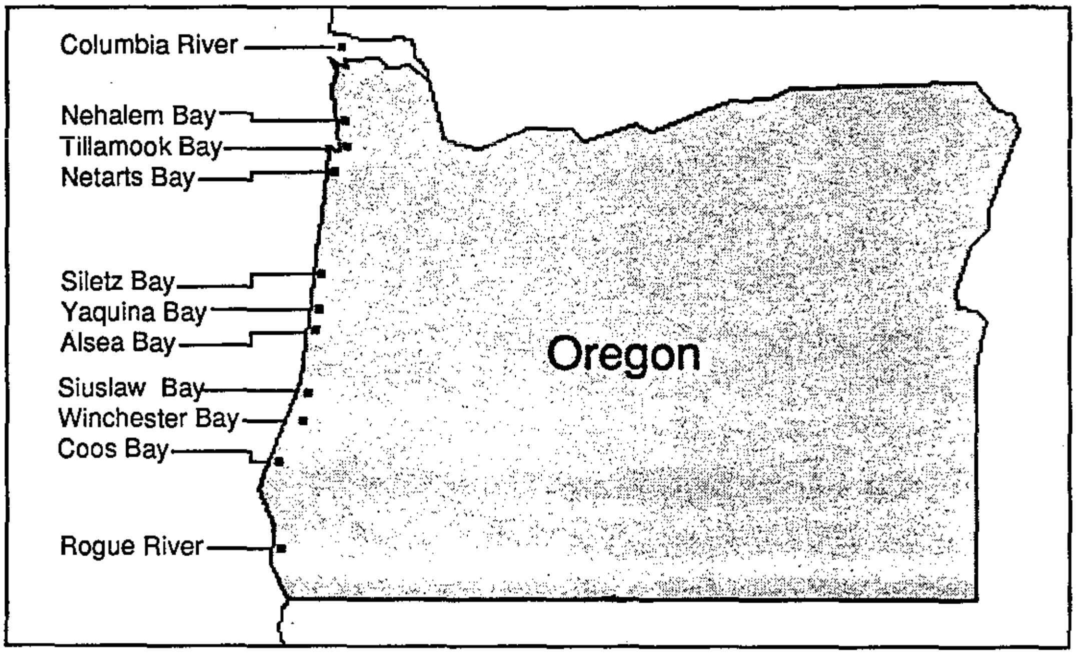
# National Estuarine Inventory: Supplement 1

*Physical and Hydrologic Characteristics*
***The Oregon Estuaries***




*November 1988*

*Strategic Assessment Branch*
*Ocean Assessments Division*
*Office of Oceanography and Marine Assessment*
*National Ocean Service*
*National Oceanic and Atmospheric Administration*
*Rockville, Maryland 20852*

# NOAA's National Estuarine Inventory

The National Estuarine Inventory (NEI) is a series of related activities of the Office of Oceanography and Marine Assessment (OMA), National Oceanic and Atmospheric Administration (NOAA) to develop a national estuarine data base and assessment capability. The NEI was initiated in June 1983 as part of NOAA's program of strategic assessments of the Nation's coastal and oceanic resources. No comprehensive inventory or data base for the Nation's estuaries could be found prior to the NEI in spite of the high value, intense use, frequent overuse, and thousands of scientific studies related to various aspects of estuaries. Without this fundamental set of information developed for the NEI, it is impossible to analyze or compare the estuaries that make up the Nation's estuarine resource base.

The cornerstone of the NEI is the National Estuarine Inventory Data Atlas. Volume 1, completed in November 1985, identifies 92 of the most important estuaries and subestuaries of the contiguous USA; presents information through maps and tables on physical and hydrologic characteristics of each estuary; and specifies a commonly derived spatial unit for all estuaries, the estuarine drainage area (EDA), for which data are compiled. These estuaries represent approximately 90 percent of the estuarine water surface area and 90 percent of the freshwater inflow to estuaries of the East Coast, West Coast, and Gulf of Mexico. Volume 2 presents area estimates for seven categories and 24 subcategories of land use as well as 1970 and 1980 population estimates. Land use data are compiled for three spatial units: (1) the estuarine drainage area; (2) U.S. Geological Survey hydrologic catalog units: and (3) counties that intersect EDAs. Population estimates are compiled for EDAs only. With these two volumes the NEI represents the most consistent and complete set of data ever developed for the Nation's estuarine resource base.

***An Evolving Process.*** The data base and assessment capabilities under development are part of an evolving process. Additional estuaries are being added to the inventory, especially along the West Coast and in the Gulf of Mexico, and refinements made to the physical and hydrologic data presented in Volume 1. Estimates of additional estuarine attributes, such as volume by salinity zone, flushing rates, and length and characteristics of shoreline, have been added to the data base. Other NOAA projects developing information that is being incorporated into the NEI include: the National Coastal Wetlands Inventory, The National Shellfish Register and related projects, the National Coastal Pollutant Discharge Inventory, Estuarine Living Marine Resources, and the Inventory of Outdoor Marine Recreational Facilities. Information from these and other projects is being incorporated into the NEI through a NOAA Geographical Information System.

***The Supplement Series.*** An NEI "Supplement Series" has been initiated to provide users with new and up-to-date information on the Nation's estuaries in as timely a manner as possible. The continued development of the NEI is an evolving process, thus there will always be changes, corrections, and additions to report. Several additional supplements are planned for FY 1989.

# National Estuarine Inventory: Supplement 1

*Physical and Hydrologic Characteristics*
***The Oregon Estuaries***


Project Team:

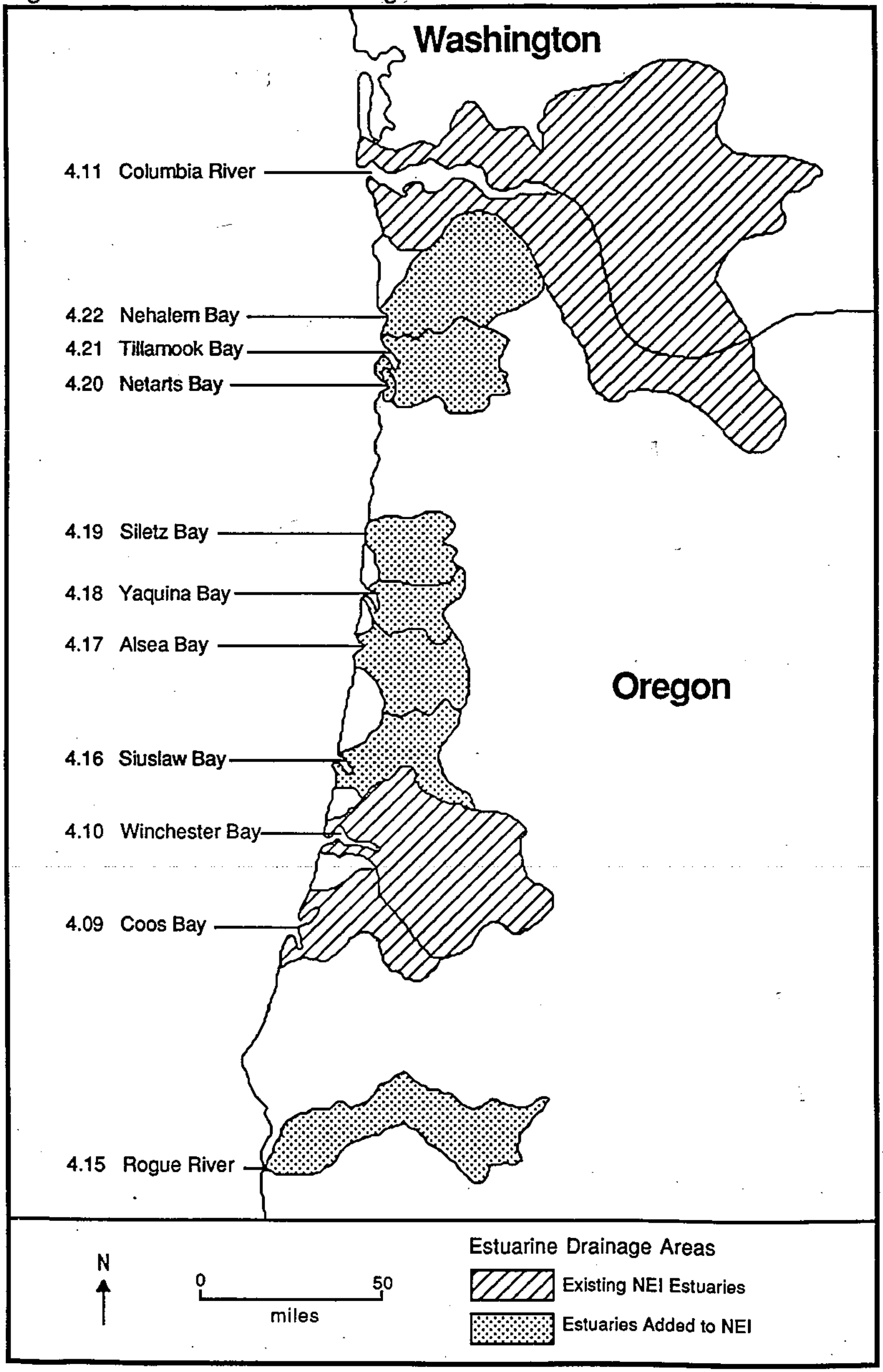
Farzad F. Shirzad
S. Paul Orlando

C. J. Klein
S. E. Holliday
M. A. Warren
M. E. Monaco



Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration

Figure 1. NEI Estuaries in Oregon



# National Estuarine Inventory: Supplement 1

## Introduction

This supplement is the first in a series presenting updates, additions and/or enhancements to Volume 1 of the NEI: Physical and Hydrologic Characteristics. This particular supplement represents the inclusion of an additional eight estuaries in Oregon: Rogue River, Siuslaw Bay, Alsea Bay, Yaquina Bay, Siletz Bay, Netarts Bay, Tillamook Bay, and Nehalem Bay (Figure 1).

The criteria for inclusion in the supplement is based upon the biological significance of the systems as important habitats for West Coast estuarine dependent fisheries. The format for presentation parallels that of the original Volume 1, having both tabular and mapped components. A two page presentation for each system addresses the physical and hydrologic statistics, and spatial depictions of salinity zones and their variability, tide gauges, and head of tide, respectively. Certain enhancements such as volume by salinity zone and freshwater retention time as an indictator of flushing have been added. The later parameters for all NEI systems will constitute a future supplement.

The approaches used in data generation and compilation are consistent with Volume 1, and are included in the definitions and methods section. Similarly, a reference section is provided in the back.

## Definitions and Methods

Base Map, U.S. Geological Survey (USGS) topographic quadrangle maps (1:24,000), were used as a standard base to identify and map estuarine boundaries and features. The USGS maps were chosen because they clearly and consistently depict the boundaries of coastal drainage basins, identify numerous features important for plotting information, and provide reasonable coastline definition.

***Estuarine and Fluvial Drainage Areas.*** The estuarine drainage area (EDA) is that land and water component of an entire watershed that most directly affects an estuary. The purpose of identifying an estuarine drainage area is to establish the spatial unit for compiling biotic and abiotic estuarine attributes.

EDAs were defined based on the limits of tidal influence within an estuarine system and the boundaries of U.S. Geological Survey (USGS) hydrologic cataloging units. A hydrologic unit is a geographic area representing part or all of a surface drainage basin or a distinct hydrologic feature. Cataloging units, the smaller of four levels of hydrologic units, are usually greater than 700 square miles in area.

EDAs were drawn to coincide with hydrologic cataloging unit(s) that contain the heads of tide and seaward estuarine boundaries. In many cases, this means the EDA extends landward beyond the head of tide. In other more limited instances, the EDA may intersect a cataloging unit.

Where the EDA coincided with cataloging units, area estimates were obtained from USGS. In cases where the EDA did not coincide with cataloging unit boundaries, areas were measured with a planimeter to derive a value for the estuarine drainage area.

In addition to identifying the EDA, the fluvial drainage area (FDA) was determined by inspection of hydrologic unit maps and reviews of USGS state water resource reports. The FDA is the land and water portion of the entire watershed upstream of the EDA.

***Estuarine Surface Area.*** The surface water area of an estuary was estimated from the physical head of tide of the estuary and its tributaries to the mouth, where the estuary empties into an ocean, bay, gulf, sound, or other water body. Head of tide was interpreted from coastal ecological inventory maps prepared by the U.S. Fish and Wildlife Service (DOI, 1980-81, scale 1:250,000) and from graphics included in "Oregon's Estuaries" by Percy, Sutterlin, Bella and Klingeman (1974). These maps indicate areas of change in the distribution of living marine resources due to salinity concentrations and approximate the average point on a stream where surface water elevation is no longer influenced by the rise and fall of the tide. In addition, data were obtained from *U.S. Coast Pilots*, published by NOAA, and from USGS district offices, U.S. Army Corps of Engineers, and state water or natural resource agencies.

The seaward boundary for each estuary was determined by inspection of USGS hydrologic unit maps and NOAA nautical charts to identify significant physiographic characteristics and other features, such as barrier islands, rock outcrops, and man-made structures. If no clear physiographic limits existed, the charts were used to decipher bottom features that can affect circulation patterns and mixing processes.

These include overall bathymetry, sills, and reefs. The shoreline at mid-tide level was measured for each salinity zone.

***Estuary Length.*** Estuary length was delineated along the main axis of the estuary from the head of tide of the principal tributary stream to the midpoint of the estuary mouth or principal opening to the sea.

***Estuary Width.*** Average width was determined by measuring a series of regularly spaced perpendiculars to the main axis of the water body on NOAA nautical charts, drawn at mid-tide level, and averaged. The number of perpendiculars for an individual system was a function of estuary length and the shoreline irregularity. Maximum and minimum estuary widths were measured on NOAA nautical charts along perpendiculars to the main axis at approximately mid-tide level.

***Estuary Depth.*** Average estuary depth was calculated for each salinity zone by overlaying a transparent grid of equal horizontally- and vertically-spaced lines on NOAA nautical charts that show depth soundings. Depths were recorded at the intersection of these lines or interpolated, where necessary, and summed and divided by the number of intersections. Because depth soundings are recorded for low-water level, the final average depth was obtained by adding the difference in elevation between low-water datum and mid-tide elevation. In cases where NOAA charts did not exist, depths were cited from published reports or inferred from documented field surveys in which water column depths were recorded.

***Average Depth to Width Ratio.*** This parameter provides an indication of the depth of an estuary relative to its width. It was calculated as a ratio of the values obtained for average depth and average width.

***Estuary Classification.*** Estuaries are classified based upon the degree of salinity stratification, which is often used to infer circulation features. Salinity profiles are affected by such factors as the amount of freshwater inflow, the size and shape of the basin, and the effects of tides and winds. Since estuaries are dynamic, circulation patterns may vary and salinity structures will change as a result. When using any classification scheme, it is important to recognize this dynamic quality and to realize that generalizations concerning salinity profiles do not reflect such variability.

Stratification classification was determined for each estuary from published and unpublished data, and by consulting local experts. The classification assigned to an estuary is specific to the mixing zone of a system where freshwater interfaces with seawater. In certain cases, such as the estuaries in Maine, the area of the mixing zone is limited due to the strong oceanic influences. However, stratification occurs within this band as freshwater maintains its continuity over a limited distance before its dispersion into the seawater zone. Three classes of stratification based on the degree of vertical stratification are reported.

- Highly stratified (salt wedge estuary) - Very little mixing occurs between the surface and the bottom layers; mixing that does occur results from shear forces at the junction of upper and lower layers.
- Moderately stratified (surface salinity less than bottom salinity) - Significant mixing occurs between surface and bottom water and the dominant mixing agent is turbulence caused by tidal action.
- Vertically homogeneous (surface salinity equals bottom salinity) - An estuary is vertically homogeneous when tidal mixing and turbulence is sufficient to break down stratification.

***Estuarine Zones.*** Each estuary was subdivided into three zones between the heads of tide and the seaward boundaries based on average annual and depth-averaged salinity concentrations. Salinity zones are important to determine since they often dictate the distribution of biological communities and contribute to the understanding of estuarine circulation. These zones correspond to the following salinity regimes:

Approximate Salinity Ranges for
Estuarine Zones (parts per thousand)

| | |
|---|---|
| Tidal Fresh | 0.0 to 0.5 |
| Mixing | 0.5 to 25.0 |
| Seawater | 25.0 and greater |

Salinity data were obtained, and subsequent boundaries determined, from published and unpublished sources, and through consultation with experts.

Segmentation of an estuary on the basis of salinity is highly variable due to the many interacting factors affecting salinity concentrations, such as variations in freshwater inflow, wind and tides. Several guidelines were therefore developed to provide a uniform approach and to account for variability in data presentation.

First, episodic anomalies of salinity conditions that occur during low or high freshwater inflows were screened out to provide an average annual scenario of the system. Second, surface and bottom salinities were averaged. Finally, delineation between zones was depicted by a band which indicated the spatial variability which could be experienced over an annual cycle. Low, moderate, and high variability classifications are a function of the relative proportion of the variability to the length of the estuary. For example, an estuary with a length of five miles and salinity zone boundary of four miles, would be classified as highly variable.

***Estuarine Volume.*** Volume was estimated for each salinity zone at mid-tide level. This estimate is the product of the surface area and average depth for each zone.

***Freshwater Inflow.*** Flow statistics were determined for the entire drainage basin from flows measured by USGS flow gages, through estimation techniques for ungaged areas, and from records of significant diversions of flow regulations (dams) unaccounted for by flow gages. Long-term average flow and extreme low- and high-flow conditions were determined for each estuary. These conditions are used to characterize the hydrology of a system and are important for determining estuarine hydrodynamics.

***Flow Rates.*** Gaged flows. - Average for daily freshwater inflow for streams discharging to an estuary were obtained from the USGS WATSTORE hydrologic data base system. The statistics developed for each gage were long-term daily average flows calculated on an annual and monthly basis, 7-day, 10-year low flow, and the 50- and 100-year high flows. It was verified that no major flow regulations or diversions were constructed during the period of record which would have significant effect on flow.

Ungaged Flows. - Unit runoff factors (URF) were used to determine ungaged flows. The URF represents the ratio of gaged flow to the drainage contributing to this flow, calculated from nearby gaged areas that were comparable in size and land use to the ungaged area. The area of ungaged drainage was then multiplied by the URF to derive its flow contribution to the estuary. These additional flow data were then added to the gaged portion of a gaged stream, or were substituted for unacceptable gaged data.

***Flow Ratios.*** Flow ratio is the proportion of the volume of freshwater entering a coastal system during a tidal cycle to the volume of the tidal prism. This ratio provides an estimate of whether freshwater inflow or tidal influence is the dominant factor affecting the water body. Higher ratios indicate freshwater or riverine inputs dominate the system. Conversely, tidal domination is indicated by a small flow ratio value. Average annual, high- and low-flow period ratios were calculated for each estuary.

***Freshwater Retention Time.*** This parameter is based on Ketchum's (1955) fractional freshwater method. It is derived from the replacement of the freshwater component of the total system volume due to freshwater inflow. Volumes of fresh and saltwater are estimated for the three salinity zones, as depicted for each estuary and summed to obtain system totals. Computations are based on average annual freshwater inflow and salinity characteristics.

***Tides.*** Tides are grouped into two types based on the number of high and low tides per day, the relationship between the heights of successive highs or lows, and the time between corresponding high or low stands of sea level. The two types of tides are diurnal (one high and low per day) and semidiurnal (two highs and two lows per day). The tide type is reported for each estuary. In general, tides along the east and west coasts are semidiurnal and those along the Gulf of Mexico are diurnal or semidiurnal. The tidal period is either 12 hours and 25 minutes (semidiurnal), or 24 hours and 50 minutes (diurnal). The tidal range calculated for each estuary is the difference in water level between mean high water (MHW) and mean low water (MLW) for semidiurnal and diurnal tides. Tidal ranges were obtained from NOS tidal observation stations.

***Tidal Prism.*** The tidal prism is the volume of water entering a coastal system during flood tide, excluding freshwater inputs. Data for each estuary were obtained from NOS mean tidal range information and nautical charts. Tidal prisms were calculated using the cubature method (Jarrett, 1976). The cubature method takes into account the time required for a flood wave to propagate through the system, rather than assuming a uniform and simultaneous rise and fall of tide over the entire estuary.

Each estuary was segmented based upon areas that experience the same phase range. The phase range is defined as the difference in tidal elevation at a particular location relative to the occurrence of high and low tide at a tidal reference station, which is usually located at the mouth of the estuary. The time interval between two succeeding high and low tides represents the time during which water flows into the estuary. The surface water elevation at each tide gage station was plotted versus time for each station on a common chronological scale, assuming a 12-hour 25-minute period for semidiurnal tide and a 24-hour, 50-minute period for a diurnal tide. From this curve, the high and low water elevations for each tide gage were determined. The difference between these two elevations for a specific station represents its phase range.

After determining the phase range for each station, the estuary was segmented into subareas of approximately the same phase range. The mean surface area of each subarea was measured with a planimeter. The tidal prism for each subarea was then computed by multiplying the mid-tide water surface area for each subarea by the average phase range corresponding to that segment. The sum of the tidal prisms for each subarea is the average tidal prism volume for the estuary.

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Additional Information on NOAA's
National Estuarine Inventory is available from:

**Strategic Assessment Branch**
**Ocean Assessments Division**
**Office of Oceanography and Marine Assessment**
**National Ocean Service**
**National Oceanic and Atmospheric Administration**
**Rockville, MD 20852**

# National Estuarine Inventory: Supplement 1

## *Physical and Hydrologic Characteristics*
## ***The Oregon Estuaries***

Estuary Summaries

- *Rogue River*
- *Siuslaw Bay*
- *Alsea Bay*
- *Yaquina Bay*
- *Siletz Bay*
- *Netarts Bay*
- *Tillamook Bay*
- *Nehalem Bay*

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## Drainage Areas (sq. mi.)

| | |
|---|---|
| Estuarine Drainage Area (EDA) | 898 |
| Fluvial Drainage Area (FDA) | 4,235 |
| Total Drainage Area | 5,133 |

## Dimensions

| | | |
|---|---|---|
| Length (mi.) | | 6.0 |
| Average Depth (ft.) | | 4.6 |
| Width (mi.) | Average | 0.2 |
| | Minimum | 0.1 |
| | Maximum | 0.5 |
| Average Depth to Width Ratio (unitless) | | 0.010 |

| | Avg. Depth (ft.) | Area (sq. mi.) | Volume (cu. ft.) |
|---|---|---|---|
| Tidal Fresh | 4.0 | 0.190 | $2.118 \times 10^7$ |
| Mixing | 4.0 | 0.645 | $7.193 \times 10^7$ |
| Seawater | 12.0 | 0.066 | $2.208 \times 10^7$ |
| Total | - | 0.901 | $1.151 \times 10^8$ |

## Freshwater Inflow (1,000 cfs)

| | |
|---|---|
| Period of Record | 1961-1986 |
| Long Term Average Daily Discharge | 10.6 |
| Long Term Average Monthly Discharge: | |

| | | | |
|---|---|---|---|
| Jan | 24.2 | Jul | 2.5 |
| Feb | 20.1 | Aug | 2.0 |
| Mar | 18.1 | Sep | 1.9 |
| Apr | 12.5 | Oct | 3.0 |
| May | 8.5 | Nov | 11.1 |
| Jun | 4.4 | Dec | 21.0 |

| | | |
|---|---|---|
| 7 Day, 10 Year Low Flow | | 1.0 |
| 50 Year Flood | | 564.1 |
| 100 Year Flood | | 641.3 |
| Flow Ratios | Average Annual | 2.433 |
| | 3 - Month High Flow Period | 5.014 |
| | 3 - Month Low Flow Period | 0.492 |
| Freshwater Retention Time (days) | | 0 |

Abbreviations: cfs, cubic feet per second; cu. ft, cubic feet; sq. mi., square miles; VH, vertically homogeneous; MS, moderately stratified; HS, highly stratified; NA, not applicable; ND, No Data.

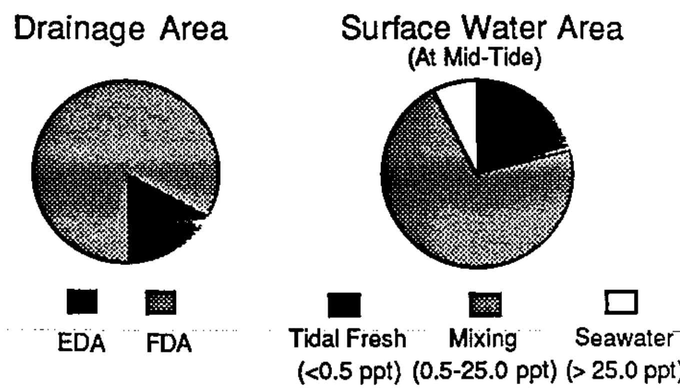
The Rogue River estuary is a river dominated system. The Rogue River has been dammed since 1977, affecting its freshwater inflow during the summer months. Consequently the tidal fresh zone may move seaward from the area shown on the map. Head of tide is usually near Elephant Rock, extreme tides push it back to Johns Hole.

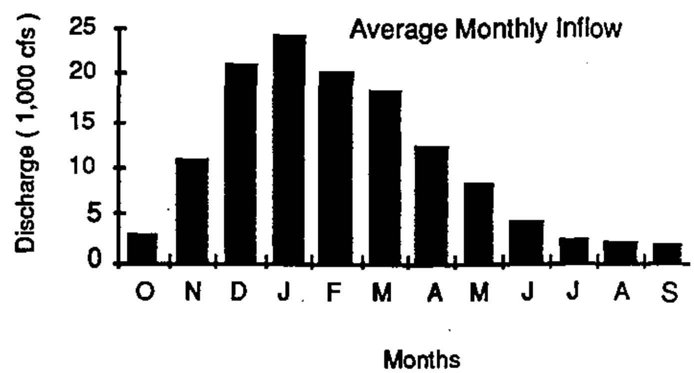
## Tides

| | | | |
|---|---|---|---|
| Prevailing Tide | | | Semidiurnal |
| Tidal Prism Volume (cu. ft.) | | | $9.75 \times 10^7$ |
| Tide Ranges (ft.) | Station | Gauge Number | Range |
| | A | 809 | 4.8 |

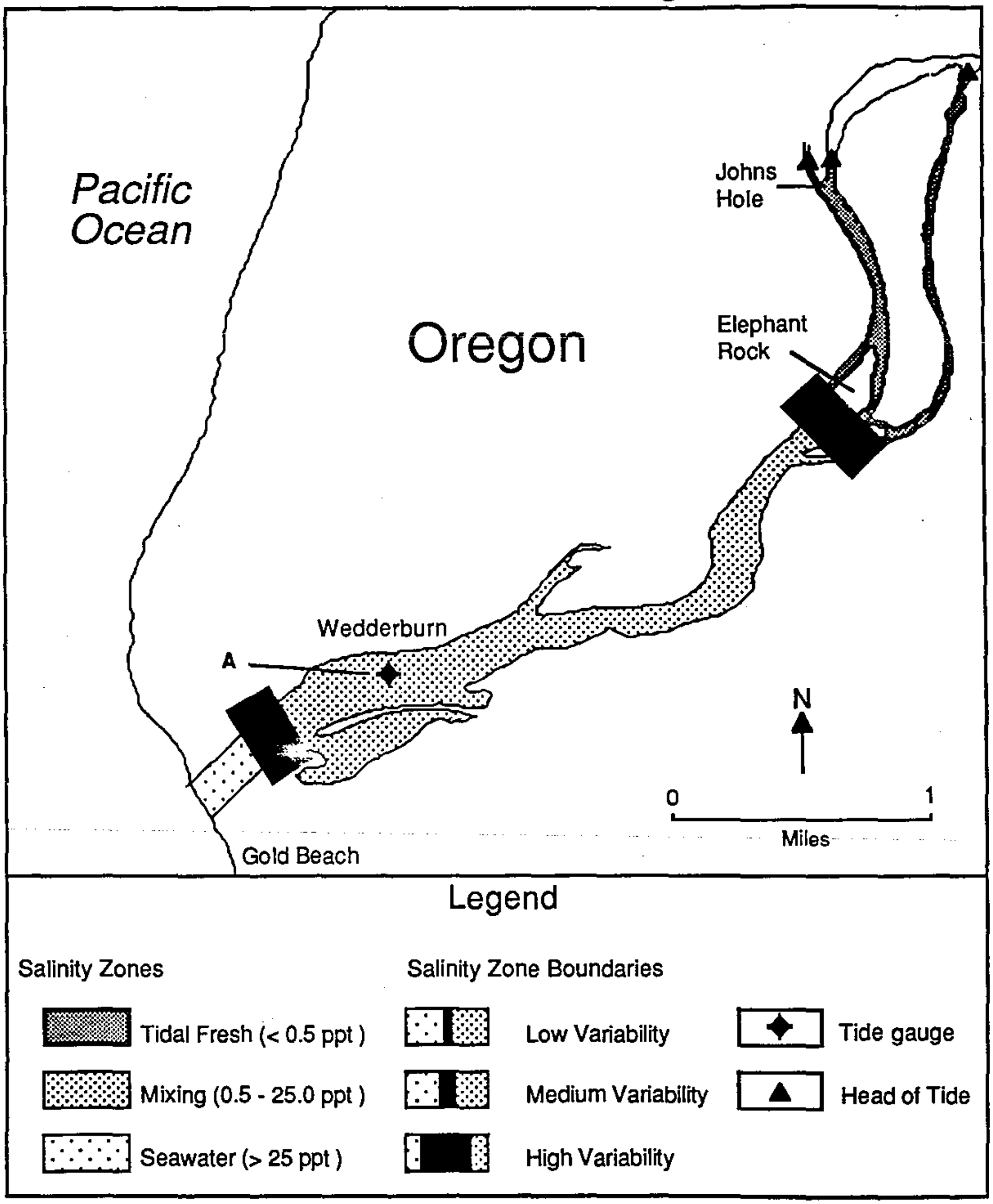
## Stratification

| | |
|---|---|
| 3- Month High Flow Classification | HS |
| 3- Month Low Flow Classification | MS |



# 4.15 Rogue River CA, OR

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## Drainage Areas (sq. mi.)

| | |
|---|---|
| Estuarine Drainage Area | 769 |
| Fluvial Drainage Area | 0 |
| Total Drainage Area | 769 |

## Dimensions

| | | |
|---|---|---|
| Length (mi.) | | 26.0 |
| Average Depth (ft.) | | 9.0 |
| Width (mi.) | Average | 0.1 |
| | Minimum | 0.0* |
| | Maximum | 0.4 |
| Average Depth to Width Ratio (unitless) | | 0.017 |

| | Avg. Depth (ft.) | Area (sq. mi.) | Volume (cu. ft.) |
|---|---|---|---|
| Tidal Fresh | 6.0 | 0.397 | $6.641 \times 10^7$ |
| Mixing | 9.2 | 2.781 | $7.133 \times 10^8$ |
| Seawater | 11.6 | 0.662 | $2.141 \times 10^8$ |
| Total | - | 3.840 | $9.635 \times 10^8$ |

## Freshwater Inflow (1,000 cfs)

| | |
|---|---|
| Period of Record | 1968-1986 |
| Long Term Average Daily Discharge | 3.0 |
| Long Term Average Monthly Discharge: | |

| | | | |
|---|---|---|---|
| Jan | 7.1 | Jul | 0.4 |
| Feb | 6.0 | Aug | 0.2 |
| Mar | 4.8 | Sep | 0.3 |
| Apr | 3.0 | Oct | 0.7 |
| May | 1.5 | Nov | 3.7 |
| Jun | 0.8 | Dec | 7.7 |

| | | |
|---|---|---|
| 7 Day, 10 Year Low Flow | | 0.1 |
| 50 Year Flood | | 82.8 |
| 100 Year Flood | | 90.6 |
| Flow Ratios | Average Annual | 0.174 |
| | 3 - Month High Flow Period | 0.400 |
| | 3 - Month Low Flow Period | 0.051 |
| Freshwater Retention Time ( days ) | | 2 |

Abbreviations: cfs, cubic feet per second; cu. ft, cubic feet; sq. mi., square miles; VH, vertically homogeneous; MS, moderately stratified; HS, highly stratified; NA, not applicable; EDA, estuarine drainage area; FDA, fluvial drainage area.

** Actual width is 0.02 mi.*

The Siuslaw Bay estuary is a river dominated system with the Siuslaw River being its main tributary. Between 30-40% of its surface area at High tide, is dominated by tidal flats, with it being more extensive upstream and nearly nonexistent in the lower parts of the estuary. Head of Tide extends to mile 25 of the Siuslaw River.

## Tides

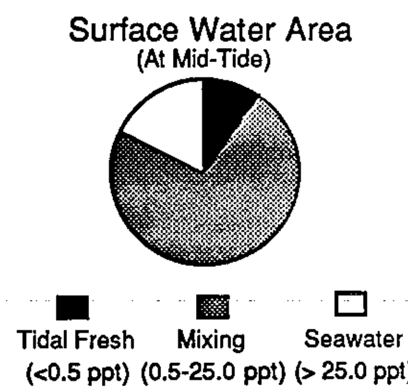
| | |
|---|---|
| Prevailing Tide | Semidiurnal |
| Tidal Prism Volume ( cu. ft. ) | $4.18 \times 10^8$ |

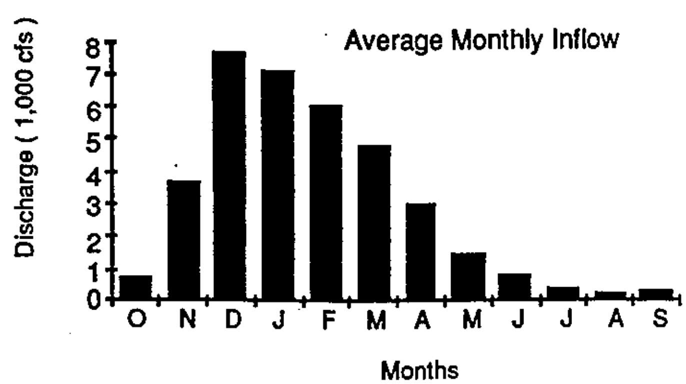
Tide Ranges ( ft.)

| Station | Gauge number | Range |
|---|---|---|
| A | 827 | 5.5 |
| B | 829 | 4.8 |

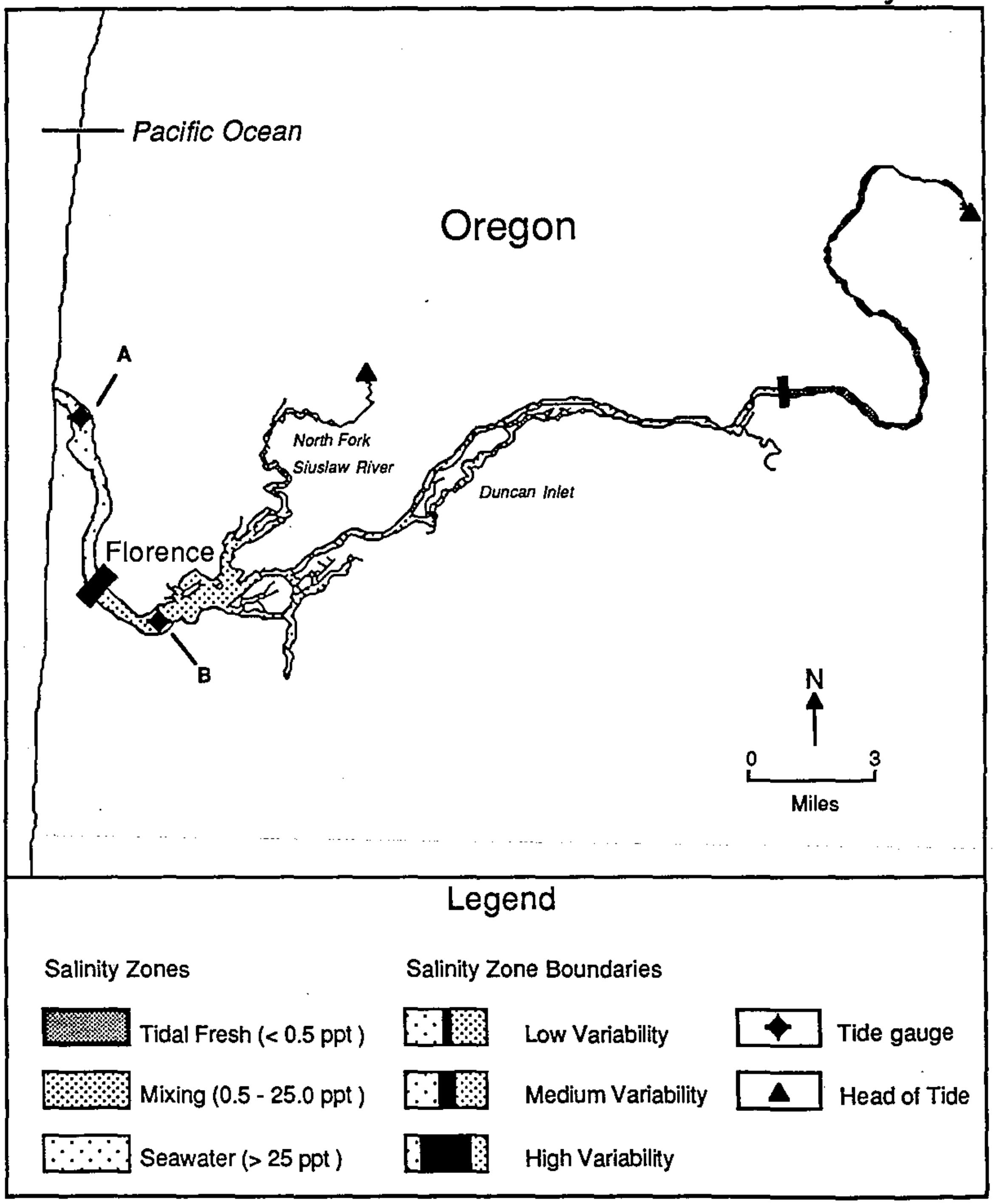
## Stratification

| | |
|---|---|
| 3- Month High Flow Classification | HS |
| 3- Month Low Flow Classification | VH |

# 4.16 Siuslaw Bay OR

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## Drainage Areas (sq. mi.)

| | |
|---|---|
| Estuarine Drainage Area | 480 |
| Fluvial Drainage Area | 0 |
| Total Drainage Area | 480 |

## Dimensions

| | | |
|---|---|---|
| Length (mi.) | | 14.0 |
| Average Depth (ft.) | | 6.5 |
| Width (mi.) | Average | 0.4 |
| | Minimum | 0.1 |
| | Maximum | 1.1 |
| Average Depth to Width Ratio (unitless) | | 0.003 |

| | Avg. Depth (ft.) | Area (sq. mi.) | Volume (cu. ft.) |
|---|---|---|---|
| Tidal Fresh | 4.3 | 0.132 | $1.582 \times 10^7$ |
| Mixing | 9.7 | 1.060 | $2.866 \times 10^8$ |
| Seawater | 4.3 | 1.325 | $1.588 \times 10^8$ |
| Total | - | 2.517 | $4.561 \times 10^8$ |

## Freshwater Inflow (1,000 cfs)

| | |
|---|---|
| Period of Record | 1940-1986 |
| Long Term Average Daily Discharge | 2.3 |
| Long Term Average Monthly Discharge: | |

| | | | |
|---|---|---|---|
| Jan | 5.1 | Jul | 0.3 |
| Feb | 4.9 | Aug | 0.2 |
| Mar | 4.4 | Sep | 0.2 |
| Apr | 2.1 | Oct | 0.6 |
| May | 1.3 | Nov | 2.6 |
| Jun | 0.6 | Dec | 4.7 |

| | | |
|---|---|---|
| 7 Day, 10 Year Low Flow | | 0.1 |
| 50 Year Flood | | 63.7 |
| 100 Year Flood | | 69.5 |
| Flow Ratios | Average Annual | 0.143 |
| | 3 - Month High Flow Period | 0.311 |
| | 3 - Month Low Flow Period | 0.014 |
| Freshwater Retention Time (days) | | 1 |

Abbreviations: cfs, cubic feet per second; cu. ft, cubic feet; sq. mi., square miles; VH, vertically homogeneous; MS, moderately stratified; HS, highly stratified; NA, not applicable; EDA, estuarine drainage area; FDA, fluvial drainage area.

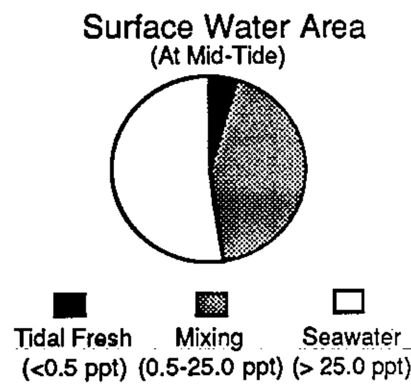
Alsea Bay estuary is a river dominated system with two tributaries; the Alsea River, and Drift Creek, with the Alsea River being the dominant one. Alsea Bay has extensive tidal flats that cover 46% percent of its surface area (measured at High tide).

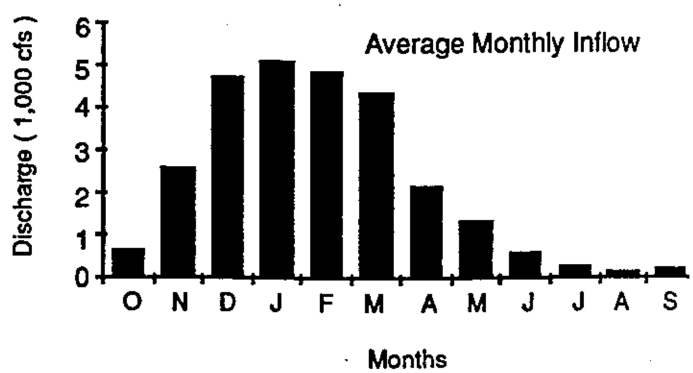
## Tides

| | | | |
|---|---|---|---|
| Prevailing Tide | | | Semidiurnal |
| Tidal Prism Volume (cu. ft.) | | | $4.06 \times 10^8$ |
| Tide Ranges (ft.) | Station | Gauge Number | Range |
| | A | 831 | 5.8 |

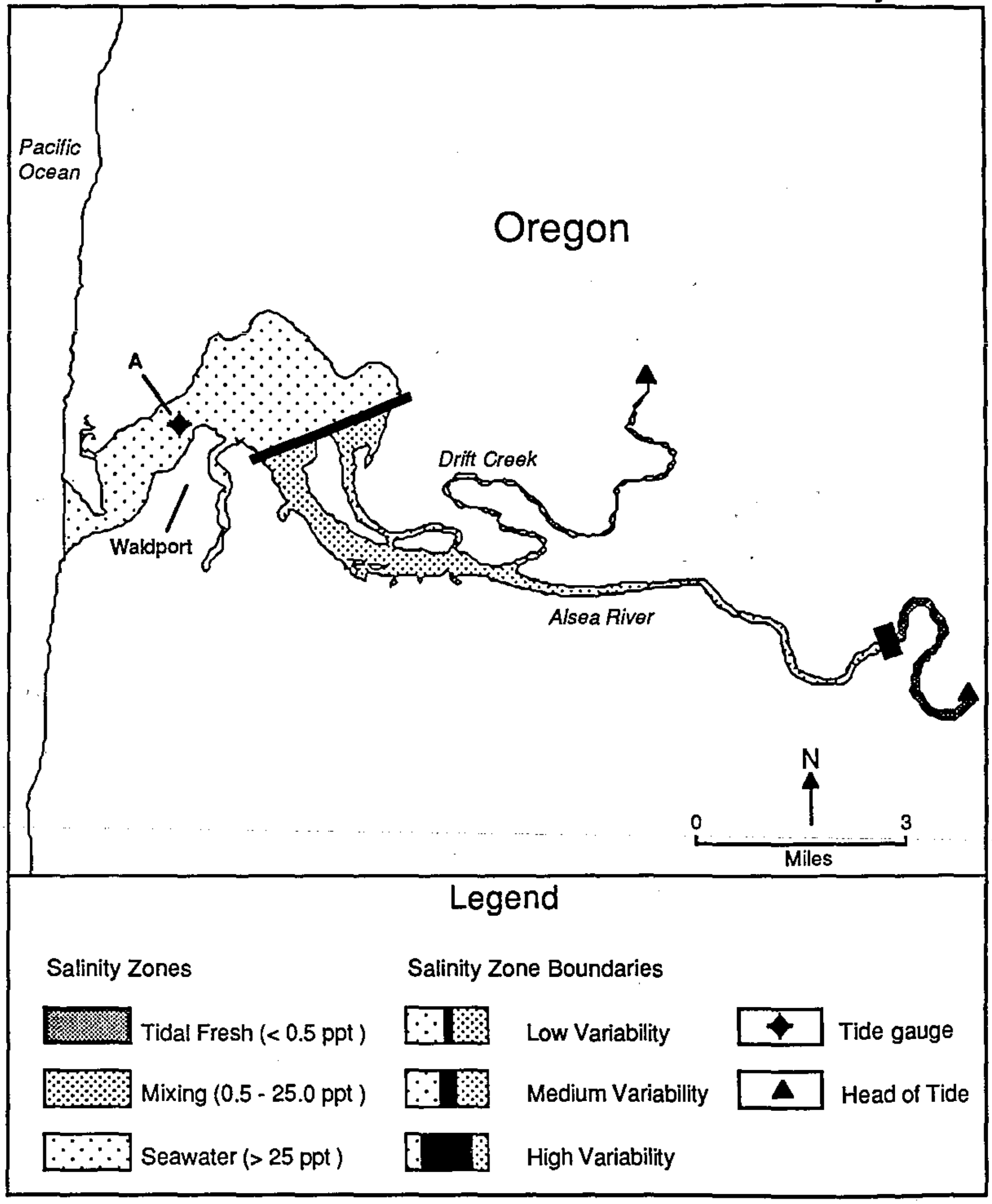
## Stratification

| | |
|---|---|
| 3- Month High Flow Classification | MS |
| 3- Month Low Flow Classification | MS |

# 4.17 Alsea Bay OR

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## Drainage Areas (sq. mi.)

| | |
|---|---|
| Estuarine Drainage Area | 254 |
| Fluvial Drainage Area | 0 |
| Total Drainage Area | 254 |

## Dimensions

| | | |
|---|---|---|
| Length (mi.) | | 23.0 |
| Average Depth (ft.) | | 9.9 |
| Width (mi.) | Average | 0.2 |
| | Minimum | 0.0* |
| | Maximum | 0.3 |
| Average Depth to Width Ratio (unitless) | | 0.011 |

| | Avg. Depth (ft.) | Area (sq. mi.) | Volume (cu. ft.) |
|---|---|---|---|
| Tidal Fresh | 3.0 | 0.132 | $1.104 \times 10^7$ |
| Mixing | 8.5 | 2.252 | $5.336 \times 10^8$ |
| Seawater | 10.9 | 2.649 | $8.050 \times 10^8$ |
| Total | - | 5.033 | $1.389 \times 10^9$ |

## Freshwater Inflow (1,000 cfs)

| | |
|---|---|
| Period of Record | 1961 - 1986 |
| Long Term Average Daily Discharge | 1.0 |
| Long Term Average Monthly Discharge: | |

| | | | |
|---|---|---|---|
| Jan | 2.0 | Jul | 0.1 |
| Feb | 1.9 | Aug | 0.0 |
| Mar | 1.4 | Sep | 0.1 |
| Apr | 1.2 | Oct | 0.1 |
| May | 0.5 | Nov | 1.3 |
| Jun | 0.3 | Dec | 2.4 |

| | | |
|---|---|---|
| 7 Day, 10 Year Low Flow | | 0.0 |
| 50 Year Flood | | 22.1 |
| 100 Year Flood | | 23.9 |
| Flow Ratios | Average Annual | 0.026 |
| | 3 - Month High Flow Period | 0.056 |
| | 3 - Month Low Flow Period | 0.002 |
| Freshwater Retention Time ( days ) | | 5 |

Abbreviations: cfs, cubic feet per second; cu. ft, cubic feet; sq. mi., square miles; VH, vertically homogeneous; MS, moderately stratified; HS, highly stratified; NA, not applicable; EDA, estuarine drainage area; FDA, fluvial drainage area.
** Actual width is 0.02 mi.*

Yaquina bay is a river dominated system who's area is primarily its tributary, the Yaquina River. The estuary contains tidal flats that cover between 40-60% of its surface area (measured at high tide). Head of Tide is twenty six miles inland from the mouth.

## Tides

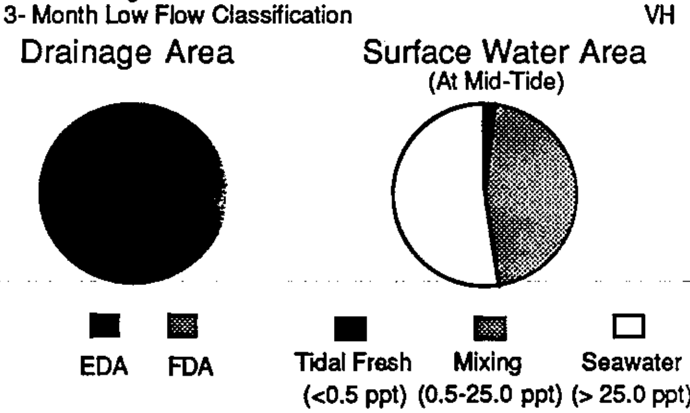
| | |
|---|---|
| Prevailing Tide | Semidiurnal |
| Tidal Prism Volume ( cu. ft. ) | $8.42 \times 10^8$ |

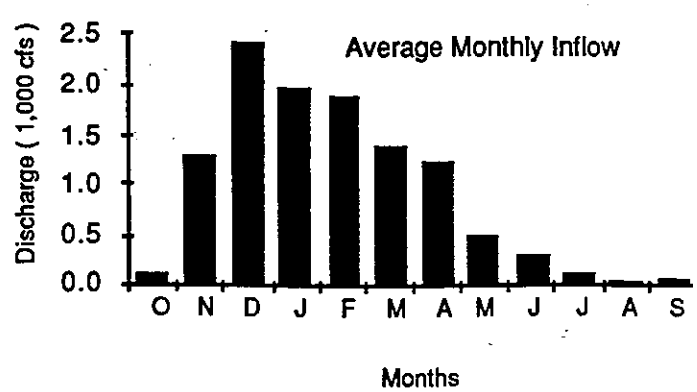
Tide Ranges ( ft. )

| Station | Gauge Number | Range |
|---|---|---|
| A | 833 | 5.9 |
| B | 835 | 6.0 |
| C | 837 | 6.3 |
| D | 839 | 6.2 |
| E | 841 | 6.2 |
| F | 843 | 6.1 |

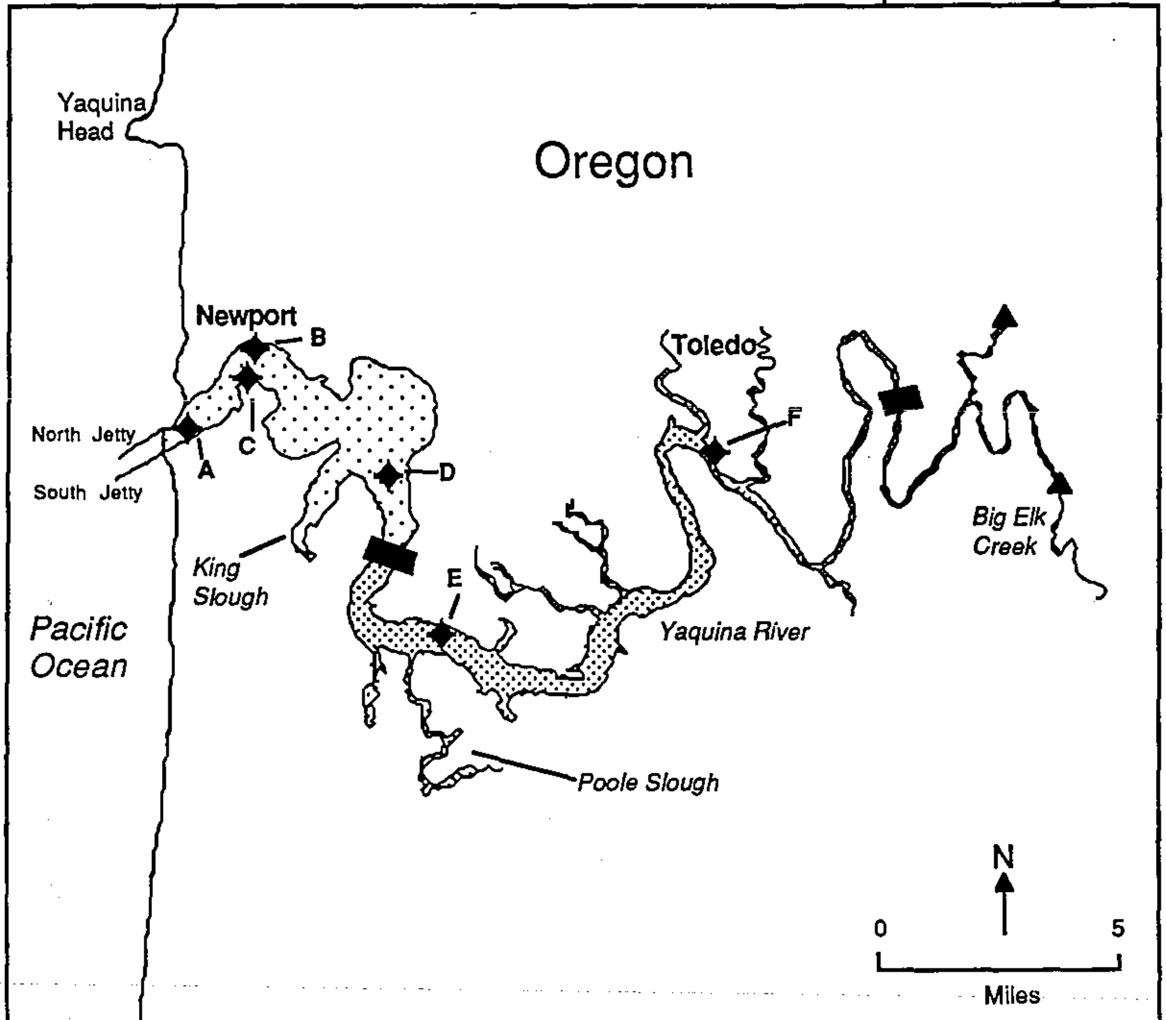
## Stratification

| | |
|---|---|
| 3- Month High Flow Classification | MS |
| 3- Month Low Flow Classification | VH |



# 4.18 Yaquina Bay OR




## Legend

**Salinity Zones**

- Tidal Fresh (< 0.5 ppt)
- Mixing (0.5 - 25.0 ppt)
- Seawater (> 25 ppt)

**Salinity Zone Boundaries**

- Low Variability
- Medium Variability
- High Variability

- Tide gauge
- Head of Tide

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## Drainage (sq. mi.)

| | |
|---|---|
| Estuarine Drainage Area | 372 |
| Fluvial Drainage Area | 0 |
| Total Drainage Area | 372 |

## Dimensions

| | | |
|---|---|---|
| Length (mi.) | | 24.2 |
| Average Depth (ft.) | | 8.1 |
| Width (mi.) | Average | 0.1 |
| | Minimum | 0.0* |
| | Maximum | 0.3 |
| Average Depth to Width Ratio (unitless) | | 0.025 |

| | Avg. Depth (ft.) | Area (sq. mi.) | Volume (cu. ft.) |
|---|---|---|---|
| Tidal Fresh | 7.9 | 0.530 | $1.167 \times 10^8$ |
| Mixing | 8.6 | 1.325 | $3.177 \times 10^8$ |
| Seawater | 6.0 | 0.265 | $4.433 \times 10^7$ |
| Total | - | 2.120 | $4.787 \times 10^8$ |

## Freshwater (1,000 cfs)

| | |
|---|---|
| Period of Record | 1906-1986 |
| Long Term Average Daily Discharge | 2.8 |
| Long Term Average Monthly Discharge: | |

| | | | |
|---|---|---|---|
| Jan | 6.0 | Jul | 0.4 |
| Feb | 5.4 | Aug | 0.2 |
| Mar | 4.1 | Sep | 0.4 |
| Apr | 2.7 | Oct | 1.3 |
| May | 1.5 | Nov | 4.3 |
| Jun | 0.9 | Dec | 6.0 |

| | | |
|---|---|---|
| 7 Day, 10 Year Low Flow | | 0.1 |
| 50 Year Flood | | 63.9 |
| 100 Year Flood | | 67.7 |
| Flow Ratios | Average Annual | 0.160 |
| | 3 - Month High Flow Period | 0.335 |
| | 3 - Month Low Flow Period | 0.020 |
| Freshwater Retention Time (days) | | 2 |

Abbreviations: cfs, cubic feet per second; cu. ft, cubic feet; sq. mi., square miles; VH, vertically homogeneous; MS, moderately stratified; HS, highly stratified; NA, not applicable; EDA, estuarine drainage area; FDA, fluvial drainage area.

** Actual width is 0.02 mi.*

Siletz bay is a river dominated estuary with the Siletz River being its major tributary. Head of Tide on the Siletz river is 24.2 miles from the mouth of the estuary. The estuary is dominated by tidal flats.

## Tides

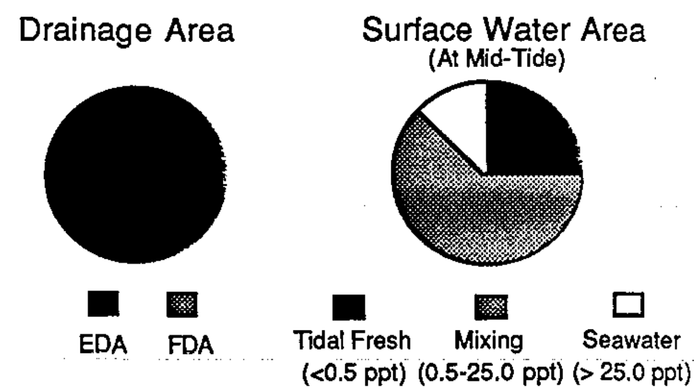
| | |
|---|---|
| Prevailing Tide | Semidiurnal |
| Tidal Prism Volume (cu. ft.) | $2.13 \times 10^8$ |

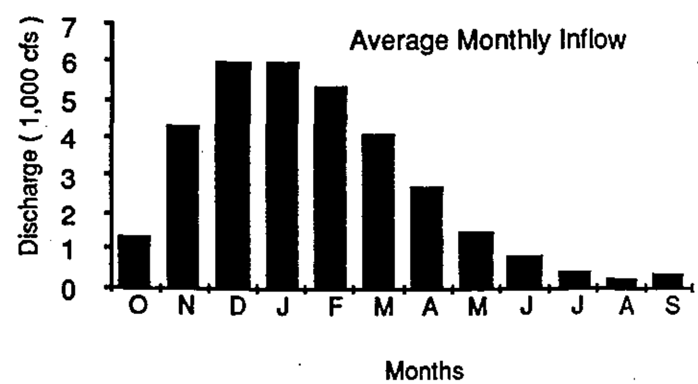
Tide Ranges (ft.)

| Station | Gauge Number | Range |
|---|---|---|
| A | 845 | 5.0 |
| B | 847 | 4.4 |

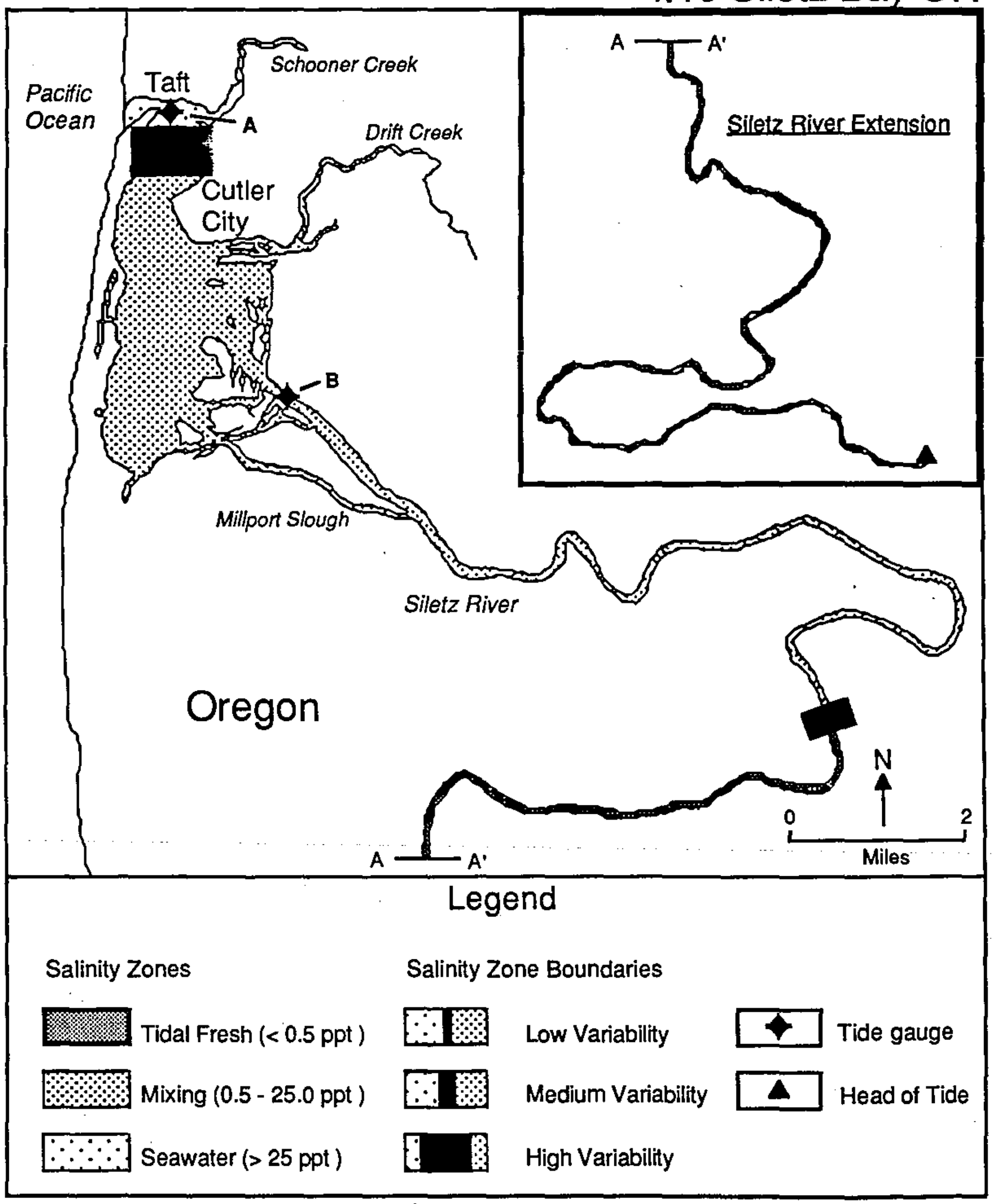
## Stratification

| | |
|---|---|
| 3- Month High Flow Classification | HS |
| 3- Month Low Flow Classification | VH |



# 4.19 Siletz Bay OR

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# National Estuarine Inventory: Supplement 1

| Drainage Areas (sq. mi.) | |
|---|---|
| Estuarine Drainage Area | 14 |
| Fluvial Drainage Area | 0 |
| Total Drainage Area | 14 |

| Dimensions | | | |
|---|---|---|---|
| Length (mi.) | | | 5.3 |
| Average Depth (ft.) | | | 4.7 |
| Width (mi.) | Average | | 0.5 |
| | Minimum | | 0.2 |
| | Maximum | | 0.7 |
| Average Depth to Width Ratio (unitless) | | | 0.002 |

| | Avg. Depth (ft.) | Area (sq. mi.) | Volume (cu. ft.) |
|---|---|---|---|
| Tidal Fresh | 0.0 | 0.0 | 0.0 |
| Mixing | 0.0 | 0.0 | 0.0 |
| Seawater | 4.7 | 2.250 | $2.948 \times 10^8$ |
| Total | - | 2.250 | $2.948 \times 10^8$ |

**Freshwater Inflow (1,000 cfs)**

| | |
|---|---|
| Period of Record | NA |
| Long Term Average Daily Discharge | 0.1 |
| Long Term Average Monthly Discharge: | |

| | | | |
|---|---|---|---|
| Jan | 0.2 | Jul | 0.0 |
| Feb | 0.2 | Aug | 0.0 |
| Mar | 0.2 | Sep | 0.0 |
| Apr | 0.1 | Oct | 0.0 |
| May | 0.1 | Nov | 0.2 |
| Jun | 0.0 | Dec | 0.2 |

| | | |
|---|---|---|
| 7 Day, 10 Year Low Flow | | 0.0 |
| 50 Year Flood | | ND |
| 100 Year Flood | | ND |
| Flow Ratios | Average Annual | 0.013 |
| | 3 - Month High Flow Period | 0.026 |
| | 3 - Month Low Flow Period | 0.002 |
| Freshwater Retention Time ( days ) | | 4 |

Abbreviations: cfs, cubic feet per second; cu. ft, cubic feet; sq. mi., square miles; VH, vertically homogeneous; MS, moderately stratified; HS, highly stratified; NA, not applicable; EDA, estuarine drainage area; FDA, fluvial drainage area.

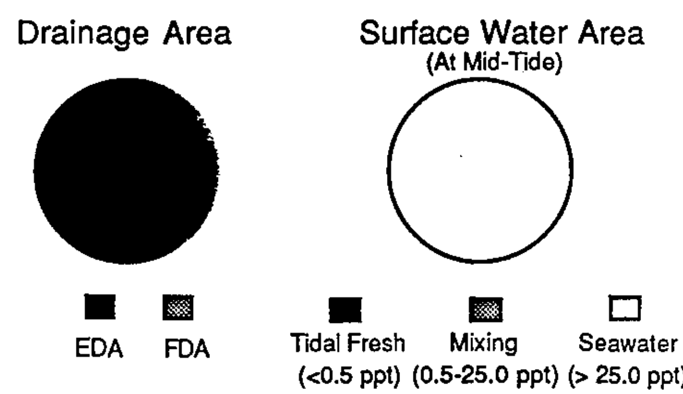
Netarts bay is a shallow estuary dominated by extensive tidal flats that cover between 65-90% of its surface area (measured at high tide). It has only twelve small creeks as its tributaries. The estuary's circulation is controlled mainly by tide and wind.

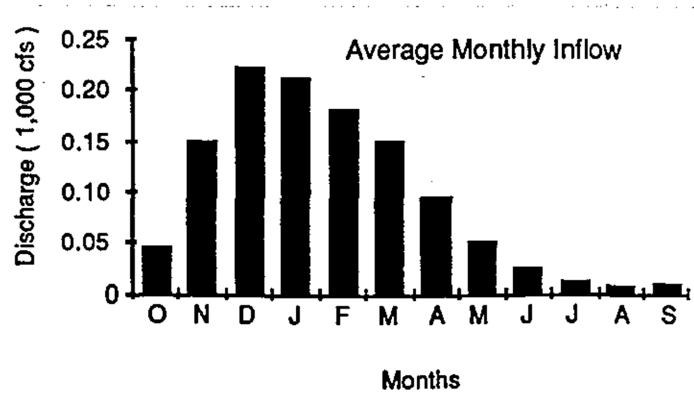
**Tides**

| | | | |
|---|---|---|---|
| Prevailing Tide | | | Semidiurnal |
| Tidal Prism Volume ( cu. ft. ) | | | $1.79 \times 10^8$ |
| Tide Ranges ( ft.) | Station | Gauge Number | Range |
| | Based on Barview Gauge Number 851 (not shown) | | 5.7 |

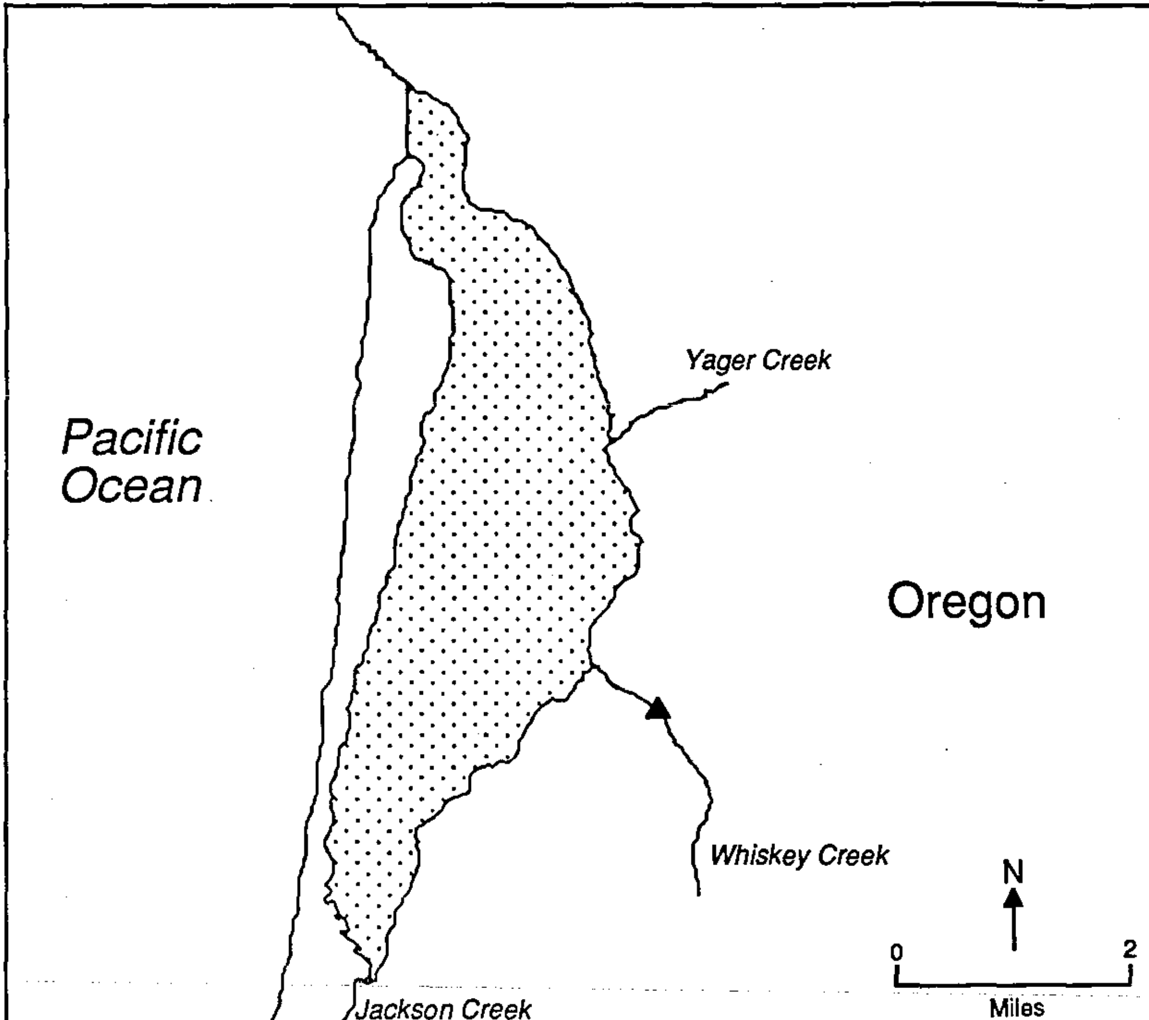
**Stratification**

| | |
|---|---|
| 3- Month High Flow Classification | VH |
| 3- Month Low Flow Classification | VH |



# 4.20 Netarts Bay OR




## Legend

**Salinity Zones**

- Tidal Fresh (< 0.5 ppt )
- Mixing (0.5 - 25.0 ppt )
- Seawater (> 25 ppt )

**Salinity Zone Boundaries**

- Low Variability
- Medium Variability
- High Variability

- Tide gauge
- Head of Tide

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# National Estuarine Inventory: Supplement 1

## Drainage Areas (sq. mi.)

| | |
|---|---|
| Estuarine Drainage Area | 571 |
| Fluvial Drainage Area | 0 |
| Total Drainage Area | 571 |

## Dimensions

| | | |
|---|---|---|
| Length (mi.) | | 7.8 |
| Average Depth (ft) | | 6.0 |
| Width (mi.) | Average | 1.9 |
| | Minimum | 0.3 |
| | Maximum | 3.2 |
| Average Depth to Width Ratio (unitless) | | 0.001 |

| | Avg. Depth (ft) | Area (sq. mi.) | Volume (cu. ft) |
|---|---|---|---|
| Tidal Fresh | 5.0 | 0.530 | $7.388 \times 10^7$ |
| Mixing | 5.0 | 6.755 | $9.416 \times 10^8$ |
| Seawater | 7.7 | 3.974 | $8.531 \times 10^8$ |
| Total | - | 11.259 | $1.883 \times 10^9$ |

## Freshwater Inflow (1,000 cfs)

| | |
|---|---|
| Period of Record | 1915 - 1986 |
| Long Term Average Daily Discharge | 3.9 |
| Long Term Average Monthly Discharge: | |

| Month | | Month | |
|---|---|---|---|
| Jan | 8.4 | Jul | 0.6 |
| Feb | 7.2 | Aug | 0.4 |
| Mar | 5.9 | Sep | 0.5 |
| Apr | 3.8 | Oct | 1.9 |
| May | 2.1 | Nov | 5.9 |
| Jun | 1.1 | Dec | 8.8 |

| | | |
|---|---|---|
| 7 Day, 10 Year Low Flow | | 0.2 |
| 50 Year Flood | | 111.8 |
| 100 Year Flood | | 122.9 |
| Flow Ratios | Average Annual | 0.068 |
| | 3 - Month High Flow Period | 0.143 |
| | 3 - Month Low Flow Period | 0.009 |
| Freshwater Retention Time ( days ) | | 2 |

Abbreviations: cfs, cubic feet per second; cu. ft, cubic feet; sq. mi., square miles; VH, vertically homogeneous; MS, moderately stratified; HS, highly stratified; NA, not applicable; EDA, estuarine drainage area; FDA, fluvial drainage area.

Tillamook bay is a shallow river dominated system where 50-60% of its water surface area( meassured at high tide) is tidal flat. the majority of the freshwater comes from five major tributaries: The Maimi , the Kilchis, the Wilson, the Trask, and the Tillamook Rivers.

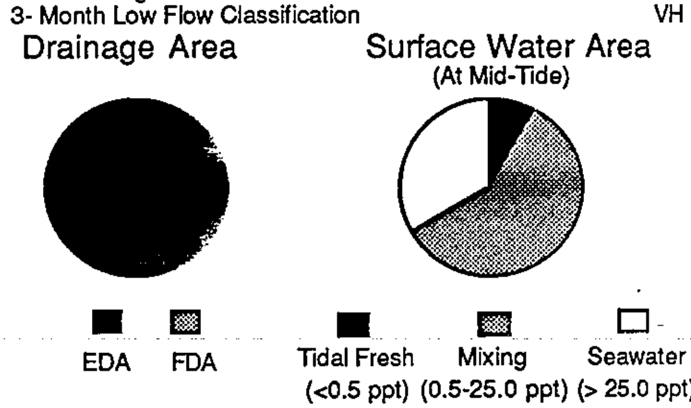
## Tides

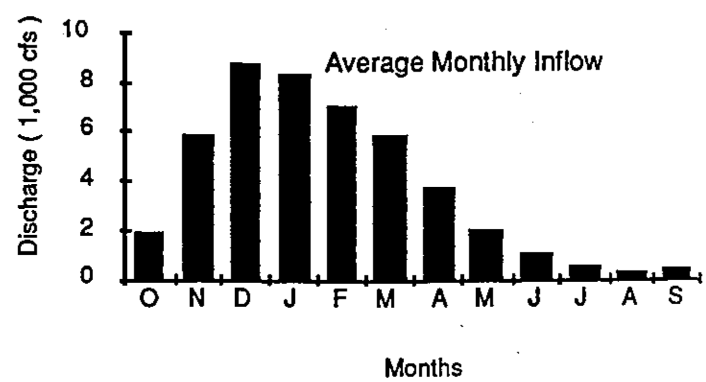
| | | |
|---|---|---|
| Prevailing Tide | | Semidiurnal |
| Tidal Prism Volume ( cu. ft. ) | | $1.70 \times 10^9$ |

| Tide Ranges ( ft ) Station | Gauge Number | Range |
|---|---|---|
| A | 851 | 5.7 |
| B | 853 | 5.8 |
| C | 855 | 5.2 |
| D | 857 | 5.2 |
| E | 859 | 4.8 |

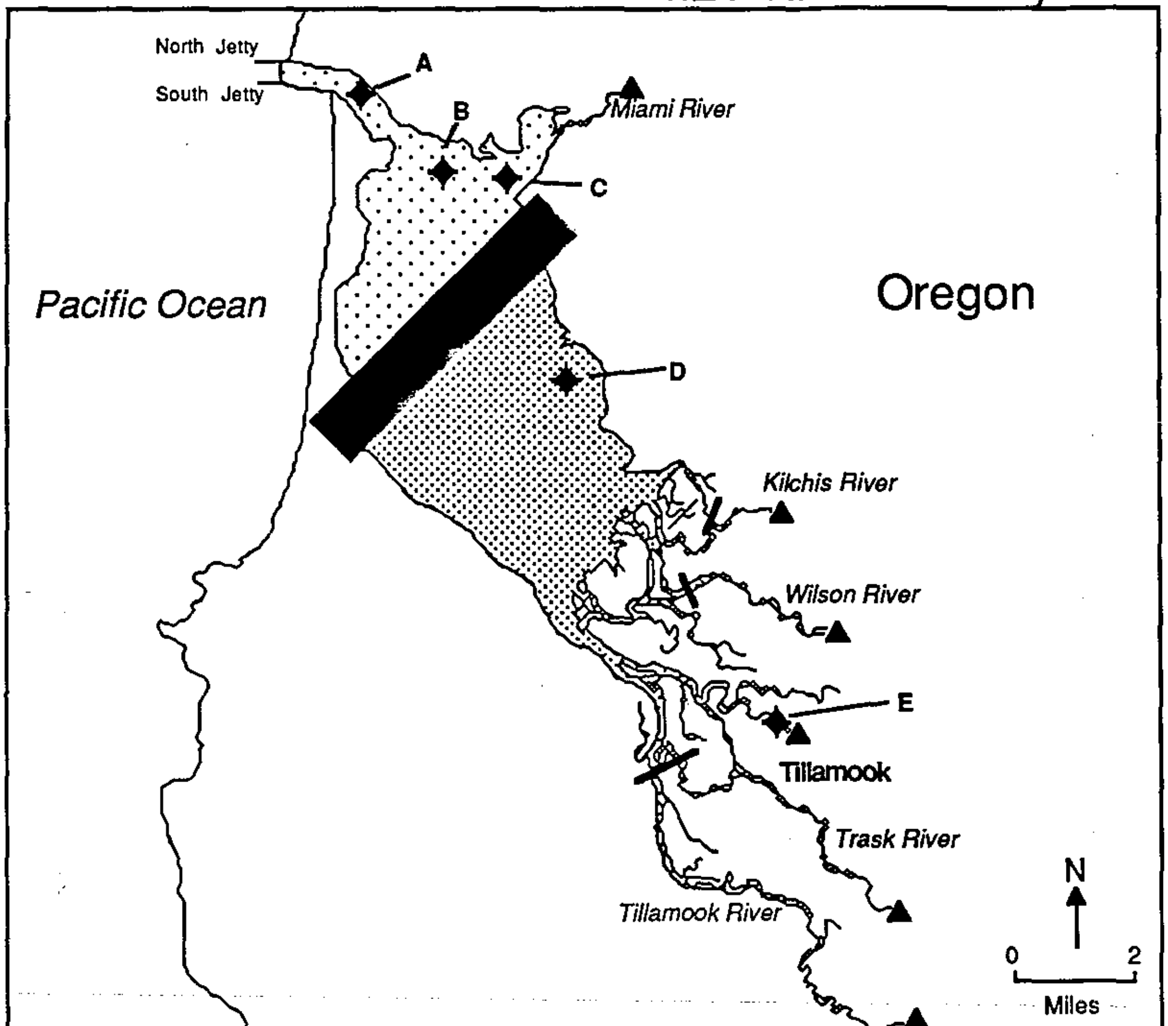
## Stratification

| | |
|---|---|
| 3- Month High Flow Classification | HS |
| 3- Month Low Flow Classification | VH |



# 4.21 Tillamook Bay OR




## Legend

**Salinity Zones**

- Tidal Fresh (< 0.5 ppt)
- Mixing (0.5 - 25.0 ppt)
- Seawater (> 25 ppt)

**Salinity Zone Boundaries**

- Low Variability
- Medium Variability
- High Variability

- Tide gauge
- Head of Tide

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# National Estuarine Inventory: Supplement 1

## Drainage Areas (sq. mi.)

| | |
|---|---|
| Estuarine Drainage Area | 860 |
| Fluvial Drainage Area | 0 |
| Total Drainage Area | 860 |

## Dimensions

| | | |
|---|---|---|
| Length (mi.) | | 7.9 |
| Average Depth (ft.) | | 7.3 |
| Width (mi.) | Average | 0.4 |
| | Minimum | 0.1 |
| | Maximum | 1.0 |
| Average Depth to Width Ratio (unitless) | | 0.004 |

| | Avg. Depth (ft.) | Area (sq. mi.) | Volume (cu. ft.) |
|---|---|---|---|
| Tidal Fresh | 8.5 | 0.025 | $5.924 \times 10^6$ |
| Mixing | 6.6 | 2.119 | $3.889 \times 10^8$ |
| Seawater | 13.1 | 0.265 | $9.678 \times 10^7$ |
| Total | - | 2.409 | $4.903 \times 10^8$ |

## Freshwater Inflow (1,000 cfs)

| | |
|---|---|
| Period of Record | 1940- 1986 |
| Long Term Average Daily Discharge | 3.4 |

Long Term Average Monthly Discharge:

| | | | |
|---|---|---|---|
| Jan | 8.0 | Jul | 0.3 |
| Feb | 7.4 | Aug | 0.2 |
| Mar | 5.5 | Sep | 0.3 |
| Apr | 3.3 | Oct | 1.1 |
| May | 1.6 | Nov | 4.6 |
| Jun | 0.7 | Dec | 8.0 |

| | | |
|---|---|---|
| 7 Day, 10 Year Low Flow | | 0.1 |
| 50 Year Flood | | 62.6 |
| 100 Year Flood | | 67.2 |
| Flow Ratios | Average Annual | 0.205 |
| | 3 - Month High Flow Period | 0.264 |
| | 3 - Month Low Flow Period | 0.017 |
| Freshwater Retention Time ( days ) | | 1 |

Abbreviations: cfs, cubic feet per second; cu. ft, cubic feet; sq. mi., square miles; VH, vertically homogeneous; MS, moderately stratified; HS, highly stratified; NA, not applicable; EDA, estuarine drainage area; FDA, fluvial drainage area.

Nehalem Bay is a river dominated estuary whos main tributary is the the Nehalem River. Tidal flats extend over 30-50% of its surface water area (area measured at high tide).

## Tides

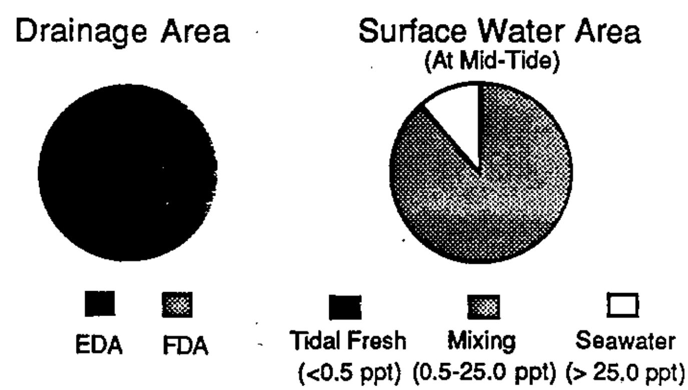
| | | | |
|---|---|---|---|
| Prevailing Tide | | | Semidiurnal |
| Tidal Prism Volume ( cu. ft. ) | | | $3.96 \times 10^8$ |

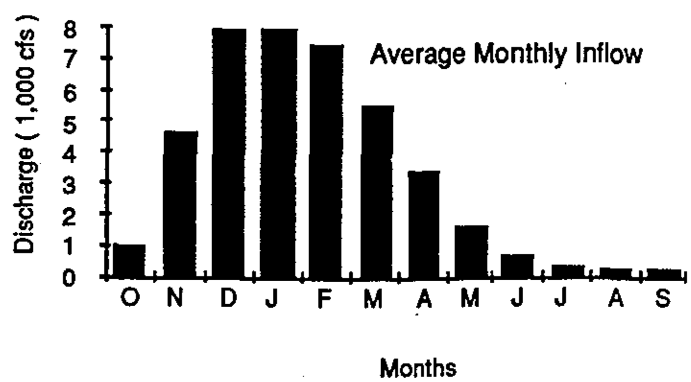
Tide Ranges ( ft. )

| Station | Gauge Number | Range |
|---|---|---|
| A | 861 | 5.8 |
| B | 863 | 5.4 |

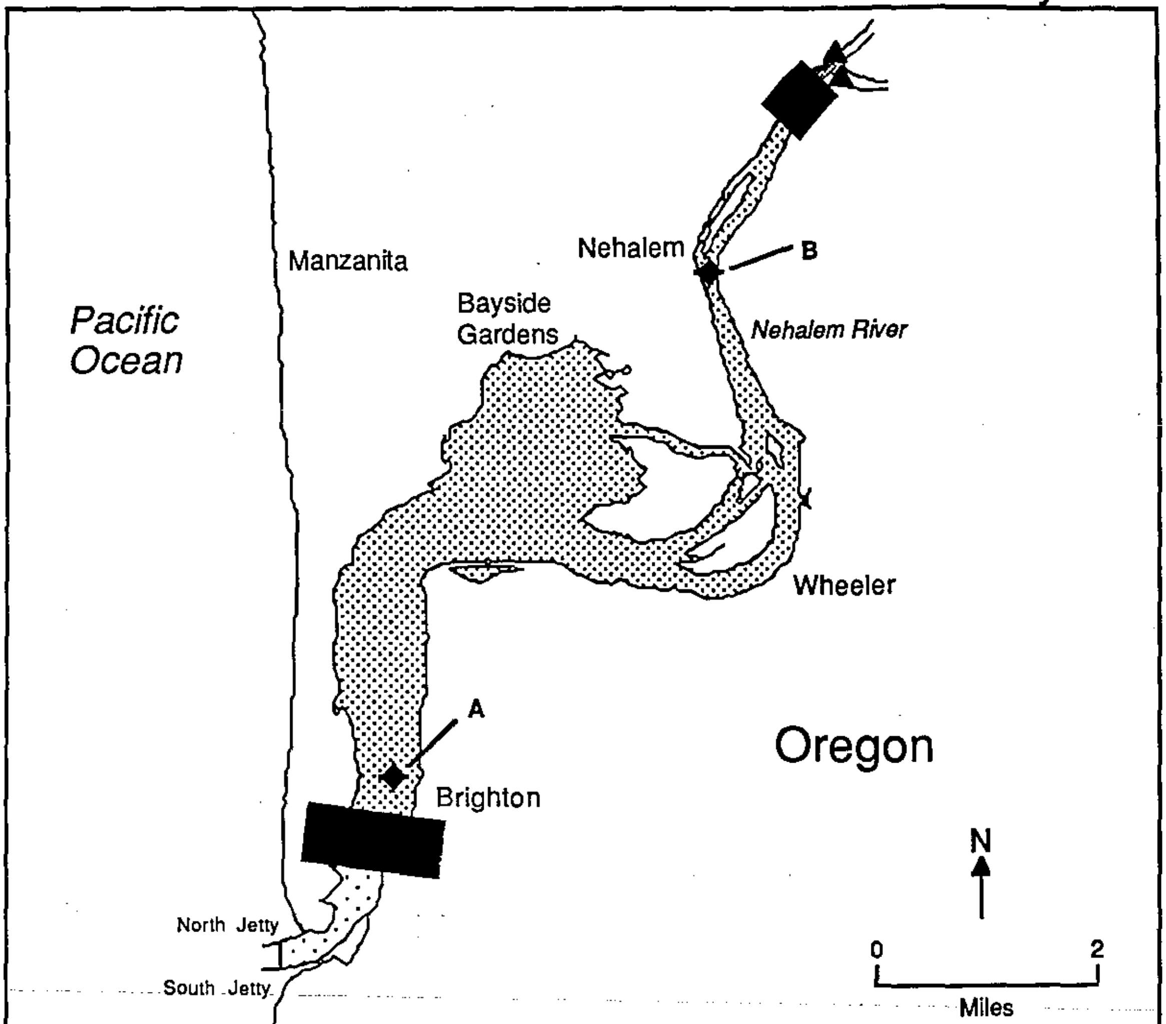
## Stratification

| | |
|---|---|
| 3- Month High Flow Classification | HS |
| 3- Month Low Flow Classification | MS |



## 4.22 Nehalem Bay OR




### Legend

**Salinity Zones**

- Tidal Fresh (< 0.5 ppt )
- Mixing (0.5 - 25.0 ppt )
- Seawater (> 25 ppt )

**Salinity Zone Boundaries**

- Low Variability
- Medium Variability
- High Variability

- Tide gauge
- Head of Tide

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# National Estuarine Atlas

## PHYSICAL AND HYDROLOGIC CHARACTERISTICS

**PHYSICAL**

| | |
|---|---|
| *Surface Areas (mi²)* | |
| Fluvial Drainage | [illegible] |
| Estuarine Drainage | [illegible] |
| *Estuarine Zones* | |
| Tidal Fresh | [illegible] |
| Mixing Zone | 31 |
| Seawater | 24 |
| Total | [illegible] |
| *Dimensions* | |
| Length (mi) | 33.0 |
| Width (mi) Average | 5.4 |
| Minimum | 0.6 |
| Maximum | 11.4 |
| Average Depth (ft) | 11.0 |
| Average Depth to Width Ratio | [illegible] |
| *Stratification Classification* | |
| 3 Month High Flow | MS |
| 3 Month Low Flow | MS |

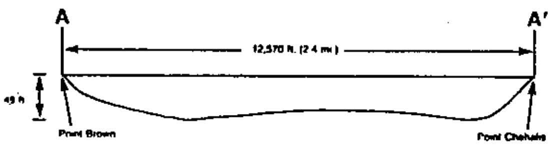
**FRESHWATER INFLOW**

| | | | | |
|---|---|---|---|---|
| *Flow Rates (1000 cfs)* | | | | |
| Period of Record | [illegible] | | | |
| Long Term Average Daily | [illegible] | | | |
| Long Term Average Monthly | J | [illegible] | J | [illegible] |
| | F | [illegible] | A | [illegible] |
| | M | [illegible] | S | [illegible] |
| | A | [illegible] | O | [illegible] |
| | M | [illegible] | N | [illegible] |
| | J | [illegible] | D | [illegible] |
| 7 Day 10 Year Low Flow | [illegible] | | | |
| 50 Year Flood | [illegible] | | | |
| 100 Year Flood | [illegible] | | | |
| *Flow Ratios* | | | | |
| Average Annual | 0.045 | | | |
| High Flow Period | 0.093 | | | |
| Low Flow Period | 0.008 | | | |

**TIDAL DATA**

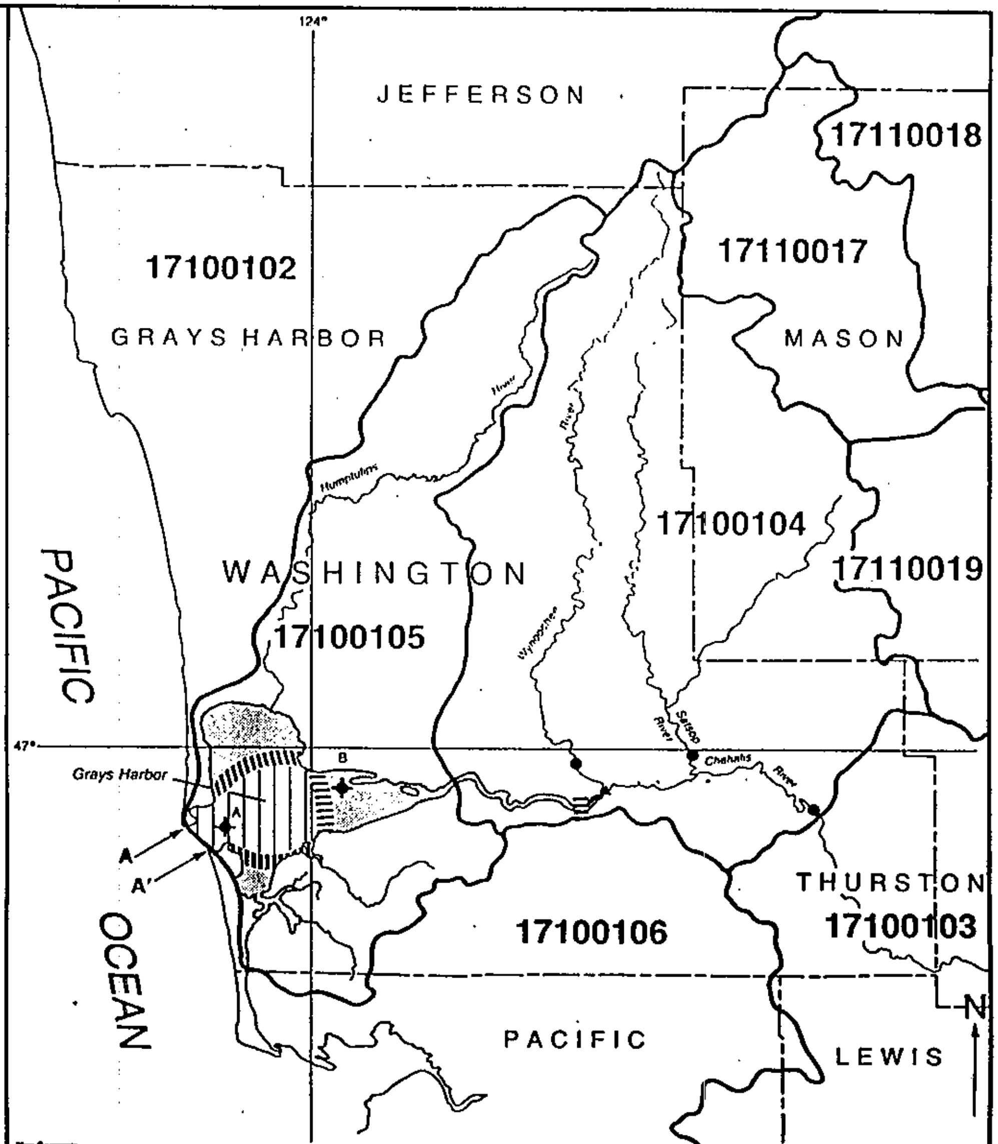
| | | |
|---|---|---|
| Prevailing Tide: [illegible] | | |
| Tidal Prism (ft³) | [illegible] | |
| *Phase Range of Tide (ft)* | | |
| Map Pos. | Station | Range |
| A | [illegible] | [illegible] |
| B | [illegible] | [illegible] |

Abbreviations: Vertically Homogeneous, VH; Moderately Stratified, MS; Highly Stratified, HS



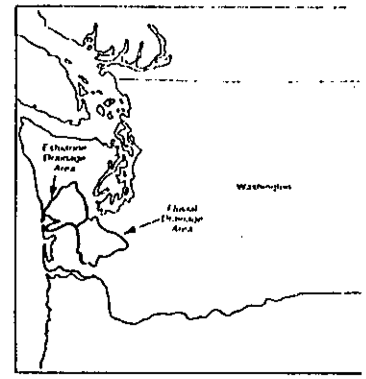

**Notes:**
One hundred percent of Estuarine Drainage Area is shown on map.

**References:**
Cummans, et al., 1975. Loehr and Collias, 1980. Smith, et al., 1976. U.S. Department of Commerce, 1983a. U.S. Geological Survey, 1985.




Map Sources: U.S. Geological Survey, State of Washington, Hydrologic Unit Map, 1974. USGS Accounting Units of the National Water Data Network, 1979, scale 1:7,500,000. NOAA/NOS Nautical Chart No. 18502, December, 1983, scale 1:40,000.

## Grays Harbor WA




- Tide Gage
- Flow Gage
- Head of Tide
- Estuarine Drainage Area (EDA)
- Tidal Fresh Zone
- Mixing Zone
- Seawater Zone
- Hydrologic Cataloging Unit Boundary
- County Boundary
- Salinity Zone Boundary - Low Variability
- Salinity Zone Boundary - Moderate Variabili
- Salinity Zone Boundary - High Variability

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Ocean Assessments Division
Office of Oceanography and Marine Assessment
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