively. Nutrient concentrations for all U.S. estuaries are shown, West Coast estuaries are highlighted, and both DCP and nutrient loads are shown on a log-log scale. Nutrient concentration zones are bounded by diagonal lines. The diagrams illustrate that certain systems can exhibit medium to high nutrient concentrations even with low loadings if the DCP is very high. Also, medium-to-high concentrations may occur in estuaries with low DCPs if the loading is very high.

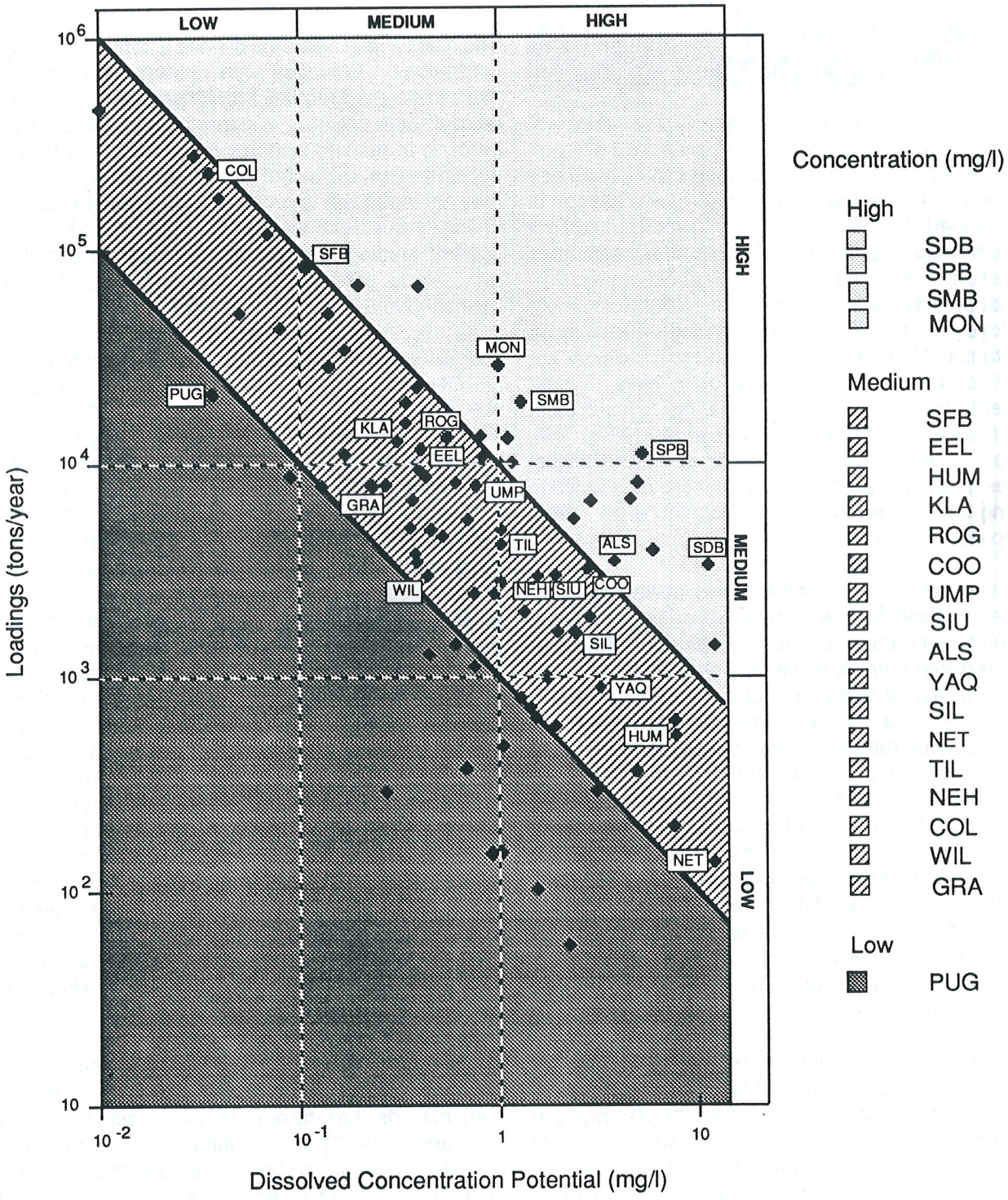
The levels used to designate high, medium, and low concentration classes differ for nitrogen and phosphorus. For nitrogen, concentrations less than 0.1 mg/l are low, between 0.1 to 1.0 mg/l are medium, and greater than 1.0 mg/l are high. For phosphorus, concentrations less than 0.01 mg/l are low, between 0.01 and 0.1 mg/l are medium, and greater than 0.1 mg/l are high. This classification scheme is based on observed estuarine characteristics at different nutrient levels as reported for the Chesapeake Environmental Quality Classification Scheme (U.S. EPA, 1983). One estuarine characteristic associated with low nutrient concentration is diverse aquatic life, while high nutrient concentrations are associated with high chlorophyll levels, low species diversity, and occasional red tides.

The classification scheme divides a continuum of concentrations. Estuaries with nutrient concentrations close to a class boundary are likely to exhibit characteristics of both classes. A minor change (less than 20 percent) in nutrient loadings may affect the estuarine concentration class, but actual estuarine conditions may not drastically improve or decline due to the small change in overall concentration. Moreover, a change in nutrient loading may not affect estuarine conditions precisely as predicted due to discrepancies between estimated and real nutrient concentrations.

N:P Ratio. In general, phytoplankton growth requires nitrogen and phosphorus in the approximate atomic N:P proportion of 16:1. (Redfield, 1934, 1958). However, this ratio may vary slightly among algal species, and a range of 10:1 to 20:1 better describes algal nutrient requirements (Boynton et al., 1982). Where the N:P ratio is 10:1 or less, nitrogen may be insufficient to balance available phosphorus, and may limit increased plant production. Conversely, where the N:P ratio is 20:1 or greater, phosphorus levels may be insufficient to allow complete use of all available nitrogen, and phosphorus may be a limiting nutrient. In estuaries where N:P ratios fall between 10:1 and 20:1, the limiting nutrient may depend on which phytoplankton species is present. Without site-specific information, a limiting nutrient cannot accurately be determined in the 10:1 to 20:1 range. In general, phosphorus is the limiting nutrient in freshwater, and nitrogen is the limiting nutrient in seawater (estuaries represent a transition zone between freshwater and seawater). Also, an element other than nitrogen or phosphorus may be the production-limiting nutrient (e.g. silica, which is required by diatoms in the proportion S:N:P=20:16:1, Redfield, 1958), or a physical parameter such as light or temperature may control primary production all or part of the year.

The N:P ratio discussed in the one-page estuary summaries is a speculative value based on estimated nutrient loads; the ratio does not reflect actual estuarine measurements. These estimated loads represent the weights of nitrogen and phosphorus from organic and inorganic molecules entering an estuary annually. N:P ratios were approximated by converting loads to the number of atoms (load divided by the corresponding atomic weight) and dividing nitrogen by phosphorus to yield a ratio with the denominator, phosphorus, equal to one.

Figure 2. Relative Status of West Coast Estuaries with Respect to Nitrogen



Concentration (mg/l)

LOW	MEDIUM	HIGH
Less than 0.1	Greater than 0.1 and less than 1	Greater than 1

Estimated N:P ratios do not account for nutrient uptake by plants and algae, or nutrient recycling which may significantly affect the ambient nutrient concentrations, and thus actual N:P ratios. Other factors influencing N:P ratios and the limiting nutrient include preferential uptake of different ionic forms (e.g. nitrate, nitrite, ammonium), and varying phytoplankton nutrient uptake rates. For example, some evidence supports the preferential uptake of ammonium (NH_4^+) over nitrate (NO_3^-) (McCarthy, 1981) and the repression of both nitrate (NO_3^-) and nitrite (NO_2^-) assimilation in phytoplankton by NH_4^+ (Falkowski, 1983). Unfortunately, studies of varying chemical-recycling and nutrient-uptake rates are uncommon and tend to be site-specific. The impact of different nutrient ions on algal growth remains to be fully explored. The N:P ratios provided, therefore, should be used only as a first approximation for evaluating nutrient dominance.

Comparisons Among Estuaries

Estuarine comparisons of NCPDI-derived estimated nutrient loads, DCPs, and predicted nutrient concentrations can be used to assess the potential extent of nutrient-related problems under existing loadings or predicted future loadings. The N:P loading ratio gives an initial estimate of which nutrient may be influential in limiting phytoplankton production. Based on this information, a variety of regional comparisons may be made for West Coast estuaries.

For example, 1982 proved to be an unusually heavy year for precipitation. In the San Francisco Bay EDA, the rain station at San Francisco International Airport reported 34.81 inches of rainfall. This represented an increase of 15.28 inches over the normal long-term precipitation at that station (NOAA, 1982a). In the Columbia River EDA, the Clatskanie rain station reported 70.76 inches of annual rainfall, an increase of 11.83 inches over the long-term average (NOAA, 1982b). In the Grays Harbor EDA the Aberdeen rain station recorded 96.76 inches of annual precipitation in 1982, an increase of 15.25 inches over the long-term normal (NOAA, 1982c). This increased rainfall is likely to have caused increased nutrient loading from nonpoint and upstream sources.

For West Coast estuaries, forest land is the dominant source of nitrogen. The dominant source of phosphorus is wastewater treatment plant discharge. Of the region's 22 estuaries, 13 have relatively poor flushing and/or dilution abilities, as indicated by high DCPs. Six of these estuaries, San Pedro Bay, Monterey Bay, Santa Monica Bay, San Francisco Bay, Columbia River, and Puget Sound have high phosphorus and nitrogen loads. San Diego Bay has a high phosphorus load and medium nitrogen load.

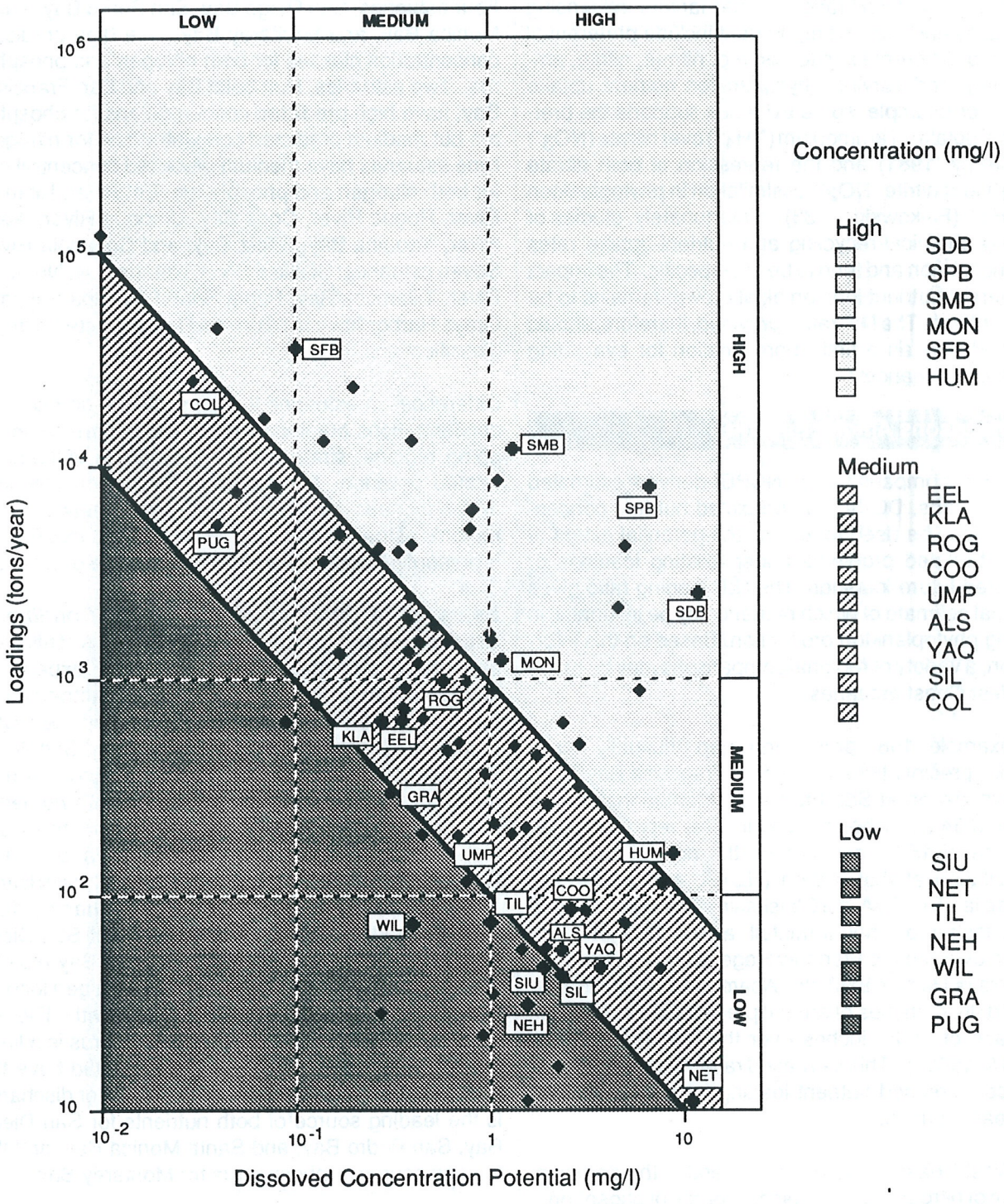
Four estuaries, San Diego Bay, San Pedro Bay, Santa Monica Bay, and Monterey Bay have high predicted concentration classes for both nitrogen and phosphorus. Two estuaries, Humboldt Bay and San Francisco Bay, have high predicted concentrations for phosphorus but medium predicted concentrations for nitrogen. Nine estuaries have medium predicted concentrations for both nitrogen and phosphorus: Eel River, Klamath River, Rogue River, Coos Bay, Umpqua River, Alsea River, Yaquina Bay, Siletz Bay, and Columbia River. Seven estuaries: Siuslaw River, Netarts Bay, Nehalem River, Tillamook Bay, Puget Sound, Willapa Bay, and Grays Harbor have medium and low predicted nutrient classifications.

Differences in estuarine loadings, DCPs, and nutrient concentrations are important considerations in developing regional strategies for the control of nutrient-related pollution. The following discussion identifies and describes significant differences between the region's estuaries that may be cause for concern, and is presented to stimulate further regionwide discussion.

Estuaries of Concern Under Existing Conditions. Estuaries with high predicted concentrations of nitrogen and phosphorus are the most likely to experience eutrophication problems (predicted concentration is a function of the estimated nutrient load and the DCP). Four West Coast estuaries, San Diego Bay, San Pedro Bay, Santa Monica Bay, and Monterey Bay are estimated to have high concentrations of both nutrients. For San Diego Bay, San Pedro Bay, and Monterey Bay high concentrations result from high DCPs (poor dilution/flushing ability) combined with generally high loads. The exception is San Diego Bay, which has medium nitrogen loading. N:P ratios suggest that San Diego Bay, San Pedro Bay, and Santa Monica Bay may be nitrogen-limited; that is, a reduction in nitrogen loading would have the greatest effect on algal growth. The N:P ratio for Monterey Bay suggests phosphorus is a limiting nutrient; reduction of phosphorus would have the greatest effect on algal growth. Wastewater discharge is the leading source of both nutrients for San Diego Bay, San Pedro Bay, and Santa Monica Bay, and the leading source of phosphorus for Monterey Bay.

Two other estuaries, Humboldt Bay and San Francisco Bay, are estimated to have high phosphorus concentrations. For Humboldt Bay, this is the result of a high DCP, which concentrates a medium phosphorus load. For San Francisco Bay, high concentration is due to high phosphorus loads despite a medium DCP. Wastewater

Figure 3. Relative Status of West Coast Estuaries with Respect to Phosphorus



treatment plant discharge is the leading source of phosphorus in both estuaries. The N:P ratio suggests that Humboldt Bay may be nitrogen-limited. The N:P ratio for San Francisco Bay does not indicate if either or both of the nutrients limit algal growth.

Future Concerns. Most estuaries require a load change of greater than 20 percent to alter their concentration class. However, five estuaries may change concentration class for one nutrient with a minor (less than 20 percent) change in nutrient loading. In San Francisco Bay, for example, nitrogen concentrations are likely to increase from medium to high with only a five percent increase in the overall nitrogen load. Similarly, Siuslaw River will change from a low to medium concentration class with only a five percent increase in phosphorus loading. Grays Harbor may increase its concentration class from low to medium with only a two percent increase in phosphorus loading. Only two estuaries, Monterey Bay and Siletz River, could shift to a lower phosphorus concentration class by reducing phosphorus loads by less than 20 percent.

Concluding Comments

The susceptibility levels and predicted nutrient concentrations described in this report provide an estimate of the relative status of West Coast estuaries with respect to nutrient-related pollution. Such estimates may be useful for regional resource management and planning, particularly in the absence of standardized quantitative nutrient concentration measures.

An assessment of "actual" eutrophication problems and characteristics can only be made after gathering site-specific information. A nationwide project is being conducted to collect such information.

For additional information on NOAA's NEI or any other Strategic Assessment program, contact:

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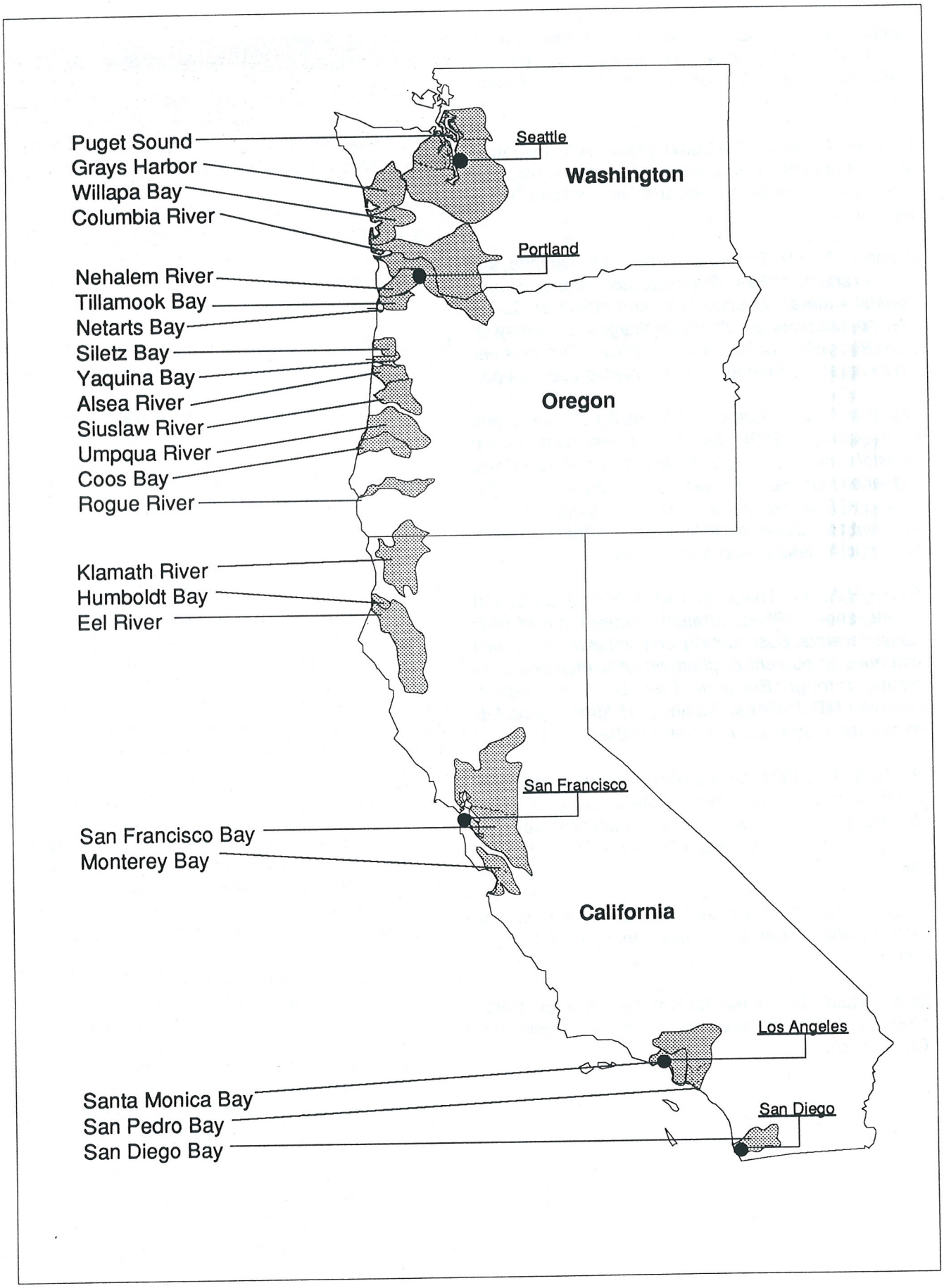

Puget Sound
Grays Harbor
Willapa Bay
Columbia River
Nehalem River
Tillamook Bay
Netarts Bay
Siletz Bay
Yaquina Bay
Alsea River
Siuslaw River
Umpqua River
Coos Bay
Rogue River
Klamath River
Humboldt Bay
Eel River
San Francisco Bay
Monterey Bay
Santa Monica Bay
San Pedro Bay
San Diego Bay
Seattle
Washington
Portland
Oregon
San Francisco
California
Los Angeles
San Diego

Susceptibility and Status of West Coast Estuaries to Nutrient Discharges: San Diego Bay to Puget Sound

Estuary Summaries

California	Oregon	Washington
San Diego Bay	Rogue River	Columbia River
San Pedro Bay	Coos Bay	Willapa Bay
Santa Monica Bay	Umpqua River	Grays Harbor
Monterey Bay	Siuslaw River	Puget Sound
San Francisco Bay	Alsea River	
Eel River	Yaquina Bay	
Humboldt Bay	Siletz Bay	
Klamath River	Netarts Bay	
	Tillamook Bay	
	Nehalem River	

P020 San Diego Bay, CA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.06×10^{10}
Surface Area (sq. mi.)	17
Average Daily Inflow (cfs)	100
Estuarine Drainage Area (sq. mi.)	462
% EDA land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	296
Total Drainage Area (sq. mi.)	758

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	12.31	H
Particle Retention Efficiency (C/l)	3.361	H

NUTRIENT CHARACTERISTICS

Estimated Loading (tons/year)

	Nitrogen	Phosphorus
Point	3,110	2,613
Nonpoint	249	22
Upstream	0	0
Total	3,359 (M)	2,635 (H)

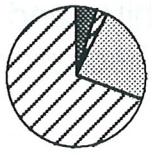
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	4.135 (H)	3.244 (H)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	NA	NA
Decrease load by	2,547 (76%)	2,554 (97%)

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

LAND USE & NUTRIENT SOURCES

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

Phosphorus

Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 1% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

San Diego Bay is estimated to have a high susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nutrient loadings results in predicted concentrations within the high range for both nitrogen and phosphorus. In San Diego Bay, these concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N:P molecular ratio of the loading is 3:1, suggesting that nitrogen may be a limiting nutrient in the estuary.

Physical Environments Characterization Branch
Strategic Environmental Assessments Division
Office of Ocean Resources Conservation and Assessment
National Ocean Service
National Oceanic and Atmospheric Administration

College of Marine Studies
University of Delaware
Office of Wetlands, Oceans, and Watersheds
U.S. Environmental Protection Agency

P050 San Pedro Bay, CA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	2.71×10^{10}
Surface Area (sq. mi.)	25
Average Daily Inflow (cfs)	300
Estuarine Drainage Area (sq. mi.)	1,725
% EDA land within coastal counties	98
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	1,725

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	4.41	H
Particle Retention Efficiency (C/l)	2.864	H

NUTRIENT CHARACTERISTICS

Estimated Loading
(tons/year)

	Nitrogen	Phosphorus
Point	9,434	6,432
Nonpoint	1,280	172
Upstream	0	0
Total	10,714 (H)	6,604 (H)

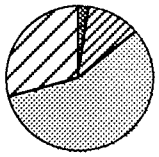
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	4.725 (H)	2.913 (H)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	NA	NA
Decrease load by	8,446 (79%)	6,378 (97%)

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

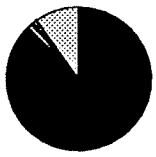
LAND USE & NUTRIENT SOURCES

Land Use



- Agriculture
- Forest
- Urban
- Range and Other Nonurban

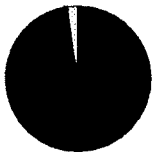
Nitrogen



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Phosphorus



Upstream Sources
- ☐

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 2% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

San Pedro Bay is estimated to have a high susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nutrient loadings results in predicted concentrations within the high range for both nitrogen and phosphorus. In San Pedro Bay, these high concentration classifications are not likely to be influenced by minor reductions (<20%) in the nutrient loadings. The N:P molecular ratio of the loading is 4:1, suggesting that nitrogen may be a limiting nutrient in the estuary.

Physical Environments Characterization Branch
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U.S. Environmental Protection Agency

P060 Santa Monica Bay, CA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.84×10^{12}
Surface Area (sq. mi.)	211
Average Daily Inflow (cfs)	900
Estuarine Drainage Area (sq. mi.)	530
% EDA land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	530

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	1.371	H
Particle Retention Efficiency (C/l)	64.83	H

NUTRIENT CHARACTERISTICS

Estimated Loading (tons/year)

	Nitrogen	Phosphorus
Point	17,478	12,755
Nonpoint	919	48
Upstream	0	0
Total	18,397 (H)	12,803 (H)

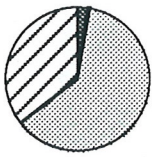
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	2.522 (H)	1.755 (H)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	NA	NA
Decrease load by	11,038 (60%)	5,505 (43%)

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

LAND USE & NUTRIENT SOURCES

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Phosphorus

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 0% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

Santa Monica Bay is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nutrient loadings results in predicted concentration classifications within the high range for both nitrogen and phosphorus. In Santa Monica Bay, these high concentration classifications are not likely to be influenced by minor reductions (<20%) in nutrient loadings. The N:P molecular ratio of the loading is 3:1, suggesting that nitrogen may be a limiting nutrient in the estuary.

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U.S. Environmental Protection Agency

P080 Monterey Bay, CA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.49×10^{12}
Surface Area (sq. mi.)	209
Average Daily Inflow (cfs)	1,200
Estuarine Drainage Area (sq. mi.)	510
% EDA land within coastal counties	98
Fluvial Drainage Area (sq. mi.)	5,470
Total Drainage Area (sq. mi.)	5,980

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	1.05	H
Particle Retention Efficiency (C/l)	39.373	H

NUTRIENT CHARACTERISTICS

Estimated Loading
(tons/year)

	Nitrogen	Phosphorus
Point	1,502	685
Nonpoint	25,609	497
Upstream	145	5
Total	27,256 (H)	1,187 (H)

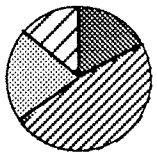
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	2.789 (H)	0.121 (H)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	NA	NA
Decrease load by	17,482 (64%)	209 (18%)

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

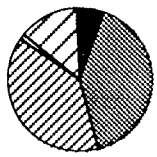
LAND USE & NUTRIENT SOURCES

Land Use

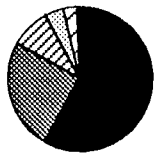


- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Phosphorus



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 2% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

Monterey Bay is estimated to have a high susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nutrient loadings results in predicted concentrations within the high range for both nitrogen and phosphorus. In Monterey Bay, the high phosphorus concentration classification may be influenced by a minor reduction (<20%) in phosphorus loading. The N:P molecular ratio of the loading is 50:1, suggesting that phosphorus may be a limiting nutrient in the estuary.

Physical Environments Characterization Branch
Strategic Environmental Assessments Division
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U.S. Environmental Protection Agency

P090 San Francisco Bay, CA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	2.61×10^{11}
Surface Area (sq. mi.)	452
Average Daily Inflow (cfs)	32,400
Estuarine Drainage Area (sq. mi.)	6,530
% EDA land within coastal counties	95
Fluvial Drainage Area (sq. mi.)	37,615
Total Drainage Area (sq. mi.)	44,145

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	0.104	M
Particle Retention Efficiency (C/I)	0.278	M

NUTRIENT CHARACTERISTICS

Estimated Loading (tons/year)

	Nitrogen	Phosphorus
Point	11,127	7,420
Nonpoint	49,952	1,188
Upstream	31,110	4,487
Total	92,189 (H)	13,095 (H)

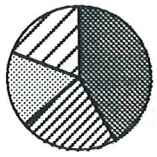
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.951 (M)	0.144 (H)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	4,483 (5%)	NA
Decrease load by	77,335 (89%)	4,005 (31%)

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

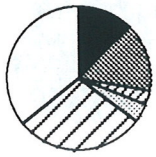
LAND USE & NUTRIENT SOURCES

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

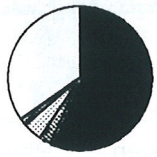


Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources

Phosphorus



Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 4% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

San Francisco Bay is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nitrogen loadings results in a predicted concentration within the medium range for nitrogen. The DCP combined with the estimated phosphorus loading results in a predicted concentration within the high range for phosphorus. In San Francisco Bay, the medium nitrogen concentration classification may be influenced by a minor increase (<20%) in nutrient loading. The N:P molecular ratio of the loading is 15:1 and does not indicate the presence of a limiting nutrient in the estuary.

Physical Environments Characterization Branch
Strategic Environmental Assessments Division
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National Ocean Service
National Oceanic and Atmospheric Administration

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Office of Wetlands, Oceans, and Watersheds
U.S. Environmental Protection Agency

P120 Eel River, CA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	3.01×10^8
Surface Area (sq. mi.)	2
Average Daily Inflow (cfs)	9,700
Estuarine Drainage Area (sq. mi.)	1,510
% EDA land within coastal counties	76
Fluvial Drainage Area (sq. mi.)	2,122
Total Drainage Area (sq. mi.)	3,632

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	0.39	M
Particle Retention Efficiency (C/l)	0	L

NUTRIENT CHARACTERISTICS

Estimated Loading
(tons/year)

	Nitrogen	Phosphorus
Point	45	28
Nonpoint	10,858	119
Upstream	740	399
Total	11,643 (H)	546 (M)

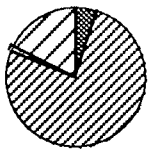
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.447 (M)	0.021 (M)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	13,971 (120%)	2,054 (370%)
Decrease load by	9,081 (78%)	286 (52%)

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

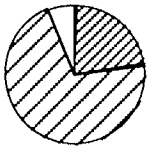
LAND USE & NUTRIENT SOURCES

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Phosphorus

Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 1% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

The Eel River estuary is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nutrient loadings results in predicted concentrations within the medium range for both nitrogen and phosphorus. For Eel River, these medium concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N:P molecular ratio of the loading is 47:1, suggesting that phosphorus may be a limiting nutrient in the estuary.

Physical Environments Characterization Branch
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National Ocean Service
National Oceanic and Atmospheric Administration

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U.S. Environmental Protection Agency

P130 Humboldt Bay, CA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	5.86×10^9
Surface Area (sq. mi.)	19
Average Daily Inflow (cfs)	700
Estuarine Drainage Area (sq. mi.)	220
% EDA land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	220

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	8.00	H
Particle Retention Efficiency (C/I)	0.265	M

NUTRIENT CHARACTERISTICS

Estimated Loading
(tons/year)

	Nitrogen	Phosphorus
Point	223	123
Nonpoint	220	17
Upstream	152	37
Total	595 (L)	177 (M)

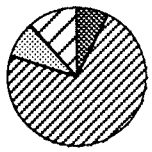
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.476(M)	0.141 (H)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	625 (105%)	NA
Decrease load by	473 (80%)	55 (31%)

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

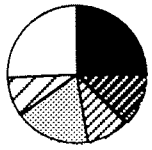
LAND USE & NUTRIENT SOURCES

Land Use



Agriculture
Forest
Urban
Range & Other Nonurban

Nitrogen



Point Sources
Wastewater Trt. Plants
Industrial Facilities

Nonpoint Sources
Agriculture
Forest
Urban
Other Nonurban

Upstream Sources

Phosphorus

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 5% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

Humboldt Bay is estimated to have a high susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nitrogen loadings results in a predicted concentration within the medium range for nitrogen. The DCP combined with the estimated phosphorus loading results in a predicted concentration within the high range for phosphorus. In Humboldt Bay, these concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N:P molecular ratio of the loading is 7:1, suggesting that nitrogen may be a limiting nutrient in the estuary.

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P140 Klamath River, CA, OR

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	6.36×10^8
Surface Area (sq. mi.)	1
Average Daily Inflow (cfs)	20,600
Estuarine Drainage Area (sq. mi.)	1,520
% EDA land within coastal counties	50
Fluvial Drainage Area (sq. mi.)	13,980
Total Drainage Area (sq. mi.)	15,500

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	0.31	M
Particle Retention Efficiency (C/l)	0.001	L

NUTRIENT CHARACTERISTICS

Estimated Loading
(tons/year)

	Nitrogen	Phosphorus
Point	1	0
Nonpoint	2,617	26
Upstream	9,490	521
Total	12,108(H)	547(M)

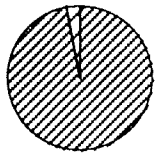
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.375(M)	0.017(M)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	20,098 (166%)	2,678 (489%)
Decrease load by	8,878 (73%)	225 (41%)

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

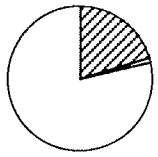
LAND USE & NUTRIENT SOURCES

Land Use

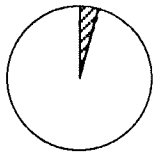


- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Phosphorus



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 0% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

The Klamath River estuary is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nutrient loadings results in predicted concentrations within the medium range for both nitrogen and phosphorus. In Klamath River, these medium concentration classifications are not likely to be influenced by minor changes in nutrient loadings. The N:P molecular ratio is 49:1, suggesting that phosphorus may be a limiting nutrient in the estuary.

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P150 Rogue River, OR

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.15×10^8
Surface Area (sq. mi.)	1
Average Daily Inflow (cfs)	10,561
Estuarine Drainage Area (sq. mi.)	898
% EDA land within coastal counties	37
Fluvial Drainage Area (sq. mi.)	4,235
Total Drainage Area (sq. mi.)	5,133

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	0.556	M
Particle Retention Efficiency (C/l)	0	L

NUTRIENT CHARACTERISTICS

Estimated Loading (tons/year)

	Nitrogen	Phosphorus
Point	5	3
Nonpoint	2,969	30
Upstream	10,160	924
Total	13,134 (H)	957 (M)

Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.744 (M)	0.054 (M)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	4,519 (34%)	815 (85%)
Decrease load by	11,357 (86%)	780 (81%)

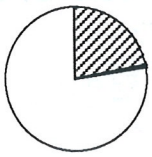
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

LAND USE & NUTRIENT SOURCES

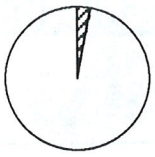
Land Use

- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Phosphorus



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 1% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

The Rogue River estuary is estimated to be in the medium range in its potential for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with estimates of actual nutrient loadings result in medium concentration classifications for both nitrogen and phosphorus. In Rogue River, these medium classification ranges are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N:P molecular ratio is 30:1 indicating that phosphorus may be a limiting nutrient in the estuary.

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P160 Coos Bay, OR

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	5.16×10^9
Surface Area (sq. mi.)	13
Average Daily Inflow (cfs)	2,900
Estuarine Drainage Area (sq. mi.)	590
% EDA land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	590

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	2.27	H
Particle Retention Efficiency (C/l)	0.056	L

NUTRIENT CHARACTERISTICS

Estimated Loading
(tons/year)

	Nitrogen	Phosphorus
Point	110	59
Nonpoint	2,944	36
Upstream	0	0
Total	3,054 (M)	95 (L)

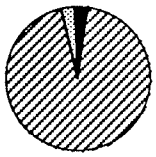
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.693 (M)	0.022 (M)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	1,351 (44%)	346 (364%)
Decrease load by	2,613 (86%)	51 (54%)

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

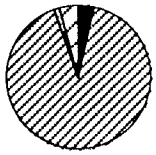
LAND USE & NUTRIENT SOURCES

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

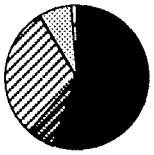


Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Phosphorus



Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 1% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

Coos Bay is estimated to have a high susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nutrient loadings results in predicted concentrations within the medium ranges for both nitrogen and phosphorus. In Coos Bay, the medium concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N:P molecular ratio of the loading is 71:1, suggesting that phosphorus may be a limiting nutrient in the estuary.

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P170 Umpqua River, OR

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	3.76×10^9
Surface Area (sq. mi.)	10
Average Daily Inflow (cfs)	9,300
Estuarine Drainage Area (sq. mi.)	1,500
% EDA land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	3,140
Total Drainage Area (sq. mi.)	4,640

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	0.793	M
Particle Retention Efficiency (C/l)	0.013	L

NUTRIENT CHARACTERISTICS

Estimated Loading
(tons/year)

	Nitrogen	Phosphorus
Point	128	60
Nonpoint	8,742	103
Upstream	0	0
Total	8,870 (M)	163 (M)

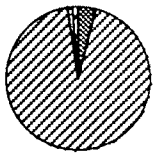
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.696 (M)	0.013 (M)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	3,630 (41%)	1,087 (667%)
Decrease load by	7,620 (86%)	38 (23%)

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

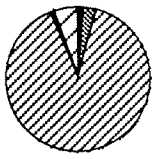
LAND USE & NUTRIENT SOURCES

Land Use

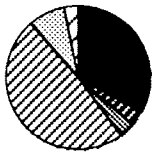


- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Phosphorus



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 0% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

The Umpqua River estuary is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nutrient loadings results in predicted concentrations within the medium range for both nitrogen and phosphorus. For the estuary, these concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N:P molecular ratio of the loadings is 121:1, suggesting that phosphorus may be the limiting nutrient in the estuary.

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P180 Siuslaw River, OR

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	9.64×10^8
Surface Area (sq. mi.)	4
Average Daily Inflow (cfs)	3,013
Estuarine Drainage Area (sq. mi.)	769
% EDA land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	769

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	1.853	H
Particle Retention Efficiency (C/l)	0.010	L

NUTRIENT CHARACTERISTICS

Estimated Loading
(tons/year)

	Nitrogen	Phosphorus
Point	23	9
Nonpoint	3,836	40
Upstream	0	0
Total	3,859 (M)	49 (L)

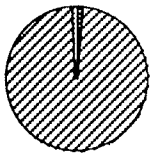
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.715 (M)	0.009 (L)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	1,538 (40%)	5 (11%)
Decrease load by	3,319 (86%)	NA

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

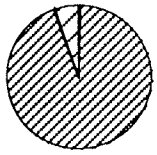
LAND USE & NUTRIENT SOURCES

Land Use

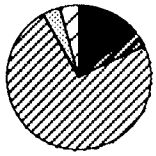


- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Phosphorus



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 1% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

The Siuslaw River estuary is estimated to be in the high range in its potential for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with estimates of actual nutrient loadings results in a medium concentration classification range for nitrogen and a low concentration classification range for phosphorus. In the estuary, the concentration range for nitrogen is unlikely to be influenced by minor changes (<20%) in nutrient loadings. The N:P molecular ratio of the Suislaw is 174:1 indicating that phosphorus could be a strongly limiting nutrient in the estuary.

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P190 Alsea River, OR

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	4.56×10^8
Surface Area (sq. mi.)	3
Average Daily Inflow (cfs)	2,250
Estuarine Drainage Area (sq. mi.)	480
% EDA land within coastal counties	64
Fluvial Drainage Area (sq. mi.)	0
Total Drainage Area (sq. mi.)	480

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	2.086	H
Particle Retention Efficiency (C/I)	0.006	L

NUTRIENT CHARACTERISTICS

Estimated Loading (tons/year)

	Nitrogen	Phosphorus
Point	4	2
Nonpoint	1,881	19
Upstream	1,990	40
Total	3,875 (M)	61 (L)

Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.808 (M)	0.013 (M)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	960 (24%)	418 (687%)
Decrease load by	3,395 (88%)	13 (21%)

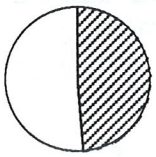
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

LAND USE & NUTRIENT SOURCES

Land Use

- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

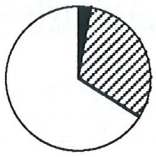


Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Phosphorus



Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 1% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

The Alsea River estuary is estimated to be in the high range in its potential for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with estimates of actual nutrient loadings results in predicted concentrations within the medium classification range for both nitrogen and phosphorus. In the estuary, these medium concentration ranges are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N:P ratio is 140:1 suggesting that phosphorus could be a strongly limiting nutrient in the estuary.

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P200 Yaquina Bay, OR

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.39×10^9
Surface Area (sq. mi.)	5
Average Daily Inflow (cfs)	950
Estuarine Drainage Area (sq. mi.)	254
% EDA land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	254

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	3.356	H
Particle Retention Efficiency (C/I)	0.046	L

NUTRIENT CHARACTERISTICS

Estimated Loading (tons/year)

	Nitrogen	Phosphorus
Point	108	37
Nonpoint	876	11
Upstream	0	0
Total	984 (L)	48 (L)

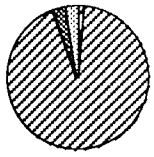
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.330 (M)	0.016 (M)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	1,996 (203%)	247 (525%)
Decrease load by	679 (69%)	18 (38%)

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

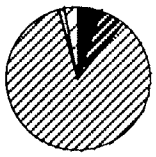
LAND USE & NUTRIENT SOURCES

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

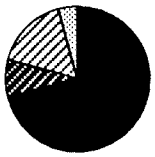


Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Phosphorus



Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 1% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

Yaquina Bay is estimated to be in the high range for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimates of actual nutrient loadings results in predicted concentrations within the medium ranges for both nitrogen and phosphorus. In Yaquina Bay it is unlikely that these medium classifications will be influenced by minor changes (<20%) in nutrient loadings. The N:P ratio for Yaquina is 47:1 indicating that phosphorus is likely to be a limiting nutrient in the estuary.

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P210 Siletz Bay, OR

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	4.80×10^8
Surface Area (sq. mi.)	2
Average Daily Inflow (cfs)	2,767
Estuarine Drainage Area (sq. mi.)	372
% EDA land within coastal counties	72
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	372

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	2.424	H
Particle Retention Efficiency (C/l)	0.005	L

NUTRIENT CHARACTERISTICS

Estimated Loading (tons/year)

	Nitrogen	Phosphorus
Point	31	13
Nonpoint	1,095	13
Upstream	390	19
Total	1,516 (M)	45 (L)

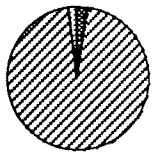
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.367(M)	0.011(M)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	2,615 (172%)	368 (817%)
Decrease load by	1,103 (73%)	4 (8%)

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

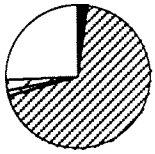
LAND USE & NUTRIENT SOURCES

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

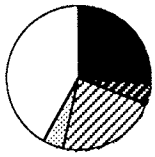


Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Phosphorus



Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 1% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

Siletz Bay is estimated to have a high potential for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the actual nutrient loadings estimates results in a predicted concentration classification within the medium range for both nitrogen and phosphorus. In the Siletz, these concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N:P ratio for the Siletz is 74:1 indicating that phosphorus may be a limiting nutrient in the estuary.

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P220 Netarts Bay, OR

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	2.96×10^8
Surface Area (sq. mi.)	2
Average Daily Inflow (cfs)	98
Estuarine Drainage Area (sq. mi.)	14
% EDA land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	14

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	12.564	H
Particle Retention Efficiency (C/l)	0.096	L

NUTRIENT CHARACTERISTICS

Estimated Loading
(tons/year)

	Nitrogen	Phosphorus
Point	3	2
Nonpoint	144	1
Upstream	0	0
Total	147 (L)	3 (L)

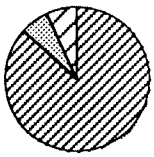
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.185 (M)	0.005 (L)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	650 (441%)	3 (100%)
Decrease load by	68 (48%)	NA

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

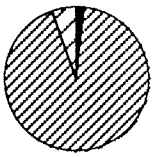
LAND USE & NUTRIENT SOURCES

Land Use

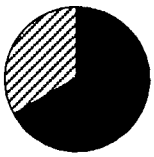


- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Phosphorus



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 1% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

Netarts Bay is estimated to have a high potential for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nutrient loadings results in a predicted medium classification concentration for nitrogen and a predicted low classification for phosphorus. In Netarts Bay these concentration classsifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. In the estuary, the N:P ratio is 90:1 indicating that phosphorus may be a limiting nutrient in the estuary.

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P230 Tillamook Bay, OR

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.88×10^9
Surface Area (sq. mi.)	11
Average Daily Inflow (cfs)	3,880
Estuarine Drainage Area (sq. mi.)	571
% EDA land within coastal counties	93
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	571

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	1.049	H
Particle Retention Efficiency (C/l)	0.015	L

NUTRIENT CHARACTERISTICS

Estimated Loading (tons/year)

	Nitrogen	Phosphorus
Point	65	30
Nonpoint	4,250	43
Upstream	0	0
Total	4,315 (M)	73 (L)

Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.452 (M)	0.008 (L)

To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	5,231 (121%)	23 (32%)
Decrease load by	3,359 (78%)	NA

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

LAND USE & NUTRIENT SOURCES

Land Use

- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

Phosphorus

Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 1% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

Tillamook Bay is estimated to be in the high range in its potential for concentrating dissolved substances). This concentration potential (DCP) combined with estimates of actual nutrient loading results in a predicted medium concentration classification for nitrogen and a low concentration classification for phosphorus. In Tillamook Bay these concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N:P molecular ratio of the loading is 130:1 indicating that phosphorus may be a limiting nutrient in the estuary.

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P240 Nehalem River, OR

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	4.90×10^8
Surface Area (sq. mi.)	2
Average Daily Inflow (cfs)	3,420
Estuarine Drainage Area (sq. mi.)	860
% EDA land within coastal counties	95
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	860

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	1.556	H
Particle Retention Efficiency (C/l)	0.005	L

NUTRIENT CHARACTERISTICS

Estimated Loading
(tons/year)

	Nitrogen	Phosphorus
Point	19	6
Nonpoint	2,888	29
Upstream	0	0
Total	2,907 (M)	35 (L)

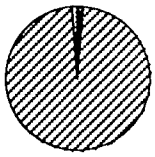
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.452 (M)	0.005 (L)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	3,525 (121%)	35 (100%)
Decrease load by	2,265 (78%)	NA

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

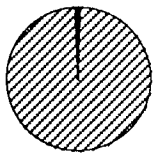
LAND USE & NUTRIENT SOURCES

Land Use

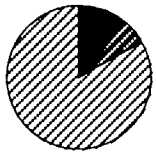


- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Phosphorus



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 0% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

The Nehalem River estuary is estimated to have a high potential for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with estimates of actual nutrient loadings results in a medium classification for nitrogen concentration and low classification for phosphorus concentration. The medium concentration classification for nitrogen is not likely to be influenced by minor changes (<20%) in nutrient loadings. In the estuary, the N:P ratio is 183:1 indicating that phosphorus may be a strongly limiting nutrient in the estuary.

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P250 Columbia River, WA, OR

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.24×10^{11}
Surface Area (sq. mi.)	284
Average Daily Inflow (cfs)	272,500
Estuarine Drainage Area (sq. mi.)	5,627
% EDA land within coastal counties	64
Fluvial Drainage Area (sq. mi.)	252,030
Total Drainage Area (sq. mi.)	257,657

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	0.032	L
Particle Retention Efficiency (C/l)	0.014	L

NUTRIENT CHARACTERISTICS

Estimated Loading (tons/year)

	Nitrogen	Phosphorus
Point	3,376	1,640
Nonpoint	9,204	200
Upstream	268,670	23,118
Total	281,250 (H)	24,958 (H)

Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.928 (M)	0.082 (M)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	21,780 (8%)	5,345 (21%)
Decrease load by	250,947 (89%)	21,928 (88%)

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

LAND USE & NUTRIENT SOURCES

Land Use

- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources

Phosphorus

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 1% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

The Columbia River estuary is estimated to have a low susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nutrient loadings results in predicted concentrations within the medium range for both nitrogen and phosphorus. In the Columbia River, the medium nitrogen concentration classification may be influenced by a minor reduction (<20%) in nitrogen loading. The N:P molecular ratio of the loadings is 25:1, suggesting that phosphorus may be the limiting nutrient in the estuary.

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P260 Willapa Bay, WA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	4.18×10^{10}
Surface Area (sq. mi.)	92
Average Daily Inflow (cfs)	5,900
Estuarine Drainage Area (sq. mi.)	1,100
% EDA land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	1,100

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	0.466	M
Particle Retention Efficiency (C/l)	0.225	M

NUTRIENT CHARACTERISTICS

Estimated Loading
(tons/year)

	Nitrogen	Phosphorus
Point	68	33
Nonpoint	3,686	39
Upstream	0	0
Total	3,754 (M)	72 (L)

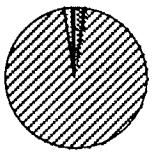
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.176 (M)	0.003 (L)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	17,522 (467%)	141 (196%)
Decrease load by	1,627 (43%)	NA

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

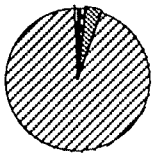
LAND USE & NUTRIENT SOURCES

Land Use

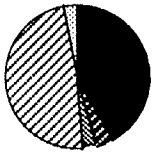


- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Phosphorus



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 3% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

Willapa Bay is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nitrogen loadings results in a predicted concentration within the medium range. The DCP combined with the estimated phosphorus loading results in a predicted concentration within the low range for phosphorus. In Willapa Bay, the present concentration classifications are not likely to be influenced by minor changes (<20%) in the nutrient loadings. The N:P molecular ratio of the loadings is 115:1, suggesting that phosphorus may be the limiting nutrient in the estuary.

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P270 Grays Harbor, WA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	2.08×10^{10}
Surface Area (sq. mi.)	58
Average Daily Inflow (cfs)	13,500
Estuarine Drainage Area (sq. mi.)	1,406
% EDA land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	1,310
Total Drainage Area (sq. mi.)	2,716

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	0.278	M
Particle Retention Efficiency (C/I)	0.049	L

NUTRIENT CHARACTERISTICS

Estimated Loading
(tons/year)

	Nitrogen	Phosphorus
Point	423	105
Nonpoint	4,756	83
Upstream	2,890	129
Total	8,069 (M)	317 (M)

Predicted Concentration Status (actual loading)

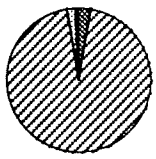
	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.225 (M)	0.009 (L)

To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	24,188 (300%)	6 (2%)
Decrease load by	4,844 (60%)	NA

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

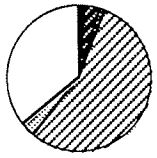
LAND USE & NUTRIENT SOURCES

Land Use

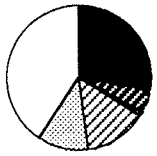


- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Phosphorus



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 2% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

Grays Harbor is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nitrogen loadings results in a predicted concentration within the medium range for nitrogen. The DCP combined with the estimated phosphorus loading results in a predicted concentration within the low range for phosphorus. In Grays Harbor, the low phosphorus concentration classification may be influenced by a minor increase (<20%) in phosphorus loading. The N:P molecular ratio of the loadings is 56:1 suggesting that phosphorus may be the limiting nutrient in the estuary.

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P280 Puget Sound, WA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	5.22×10^{12}
Surface Area (sq. mi.)	931
Average Daily Inflow (cfs)	51,100
Estuarine Drainage Area (sq. mi.)	8,012
% EDA land within coastal counties	97
Fluvial Drainage Area (sq. mi.)	4,270
Total Drainage Area (sq. mi.)	12,282

Pollution Susceptibility (per unit loading)

	Concentration	Class
Dissolved Concentration Potential (mg/l)	0.039	L
Particle Retention Efficiency (C/l)	3.233	H

NUTRIENT CHARACTERISTICS

Estimated Loading
(tons/year)

	Nitrogen	Phosphorus
Point	6,765	4,957
Nonpoint	13,971	405
Upstream	355	45
Total	21,091(H)	5,407(H)

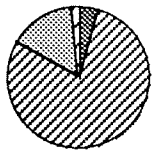
Predicted Concentration Status (actual loading)

	Nitrogen	Phosphorus
Predicted concentration mg/l (class)	0.082 (L)	0.021 (M)
To change concentration class (load in tons/year)	Nitrogen	Phosphorus
Increase load by	4,618(22%)	20,330(376%)
Decrease load by	NA	2,832(52%)

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter, (milligrams per liter is equal to parts per thousand); NA, not applicable; L, low; M, medium; H, high; C/l, volume/inflow.

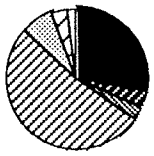
LAND USE & NUTRIENT SOURCES

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Phosphorus

Upstream Sources
- ☐

Note: Nutrient discharge estimates are unavailable for barren lands and wetlands. Barren lands and wetlands account for 3% of the land area in the coastal county portion of the estuarine drainage area.

INTERPRETATION

The Puget Sound estuary is estimated to have a low susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nitrogen loadings results in a predicted concentration within the low range for nitrogen and the medium range for phosphorus. In Puget Sound, these concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N:P molecular ratio of the loadings is 9:1, suggesting that nitrogen may be the limiting nutrient in the estuary.

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