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PUGET SOUND NO DISCHARGE ZONE FOR VESSEL SEWAGE

Puget Sound Condition, Vessel Sewage Discharge, and the Costs and Benefits of Establishing a NDZ

Prepared for
Washington State Department of Ecology

Prepared by
Herrera Environmental Consultants, Inc.

Note:
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Puget Sound Condition, Vessel Sewage Discharge, and the Costs and Benefits of Establishing a NDZ

Prepared for
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April 12, 2012

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INTRODUCTION

The Washington State Department of Ecology (Ecology) is exploring the possibility of petitioning the United States Environmental Protection Agency (U.S. EPA) to designate some or all of Puget Sound as a No Discharge Zone (NDZ) for vessel sewage. Currently, Washington boaters and commercial vessel operators are allowed to discharge sewage into Puget Sound that has been only minimally treated by a marine sanitation device (MSD). Establishing an NDZ is not an unusual procedure; to date 81 NDZs have been designated by the EPA, most along the eastern seaboard. California has recently approved an NDZ for large commercial vessels, but no others have been established on the Pacific Coast. Sewage discharges from vessels may contain harmful levels of pathogens (viruses and bacteria), nutrients, and toxic chemicals (such as chlorine or other disinfectants, pharmaceuticals, and other personal care products), that are detrimental to water quality. As such, vessel sewage poses a threat to commercial and recreational shellfish beds, swimming beaches, aquatic life, and waters prone to nutrient enrichment, algae blooms, and oxygen depletion.

Several areas within Puget Sound are on the U.S. EPA 303(d) list of impaired waters due to fecal coliform bacteria concentrations exceeding applicable water quality standards. Many commercial and recreational shellfish harvest areas and swimming beaches have been closed because of high bacteria levels. Other areas are listed based on having depleted dissolved oxygen (DO) levels that stress aquatic life, caused in part by nutrient enrichment. These problems are highly complex and likely result from a combination of natural and human actions. Sewage discharges from vessels are not suspected to be the root cause of specific impairment listings or beach closures, but certainly contribute to the problem. This contribution may be reduced through the establishment of a NDZ.

The U.S. EPA is authorized, under the Federal Clean Water Act (CWA), to institute a NDZ in waters that are threatened by the discharge of sewage waste from vessels. The authorization, as documented in federal code, allows the U.S. EPA to "completely prohibit the discharge from all vessels of any sewage, whether treated or not" (40 CFR 401.4 [a]). The U.S. EPA, however, cannot act unilaterally to establish a NDZ. A NDZ can only be established following receipt and approval of a petition from a state requesting that the U.S. EPA designate a specific area as a NDZ. Currently, 8 out of 10 U.S. EPA regions have instituted NDZs; Washington State's region (Region 10) is not one of them.

Ecology and Washington State Department of Health are managing funds received from U.S. EPA to coordinate a 6-year strategy to prevent, reduce, and control pathogens in Puget Sound. Herrera Environmental Consultants (Herrera) is assisting Ecology with the first phase of the NDZ Project by preparing summary reports on the following:

- NDZ petition requirements
- Puget Sound condition, vessel sewage discharge characteristics, and benefits of establishing a NDZ
- Vessel use and pumpout facility data

This report provides an inventory of Puget Sound conditions and identifies areas that are sensitive to nutrients and pathogens. It also provides an overview of the existing regulations and agreements governing vessel sewage discharges in Puget Sound, and provides a basic assessment of the types and efficacy of MSDs. Last, it provides summary information on the costs and benefits of establishing a NDZ. The information presented in this report is intended to provide the foundation for the *'certification of need'* section of the NDZ proposal, if Ecology should choose to move forward with the process.

PUGET SOUND CONDITIONS

Puget Sound is a natural resource of incredible value to Washington State and the Nation. It is estimated that Puget Sound drives $20 billion in economic activities in Washington State resulting from commercial and recreational fishing, shellfish aquaculture, tourism, boating, and international trade (Ecology 2008). Bound by the Olympic Mountains and Vancouver Island to the West, and the Cascade Mountains to the East, it is place of unparalleled beauty. The nutrient rich waters brought in by tidal currents from the Pacific Ocean provide nourishment for a vast diversity of life from microscopic invertebrates to the salmon and orca whales so vital to the region's cultural history and identity. Its 2,500 miles of shoreline provide critical habitat for fish, mammals, and birds, and provide shellfish harvesting and swimming opportunities for the regions residents and visitors. Sadly, deteriorating water quality is placing many of Puget Sound's valuable resources at risk.

Tremendous efforts are being made by the state, local municipalities, and environmental advocacy groups aimed at improving water quality and restoring habitat in Puget Sound. The Puget Sound Partnership (PSP) is tasked with restoring and protecting Puget Sound. PSP has delineated seven action areas to guide restoration efforts and foster community involvement at the local scale (Figure 1). While the action area boundaries are not related to the proposed NDZ (the NDZ boundaries have yet to be determined), action area designations will be used in this document when referring to particular areas of Puget Sound. PSP has developed an Action Agenda for Puget Sound. The Action Agenda is a continuously evolving management strategy that prioritizes cleanup and improvement projects, coordinates federal, state, local, tribal and private resources, and ensures cooperation among organizations. As part of the most recent Action Agenda update, PSP adopted a set of 19 ecosystem indicators of Puget Sound health and established recovery targets to be achieved by 2020 for most of them (PSP 2011a).

Establishing an NDZ would address in part, the following Puget Sound Action Agenda management targets:

- **Dissolved Oxygen in Marine Waters:** By 2020, human related contributions of nitrogen do not result in more than 0.2 mg/L reductions in dissolved oxygen anywhere in Puget Sound.
- **Shellfish Beds:** Between 2007 and 2020, achieve a net increase of 10,800 harvestable shellfish acres that include 7,000 acres where harvest is currently prohibited.
- **Swimming Beaches:** By 2020, all monitored Puget Sound beaches will meet enterococci standard.
- **Toxics in Fish:** By 2020, toxics in fish are below threshold levels.

More detail on the PSP recovery targets can be found at the following link: http://www.psp.wa.gov/downloads/AA2011/2011_Targets_11_03_11.pdf.

Hydrology

The hydrology of Puget Sound, or the movement of water into and out of Puget Sound and between the different areas of the Sound, is driven by tidal currents, freshwater inflow from rivers and streams, and physical features such as the size, shape, and depth of the different areas. The hydrology of Puget Sound is more complex than the hydrology of other large estuaries in the United States such as Chesapeake Bay. The deeply incised fingers and large and small islands, left behind by the last glaciations resulted in a network of narrow channels and shallow sills, which restrict and alter the mixing and circulation of water. As a result, some areas of the Sound, particularly South Puget Sound and Hood Canal, experience poor circulation and are prone to water quality impairments (PSP 2010).

The main portion of Puget Sound is comprised of four deep basins separated by shallower sills; Whidbey basin, Central Puget Sound, South Puget Sound, and Hood Canal (University of Washington 2009). The sills that separate these basins act like the sides of a bathtub and to a large extent prevent mixing between them.

Central Puget Sound is the deepest basin, with depths consistently exceeding 200 meters (m) (Cannon 1983). South Puget Sound is much shallower; although water depths in South Puget Sound reach 150 m, many of the inlets are 50 m or shallower (Ecology 2009). The Whidbey Basin is also shallow and has depths ranging from 8 to 150 m (University of Washington 2012). Hood Canal is deep throughout the north-south trending portion, with depths frequently exceeding 175 m. Where the Canal bends to the east and changes to an east-west orientation, it is much shallower, with depths only reaching about 40 m (Turney 2004).

There are many thousands of rivers and streams that contribute freshwater to Puget Sound; however, 14 rivers account for the vast majority of the inflow. Most of these are located in central and north Puget Sound. Since this freshwater is not as dense as saltwater, it remains near the surface. Conversely, the denser and more nutrient rich saltwater coming from the ocean enters the Sound at depth. So, the general circulation pattern is that ocean water enters the Sound at Admiralty Inlet at depth and travels south through the main basin, while freshwater enters primarily through the 14 major river basins and moves out through the surface at Admiralty Inlet. Some mixing occurs between the deep, salty ocean water and the less dense surface water as the ocean water is forced upward as it travels over the sills that separate the four main basins.

Water circulation and flushing rates influence water quality, and are especially important factors in determining an area's susceptibility to eutrophication. The pattern of currents in Puget Sound have been extensively studied and modeled over the past few decades. These studies have revealed that there is significant variability spatially as well as seasonally. In general, circulation and flushing is more rapid in the northern segments of Puget Sound (i.e., Central Puget Sound and Whidbey basins). Greater river water inputs and a shorter, more direct connection with the ocean facilitate greater net flow and circulation in these areas. Hood Canal and South Puget Sound are more poorly flushed due in part to sills at their mouths, which restrict exchange with the rest of Puget Sound. Other factors related to the timing and strength of stratification in Hood Canal and South Puget Sound also limit the net volume of water exchange flushing time (Gustafson et al. 2000).

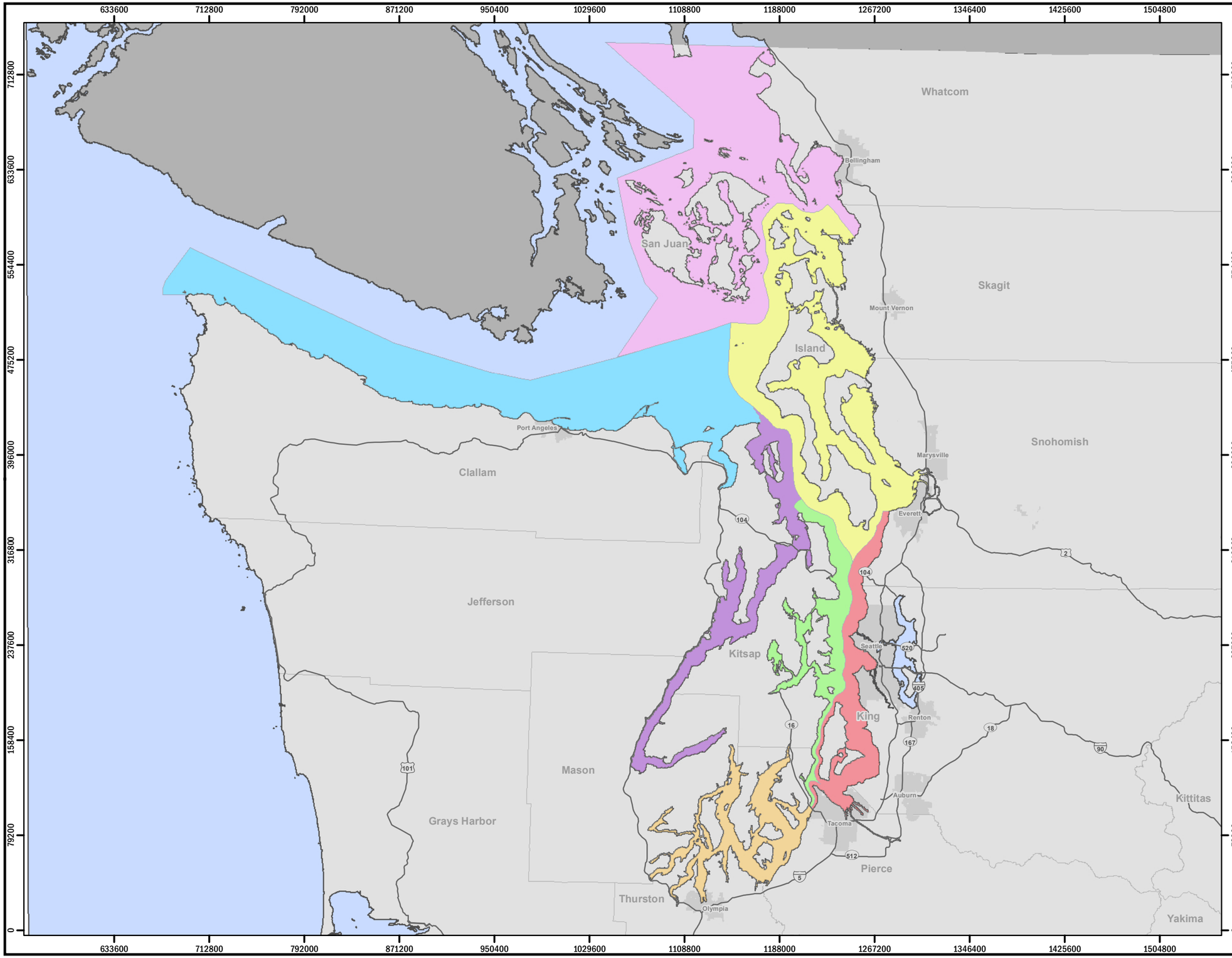

Figure 1.
Puget Sound action areas.

Legend

Action area

- Hood Canal
- North Central Puget Sound
- San Juan / Whatcom
- South Central Puget Sound
- South Puget Sound
- Strait of Juan de Fuca
- Whidbey Basin

N

0 7.5 15 30

Miles

HERRERA

Coordinates: NAD83 Wahington
State Plane North (feet)

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Project: K:\Projects\11-05217-000\Project\action_areas_ps.mxd (4/9/2012)

Water Quality

Good water quality is at the heart of the ecological, economic, and recreational benefits provided by Puget Sound. Over the past several decades, human caused sources of nutrients, pathogens, and toxic contaminants are thought to have degraded the water quality of Puget Sound, and are putting many of its beneficial functions at risk. Treated vessel sewage discharges often contain high concentrations of nutrients and pathogens, may contribute to decreased dissolved oxygen, and may contain toxic disinfection chemicals, and excreted pharmaceuticals. The following sections provide a general overview of Puget Sound water quality in relation to four indicators; nutrients, pathogens, dissolved oxygen, and toxic chemicals. This section begins with a discussion of applicable water quality standards and impairments. This is followed by a description of status and trends associated with each of the four water quality indicators.

It is not the purpose of this section to link vessel sewage discharges to any specific water quality issues. It is intended to provide a platform for informed discussion for evaluating the potential merits of establishing a NDZ for Puget Sound.

Water Quality Standards and Impaired Waters

In Washington, water quality is regularly evaluated against the surface water quality standards that are set forth in WAC 173-201 to assess whether the water complies with the federal Clean Water Act (CWA). The water quality standards establish numeric and narrative criteria for a water body to protect its existing beneficial uses for both aquatic life and recreation. As shown in Figure 2, the majority of Puget Sound is designated as *extraordinary or excellent* aquatic life use, and *primary contact recreation* beneficial uses. Very few areas are designated as *good* or *fair* for aquatic life uses, or *secondary contact recreation*.

Of the four water quality indicators selected for summary in this report, fecal bacteria and dissolved oxygen are the two that are most closely associated with numeric water quality standards. Some toxic contaminants are also assigned numeric standards and are most frequently evaluated by fish tissue and sediment sampling, rather than water quality monitoring. Nutrients are not discussed in relation to the water quality standards, because there are no marine water quality standards for nutrients. However, low DO concentrations are often an indicator of elevated nutrients and eutrophication, therefore the discussion of DO impairments cannot be isolated from the discussion of elevated nutrients.

Fecal indicator bacteria (fecal coliform and enterococci bacteria) and dissolved oxygen (DO) standards include numeric criteria that are defined in Table 1. Waters that fail to meet water quality standards are designated as impaired, and are included on the Clean Water Act Section 303(d) list of impaired waters as per the code of federal regulations (CFR) (40 CFR 130.7).

There are a number of locations in Puget Sound that are designated as impaired as the result of persistent low DO and high fecal indicator bacteria concentrations. These impaired waters are identified on Figures 3 and 4. These waters were designated impaired as part of Ecology's 2010 water quality assessment, and will be included on the U.S. EPA 303(d) list of impaired waters pending U.S. EPA approval (Ecology 2012a). DO and fecal indicator bacteria impairments are prevalent in Puget Sound, but are found more frequently in urbanized areas or poorly flushed bays. Fecal impairments are more common than DO impairments. Impaired waters are addressed further in the DO and bacteria sections below.

Table 1. Marine Water Quality Standards for Dissolved Oxygen and Indicator Bacteria in Puget Sounds.			
Beneficial Uses		**Dissolved Oxygen**	**Indicator Bacteria**
Aquatic Life	*Recreation*	*Lowest 1-day minimum*	
Extraordinary	Primary Contact	7.0 mg/L.	Fecal coliform organism levels must not exceed a geometric mean value of 14 colonies/100 mL, with not more than 10% of all samples (or any single sample when < 10 sample points exist) obtained for calculating the geometric mean value > 43 colonies/100 mL.
Excellent	Primary Contact	6.0 mg/L.	Fecal coliform organism levels must not exceed a geometric mean value of 14 colonies/100 mL, with not more than 10% of all samples (or any single sample when < 10 sample points exist) obtained for calculating the geometric mean value > 43 colonies/100 mL.
Good	Secondary Contact	5.0 mg/L.	Enterococci organism levels must not exceed a geometric mean value of 70 colonies/100 mL, with not more than 10% of all samples (or any single sample when < 10 sample points exist) obtained for calculating the geometric mean value > 208 colonies/100 mL.
Fair	Secondary Contact	4.0 mg/L.	Enterococci organism levels must not exceed a geometric mean value of 70 colonies/100 mL, with not more than 10% of all samples (or any single sample when < 10 sample points exist) obtained for calculating the geometric mean value > 208 colonies/100 mL.

Status and Trends of Key Pollutants

This section provides an overview of the status and trends of pathogens (fecal indicator bacteria), nutrients, DO, and toxic contaminants. These parameters were chosen for discussion because they are the most likely to be impacted by vessel sewage discharges. A number of sources were used to develop the following summaries; however, the bulk of information was summarized from the 2011 Puget Sound Science Update (PSP 2011b).

Bacteria

Bacterial contamination problems are prevalent throughout Puget Sound. In Puget Sound, fecal bacteria monitoring is conducted by numerous state and local agencies. Ecology conducts bacteria monitoring at PSMAP stations. Washington Department of Health (WDOH) monitors fecal bacteria in shellfish growing areas and administers the bacterial environmental assessment communication and health (BEACH) monitoring program for recreational beaches. Many local municipalities also have bacteria monitoring problems to study and address local problems. All of these programs have identified bacterial contamination problems in many areas of Puget Sound.

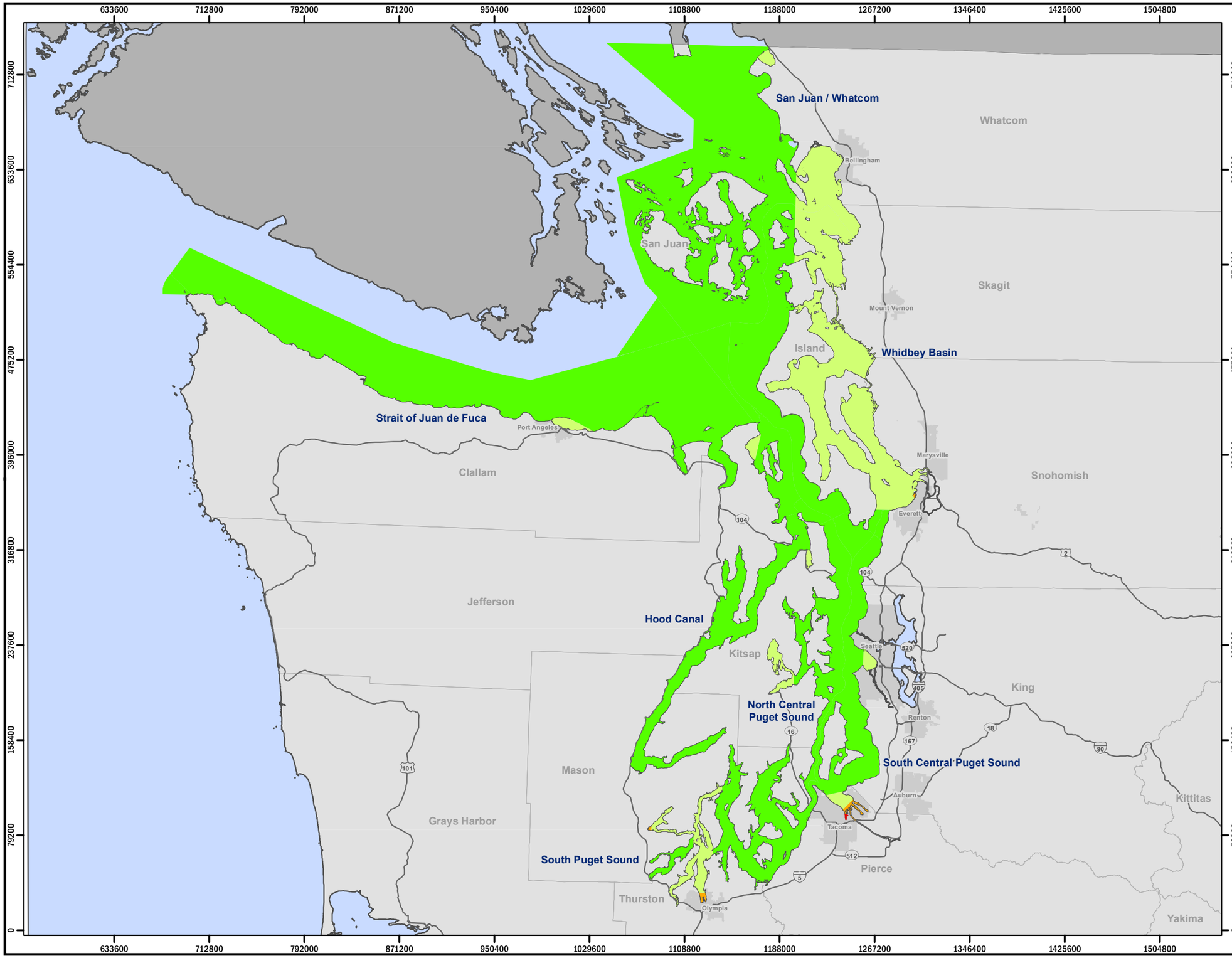

Figure 2.
Designated beneficial use of waters in Puget Sound based on water quality standards.

Legend

Aquatic life use

- Extraordinary - primary contact
- Excellent - primary contact
- Good - secondary contact
- Fair - secondary contact

N

0 7.5 15 30

Miles

HERRERA

Coordinates: NAD83 Wahington State Plane North (feet)

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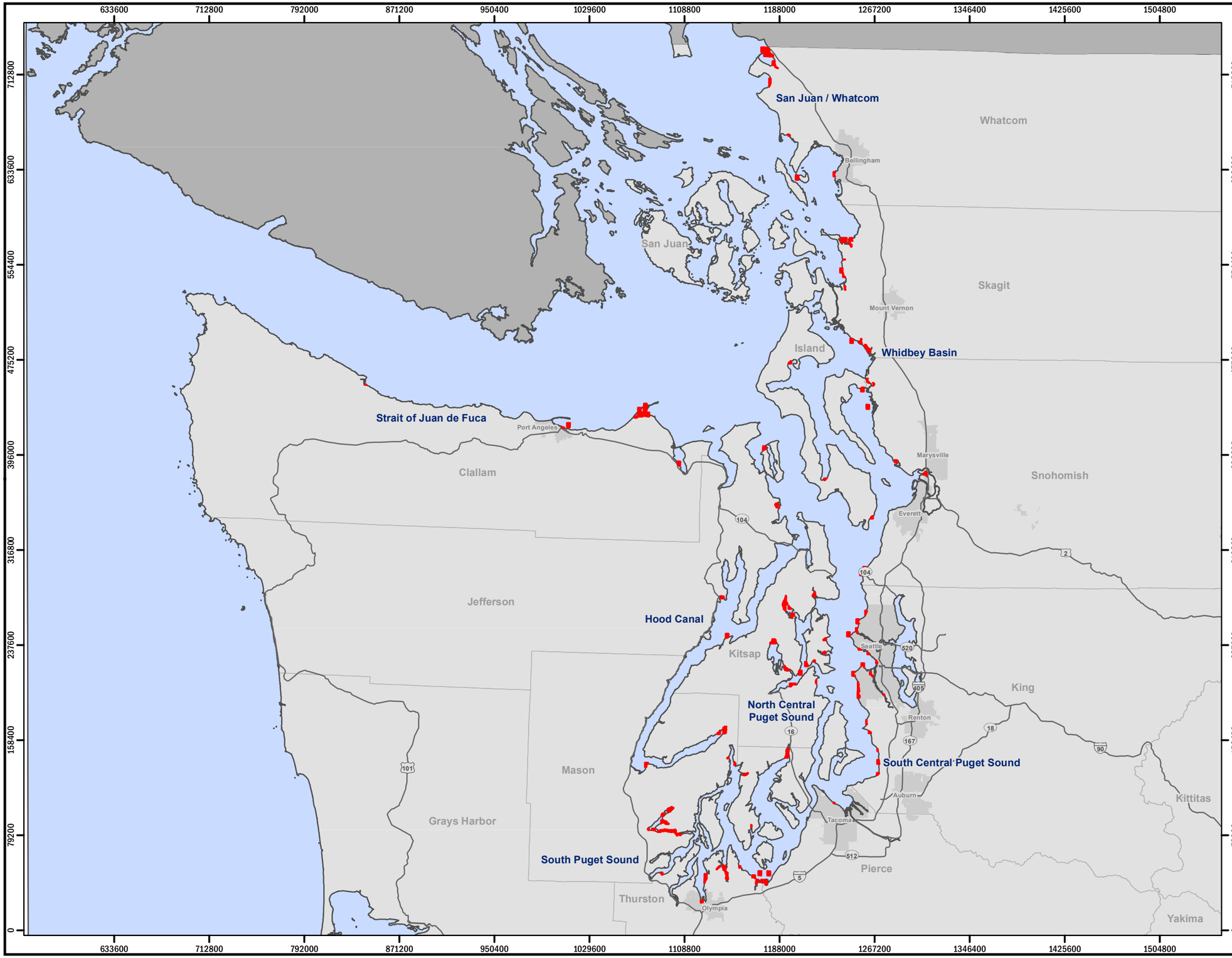

Figure 3.
2010 proposed Puget Sound waters impaired due to high bacteria concentrations.

Legend

Impaired water

Bacteria

N

0 7.5 15 30

Miles

HERRERA

Coordinates: NAD83 Wahington State Plane North (feet)

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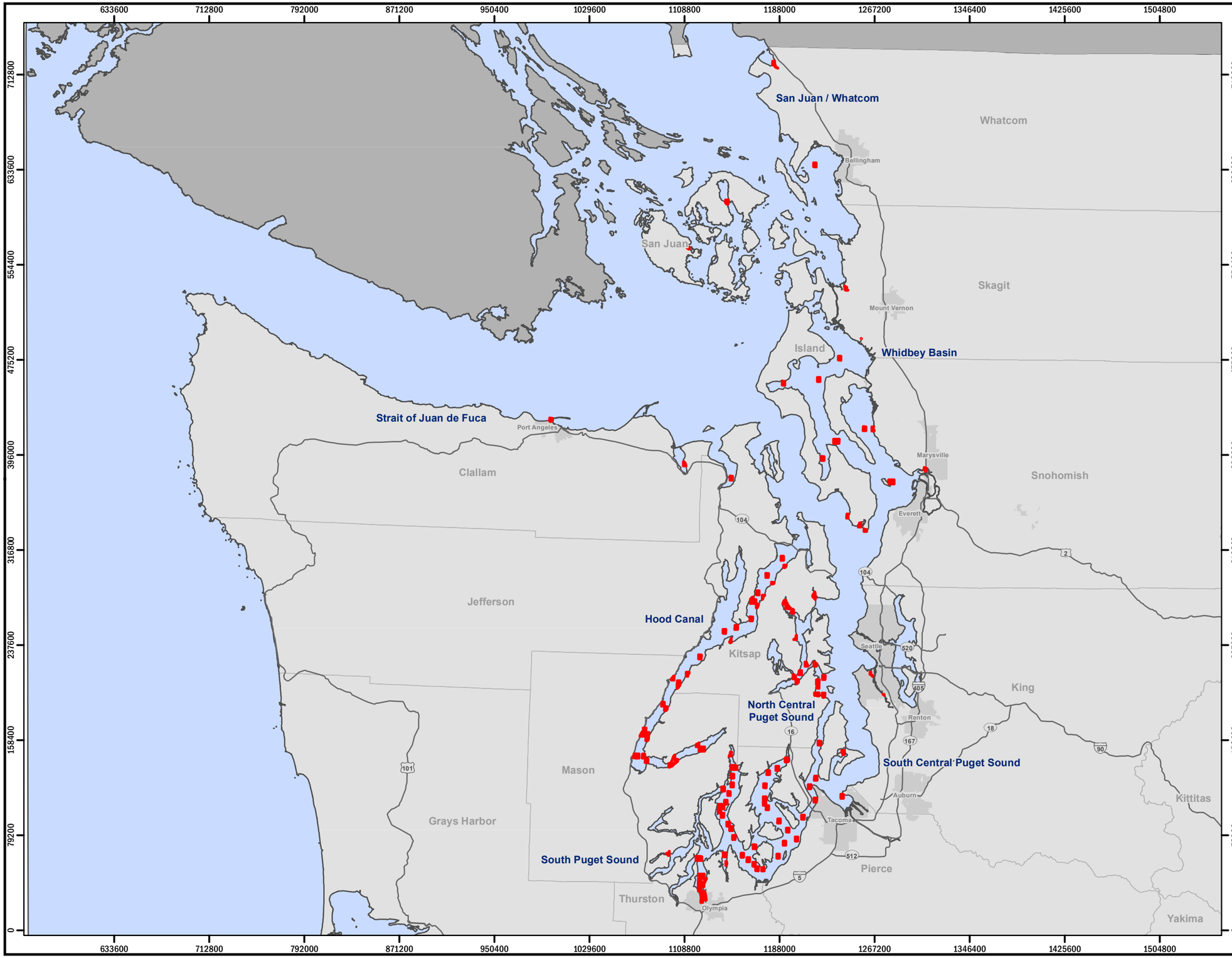

Figure 4.
2010 proposed Puget Sound waters impaired due to low dissolved oxygen concentrations.

Legend

Impaired water

Dissolved oxygen

N

0 7.5 15 30

Miles

HERRERA

Coordinates: NAD83 Wahington State Plane North (feet)

Produced By: GIS ( )
Project: K:\Projects\11-05217-000\Project\ndz\impaired_do.mxd (4/11/2012)

Water Quality Standard Impairments

There are 139 segments designated as impaired resulting from bacteria levels failing to meet water quality standards presented in Table 1 (Figure 3). Bacterial impairments have been documented in all areas of Puget Sound. Although they appear to occur more frequently in South Puget Sound, the southern reaches of Hood Canal and in shallower embayments (Figure 3.) A site can only be listed as impaired if there is water quality monitoring data available to document conditions. It is possible that there are other areas in Puget Sound where bacteria concentrations are elevated but for which no data is available to verify conditions.

Recreational Beaches

Recreational beaches are monitored as part of the BEACH Program (Ecology 2011a). The BEACH program monitoring uses the U.S. EPA Beach Act (40 CFR 131) single sample maximum standard for enterococci of 104/100 mL to determine whether beaches are safe for swimming. Between 2004 and 2011, 123 Puget Sound beaches were monitored. Among the sampled beaches, 86 had at least one sample exceeding the standard. BEACH program monitoring during 2004 and 2005 also documented that the highest number of bacteria exceedances were in locations where communities rely predominately on on-site septic systems (PSP 2007).

Herrera analyzed the monitoring data from beaches that were sampled more than 10 times to determine where the standard was exceeded most frequently. Low, moderate, and high categories were assigned based on the relative frequency of samples exceeding the 104/100 mL standard. These categories were designated based on the 25th percentile (low), inter quartile range (moderate) and 75th percentile (high) for the number of samples exceeding the standard. Beaches receiving a 'low' rating were those that did not have any samples exceeding the enterococci standard. Beaches that received a 'moderate' rating were those where at least one, but less than 7.4 percent of the samples exceeded the standard. Beaches rated as 'high' were those at which more than 7.4 percent of samples exceeded the standard. Based on this criterion, 31 beaches were rated as a high risk for bacterial contamination and 85 were rated as having a moderate risk. There were also a number of beaches that were not monitored, so it is possible that many more beaches pose a public health risk due to fecal contamination. The locations of the monitored beaches and the bacteria contamination risk is illustrated in Figure 5.

Commercial Shellfish Harvest

Shellfish are filter feeders and they can accumulate pathogens that are present in the water column and sediments. High concentrations of bacteria can result in the closure of commercial shellfish growing areas and closures of beaches used for recreational shellfish harvest. Due to the potential health risk associated with eating contaminated shellfish, WDOH monitors bacteria concentrations in waters that are used for shellfish aquaculture or recreational harvest on a regular basis. Approximately 190,000 acres of commercial shellfish growing tidelands are monitored. This includes shellfish growing tidelands managed by private companies, and commercial tidelands managed by the tribes. All harvesting areas, whether commercial or recreational, are subject to the bacteria standard described in Table 1 for primary contact. Based on the results of sampling and other hydrologic factors, commercial shellfish growing areas are designated using the following systems:

- **Commercial Growing Areas**:
    - **Approved:** Geometric mean concentration of fecal coliform bacteria does not exceed 14/100 mL, with 90th percentile not to exceed 43/100 ml.
    - **Conditionally Approved**: Meets the bacterial standard for **Approved** conditions during predictable periods and therefore is approved for use only during those periods.
    - **Restricted:** Geometric mean must not exceed 88/100 mL, with a 90th percentile not to exceed 260/100 mL. Shellfish grown in restricted areas may be relayed (transplanted) to another area for an extended period before marketing.
    - **Prohibited:** Fecal material, pathogenic organisms, or otherwise harmful substances have been detected at dangerous concentrations. There are also categorically prohibited areas such as near wastewater outfalls, marinas or other areas where there is a known potential pollution source. Commercial harvest is not allowed in these areas.

The locations and status designations of commercial growing areas are shown on Figure 6.

The majority of commercial harvest areas remain open or conditional. However, of the 190,000 classified acres, about 36,000, or 19 percent of the total potential growing area, are closed. Some of these areas are closed due to pollution sources such as biotoxins or synthetic chemicals, but the majority of closures are due to fecal bacteria pollution (PSP 2011c). A substantial number of recreational beaches are also listed as closed particularly in South Puget and Central Puget Sound.

WDOH recently evaluated long-term trends in fecal pollution at 21 commercial growing areas for the period between 1998 and 2011. While there was some variability among the areas evaluated, most showed a moderate improving trend over the study period. A few areas showed marked improvements; these improvements were thought to be the result of remediation of failing onsite septic systems, and public education (WDOH 2011).

Recreational Shellfish Harvest

Recreational shellfish harvest takes place at 500 beaches throughout the Sound. As with commercial shellfish growing areas, WDOH monitors bacteria and biotoxins levels to minimize public health risks associated with harvesting and consuming shellfish. Evaluations of public harvesting beaches are similar to that of commercial shellfish growing areas. Based on factors such as proximity to pollutant sources and measured fecal indicator bacteria concentrations, WDOH will classify the beaches as:

- **Open:** Water has been tested and determined safe for shellfish harvest.
- **Advisory:** Shellfish harvest is permitted, but thorough cooking of shellfish is recommended.
- **Closed:** Harvest is prohibited, either due to contaminants, fecal pollution, or because the beach hasn't been tested.

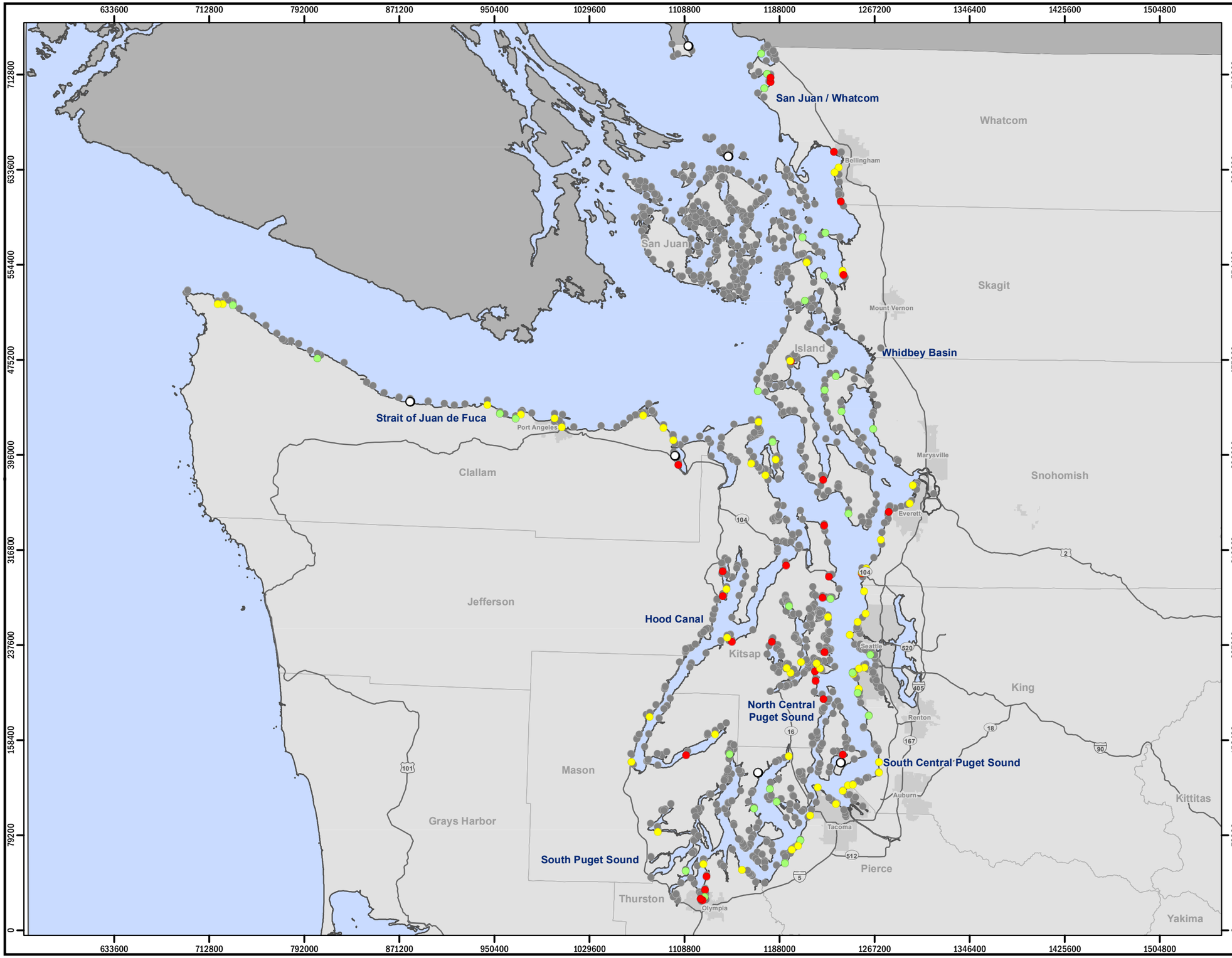

Figure 5.
Frequency of water samples exceeding the bacteria standard at public beaches in Puget Sound.

Legend

- Not monitored
- Insufficient data (<10 samples)
- No samples exceed criterion
- <= 7.5% of samples exceed criterion
- >7.5% of samples exceed criterion

Note: Bacteria standard is 104 MPN/100 mL for Enterococcus.

N

0 7.5 15 30

Miles

HERRERA

Coordinates: NAD83 Wahington State Plane North (feet)

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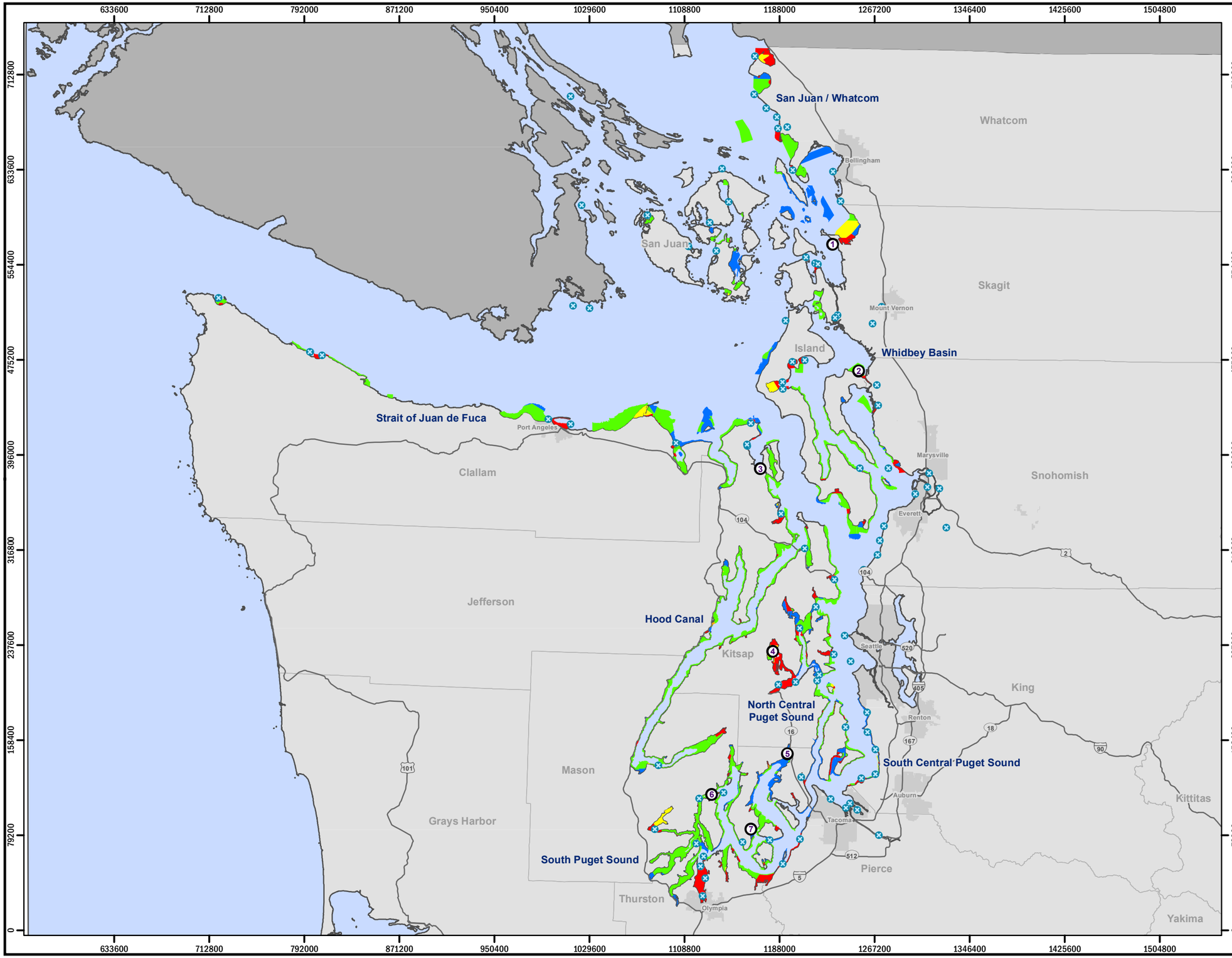

Figure 6.
Classification of commercial shellfish growing areas in Puget Sound.

Legend

Commercial shellfish growing area

- Approved
- Conditional
- Prohibited
- Restricted
- Unclassified

Threatened growing area

1. Padilla Bay
2. South Skagit Bay
3. Port Townsend
4. Dyes Inlet
5. Burley Lagoon
6. Pickering Passage
7. Filucy Bay

Wastewater treatment plant

N

0 7.5 15 30

Miles

HERRERA

Coordinates: NAD83 Wahington
State Plane North (feet)

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The locations and status designations of recreational growing areas are shown on Figure 7.

There are also many areas throughout Puget Sound that are designated as 'Usual and Accustomed' shellfish harvesting areas and are used by tribal members. These areas also represent resources that can be affected by bacteria and other pathogens.

Marinas

Bacterial pollution can be a problem in Puget Sound marinas. Kitsap County Health conducted studies in 1991 and 2010 which evaluated concentrations of fecal coliform bacteria inside and outside of marinas. Both studies documented significantly higher concentrations of fecal coliform bacteria inside of the marinas. Though the specific sources of fecal coliform were not determined (i.e., it was not proven that the fecal coliform originated from vessel discharges or human waste), it is thought that sewage management practices within the marinas are the likely cause of high fecal bacteria concentrations (Kitsap Health 2011). Marinas which have pumpout facilities are thought to have better water quality. Accordingly, there is generally a smaller area surrounding the marina in which shellfish harvesting is prohibited (Mark Toy, WDOH. Pers. Comm.).

Nutrients

Nitrogen, specifically dissolved inorganic nitrogen (DIN), is the nutrient that is typically of most interest in Puget Sound. Puget Sound is a naturally nutrient rich water body; the single largest source of DIN is brought in from the ocean through the Strait of Juan de Fuca. This accounts for about 86 percent of the DIN load (Table 2). Although rivers, shoreline groundwater inputs, and sewage inputs individually account for only small portions of the total DIN load (Table 2) (Herrera 2010), they represent the sources that are most influenced by human activity which may be managed and reduced. It is believed by many that a 'tipping point' may have been reached in Puget Sound in terms of nutrient inputs. If this is the case, even small additions of nutrients could cause significant changes in water quality. As a consequence, the agencies that manage Puget Sound are looking at ways to reduce nutrient contributions from rivers and wastewater treatment plants, as well as from sewage from vessel discharges.

Table 2. Major Components of the Puget Sound Nitrogen Cycle.

DIN Input	Annual Loading (MT/year)	Annual Loading (percent)
Sewage	5,658	3.3%
Rivers	11,000	6.4%
Shoreline Groundwater Input	3,650	2.1%
Atmospheric	3,103	1.8%
Ocean Exchange	148,920	86.4%
Total Input	172,331	100%

Note: This table was adapted from Table 2 in Herrera (2010).

The abundance of nutrients is responsible for the incredible biomass and biodiversity supported by Puget Sound, but it is also a liability since excessive amounts of nutrients lead to increased algal growth and increased frequency of harmful algal blooms (HABs).

Nitrogen is the limiting nutrient for algal growth in Puget Sound during the summer months. As a result, influxes of nitrogen during the summer can cause a corresponding increase in algae growth. Increased algae growth and their subsequent death and decomposition can result in low oxygen concentrations. Increased algae growth can also result in more immediate impacts through development of harmful algal blooms (HABs). HABs are caused by the proliferation of acutely toxic algae and pose a risk to humans and marine life. Shellfish may accumulate dangerous levels of biotoxins during HAB events. Consumption of these contaminated shellfish by humans, marine mammals and birds leads to illnesses such as paralytic shellfish poisoning (PSP) or amnesic shellfish poisoning (ASP). WDOH regularly monitors biotoxin levels in shellfish collected in commercial growing areas and at recreational beaches. HABs most frequently cause shellfish bed closures and advisories during the summer. According to WDOH data, the frequency of HABs has increased in Puget Sound over the past half century (PSP 2011). It is suspected that the observed increase may be due to increased nitrogen contributions from watershed-based sources.

Water Quality Standard Impairments and General Condition

There are no marine water quality standards for nutrients so there are no segments that have been officially listed as 'impaired' as a result of high nutrient concentrations. However, nutrients are regularly monitored at Ecology's Puget Sound Ambient Monitoring Program (PSAMP) stations.

Nitrogen data (as nitrate) collected from 18 PSAMP sites in Puget Sound, between 1999 and 2008 (as published in Krembs (2012)) was used to assess the relative nitrate concentrations among the stations; and to assess spatial patterns. Three categories were assigned: low (representing the sites with concentrations in the lowest 25 percent of the sites), medium (representing the sites with concentrations that fell between 25 and 75 percent) and high (representing the site with concentrations in the highest 25 percent of the site). The results of this analysis are depicted on Figure 8. There was a cluster of low ranked stations in the South Sound area, but otherwise low, medium, and high sites were evenly dispersed throughout the Sound.

Chlorophyll concentrations are also measured at PSAMP stations. Chlorophyll serves as a general indicator for the amount of algae in the water column. Algae growth and therefore chlorophyll concentration is influenced by nutrient availability (e.g., nitrates) as well as by water movement. The same relative ranking procedure that was used for nitrate concentrations (described above) was used to rank chlorophyll concentrations. The results are shown in Figure 9. There were two high ranked sites in South Sound, one in Hood Canal, and two in the same general vicinity in the Whidbey Basin area. The low and medium ranked sites were widely dispersed throughout the Sound.

The Washington State Department of Ecology (Ecology) initiated the *South Puget Sound Dissolved Oxygen Study* to determine the extent of low DO levels in southern Puget Sound and to better understand how nitrogen (as DIN) from a variety of sources affects DO levels. The nutrient loading report (Ecology 2011) associated with this long-term study primarily focused on DIN loads from wastewater treatment facilities and from the major rivers. On an annual basis DIN loads to the South Sound were found to be dominated by river loading, which accounted for approximately 65 percent of the load. However, since river flows are much lower during the summer, wastewater treatment facilities were found to be the dominant source of

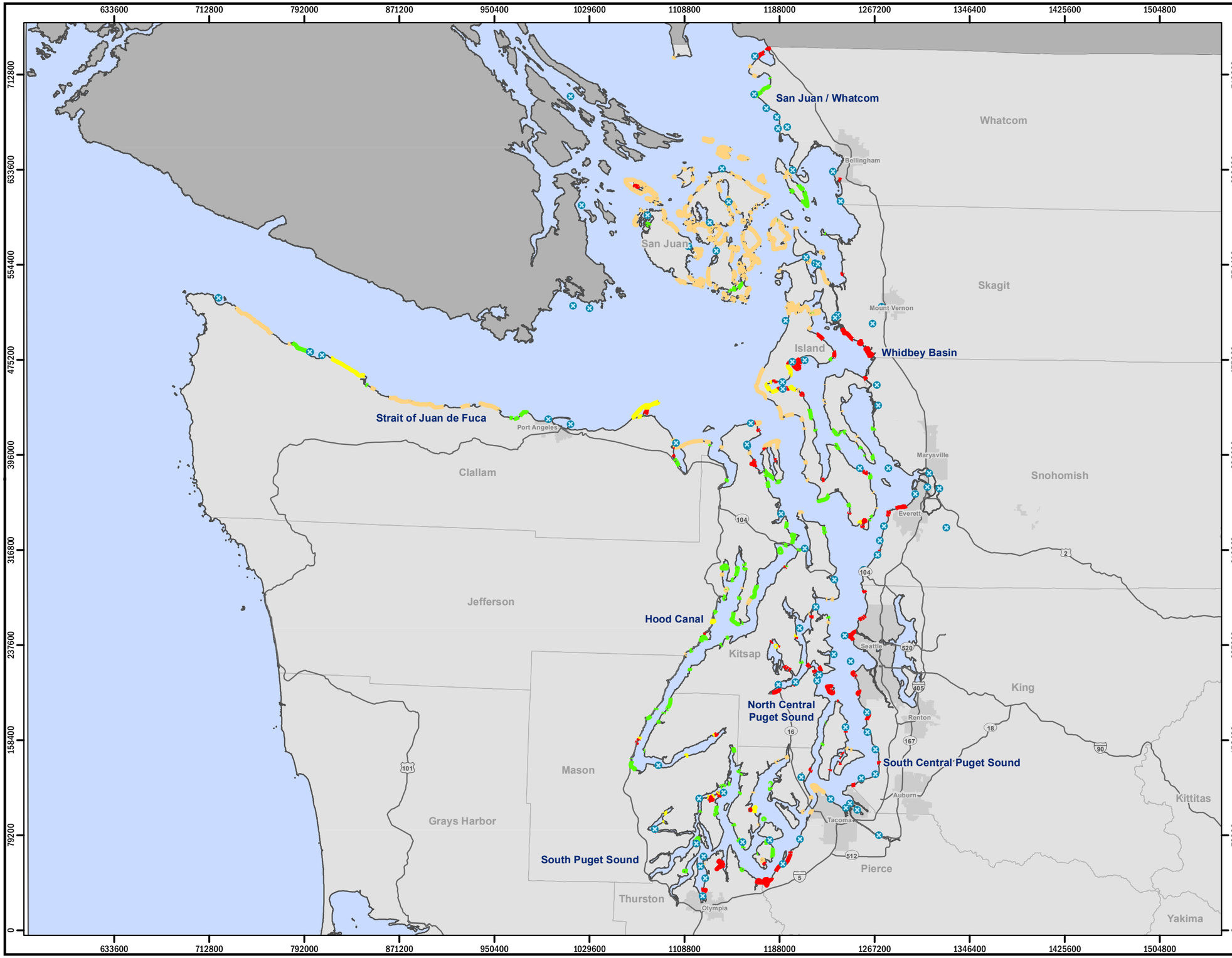

Figure 7.
Status of recreational shellfish beaches in Puget Sound.

Legend

Recreational shellfish beach

- Approved
- Closed
- Conditional
- Unclassified

- Wastewater treatment plant

N

0 7.5 15 30
Miles

HERRERA

Coordinates: NAD83 Wahington
State Plane North (feet)

Produced By: GIS ( )
Project: K:\Projects\11-05217-000\Project\ndz\recreational_shellfish_beaches.mxd (4/10/2012)

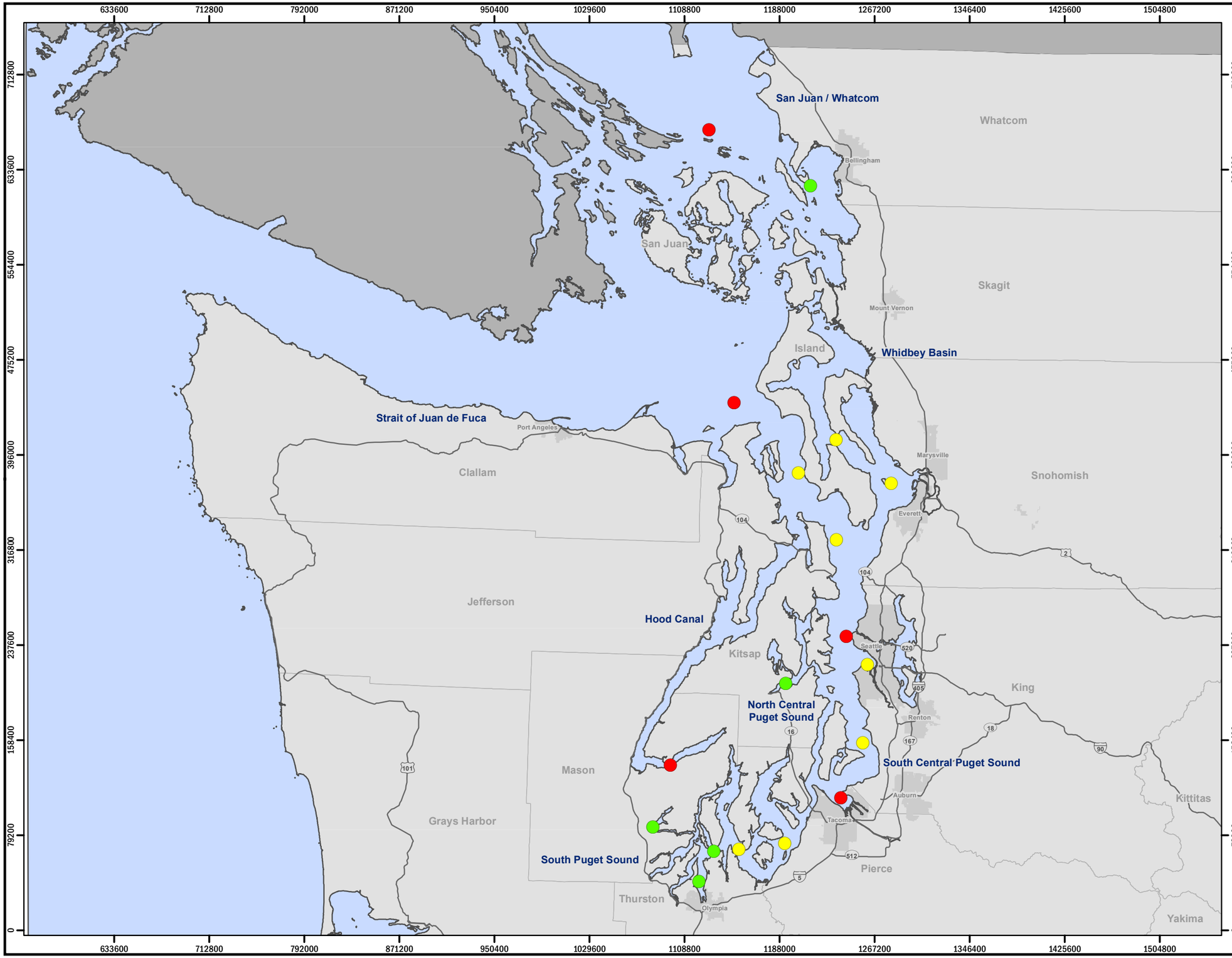

Figure 8.
Relative ranking of median nitrate concentrations at Ecology's PSAMP stations between 1999 and 2008.

Legend

Relative ranking

- Low
- Medium
- High

Note: Low represents 25th percentile.
Medium represents inner quartile range.
High represents 75th percentile.

N

0 7.5 15 30

Miles

HERRERA

Coordinates: NAD83 Wahington
State Plane North (feet)

Produced By: GIS ( )
Project: K:\Projects\11-05217-000\Project\ndz\ambient-nitrate.mxd (4/10/2012)

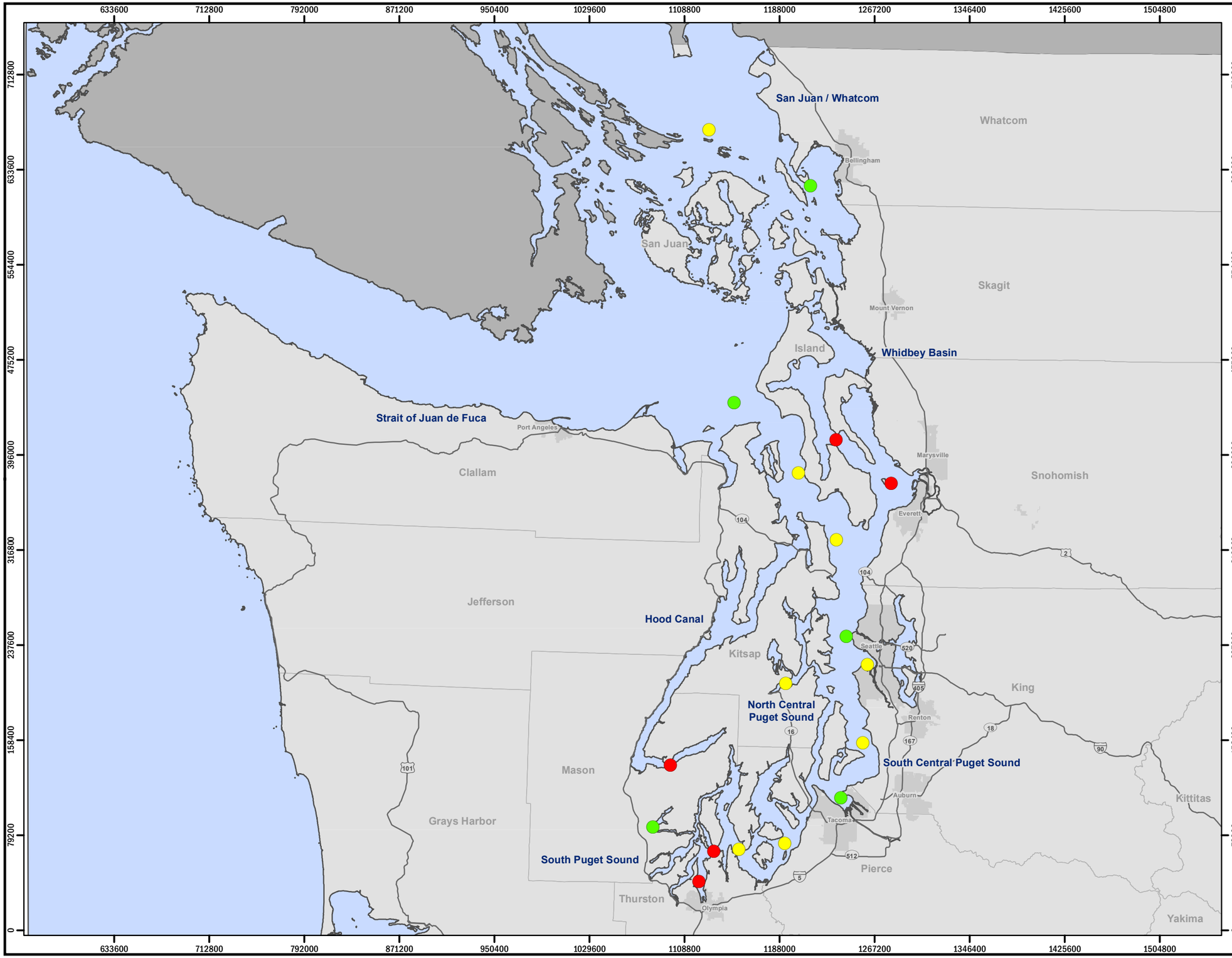

Figure 9.
Relative ranking of median chlorophyll concentrations at Ecology's PSAMP stations between 1999 and 2008.

Legend

Relative ranking

- Low
- Medium
- High

Note: Low represents 25th percentile.
Medium represents inner quartile range.
High represents 75th percentile.

N

0 7.5 15 30
Miles

HERRERA

Coordinates: NAD83 Wahington State Plane North (feet)

Produced By: GIS ( )
Project: K:\Projects\11-05217-000\Project\ndz\ambient-chlorophyll.mxd (4/10/2012)

nitrogen, representing 63 percent of the load of nitrogen during summer. Since summer months are when oxygen levels are of greatest concern in Puget Sound, the seasonal aspect of these findings is important to consider. In Central Puget Sound wastewater treatment facilities were by far the dominant source of nitrogen, regardless of time period, and contributed 81 to 94 percent of the nitrogen load. In a study of Hood Canal, input from septic systems was identified as a significant watershed source of nitrogen (Newton et. al 2010). Overall, these study findings lend further evidence to the potential significance of contributions human waste to nutrient levels in Puget Sound.

Dissolved Oxygen

DO depletion in Puget Sound is related to nutrient enrichment, water circulation, and the deep and relatively narrow inlets that comprise much of the Sound. Many regions in Puget Sound may be naturally susceptible to low DO as a natural consequence of these physical features. Low DO concentrations and related fish kills in Hood Canal have been observed as early as the 1950s (Turney 2004) suggesting that low DO is not a new phenomenon. However, there is some evidence to suggest that low DO events are increasing in frequency, severity and duration, particularly in Hood Canal and South Puget Sound (Turney 2004; PSP 2011b). For example, DO concentrations in Hood Canal in late summer 2010 were the lowest on record. Given the increase in human activities over the past 50 years (e.g., development, recreation, deforestation, and other watershed modifications), it is suspected that human factors may be leading to increasing DO problems (PSP 2011b).

Water Quality Standard Impairments and General Condition

There are 141 segments designated as impaired due to low dissolved oxygen concentrations (Figure 4). As described in the bacteria discussion a site can only be listed as impaired if there is data available to document conditions. It is possible that there are other areas in Puget Sound where dissolved oxygen is low but for which no data is available to verify conditions.

To evaluate the relative concentrations of DO among Ecology's PSAMP stations, the same ranking method applied to the nitrate and chlorophyll data was applied to the PSAMP DO data. Results are shown in Figure 10. As shown, there are many sites in the southern part of Puget Sound and Hood Canal and in shallow inlets throughout the Sound.

While Figure 10 provides a view of the relative ranking between sites based on annual concentrations, a look at the worst case conditions may be more informative. Figure 11, which was excerpted from the 2009 State of the Sound report (PSP 2009), shows the frequency and severity of low DO concentrations in the Sound. As shown, while the number and severity of low DO occurrences is certainly highest in Hood Canal and South Puget Sound, low DO events have been documented throughout Puget Sound.

Toxic Contaminants

Controlling the input of toxic chemicals has been identified as a priority for Puget Sound. While the environmental risks associated with vessel discharges are focused primarily on pathogen and nutrient deposition, toxic chemicals such as ammonia, pharmaceuticals, and personal care products are also present in the waste.

Ammonia, one of the constituents of dissolved nitrogen, can be acutely toxic to aquatic organisms. Because of this, many land based sewage treatment plants are required to remove ammonia from their discharges (WDOH 2005). However, there are no such requirements for MSDs, yet ammonia concentrations are often very high in MSD discharges. The average concentration of ammonia in traditional Type II MSDs on cruise ships is about 145 mg/L which is 3 to 12 times higher than ammonia concentrations in untreated domestic wastewater (EPA 2008). Advanced wastewater treatment systems (AWTS) remove some of the ammonia, however concentrations in discharge from these systems is still substantial with ammonia concentrations of about 36 mg/L which is within the range of typical untreated domestic wastewater ammonia concentration (EPA 2008).

Pharmaceuticals and personal care products (PPCP) are also common in domestic waste streams, and also pose a risk to the marine environment. Of particular concern are endocrine-disrupting compounds such as steroids and hormones. Reproductive effects of endocrine-disrupting compounds have been detected in benthic organisms in Puget Sound, but population level and long-term trends are not known (PSP 2011b). It is also thought that endocrine-disrupting compounds are a contributing factor to the decline of Puget Sound salmon stocks (NOAA 2009). Land based sewage treatment facilities are more than 80 percent effective at removing most PPCPs, particularly steroids and hormones, from wastewater (Ecology 2010). The removal of PPCPs by traditional MSDs has not been studied. However, the removal of PPCPs by land based facilities is due to prolonged biological contact time. Since this would not occur in a traditional MSD, it is unlikely they would be effective at removal of PPCPs (Lubliner et al. 2010). AWTS that utilize reverse osmosis filtration may be capable of removing PPCPs (EPA 2008).

Habitat and Resource Protection

There are several concurrent management programs aimed at protecting and preserving some of Puget Sound's most important, and at risk habitats and species. These management programs are administered by a number of agencies and encompass a range of management goals. The paragraphs below identify sensitive habitat and species in Puget Sound, and provide an overview of management actions intended to preserve and protect them.

Marine Protected Areas

Marine protected areas (MPAs) are areas that are designated as requiring extra protection due to their fragile and unique habitats, or species, or because they are culturally historic sites, or they enhance fisheries abundance and biodiversity. Washington State has designated 127 MPAs that are administered by a number of different agencies; 71 are located in Puget Sound (Figure 12). Marine protected areas are generally small (the average size is 23 acres); only about 5 percent of the Puget Sound coast is covered by an MPA. MPAs offer various degrees of protection for marine resources including harvest and access restrictions. While MPAs are by no means providing a complete inventory of the valuable marine resources, they are an important tool for visualizing the extent of environmentally important areas throughout Puget Sound. Despite their status, with a few exceptions, these areas are not protected from vessel discharges.

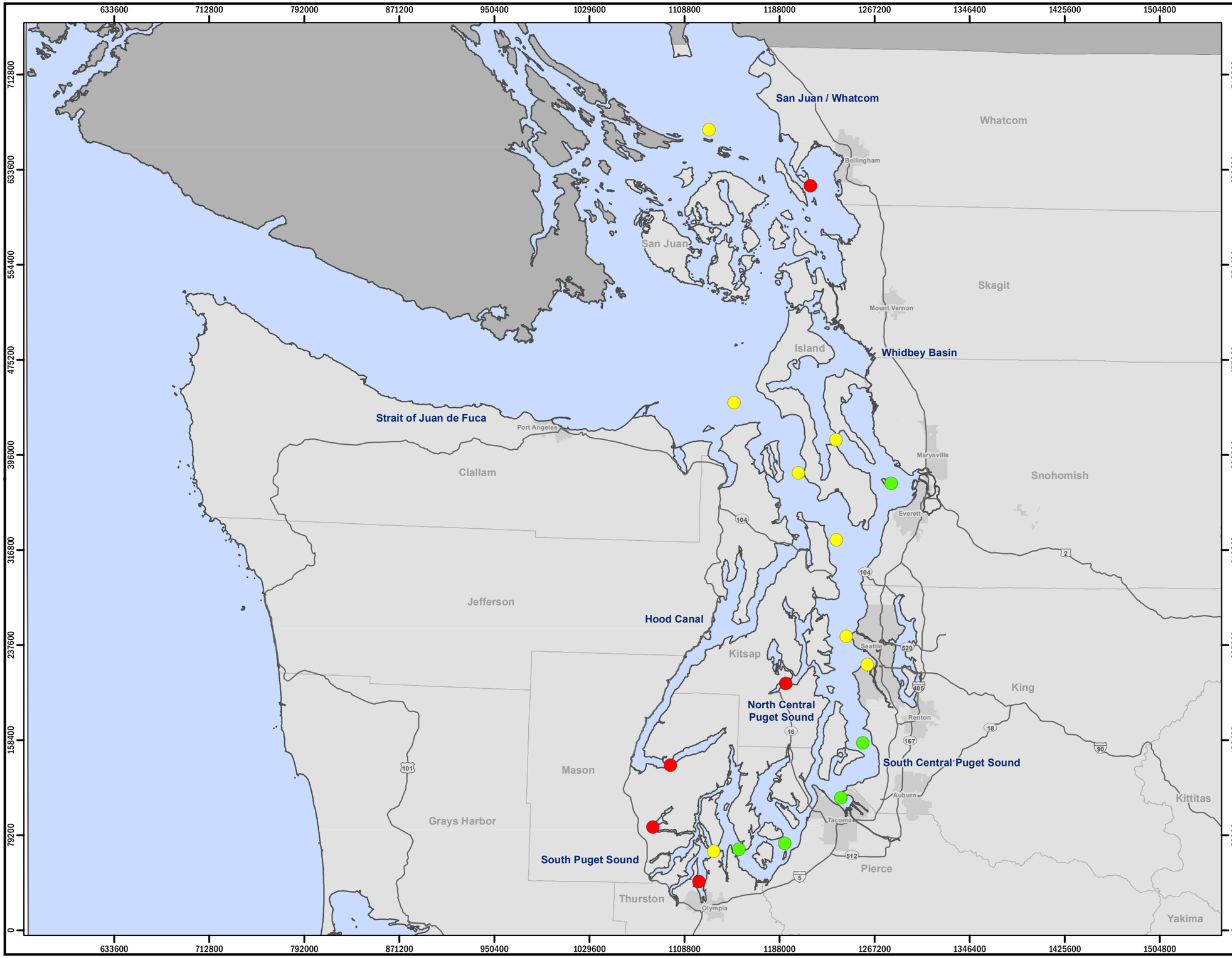

Figure 10.
Relative ranking of median dissolved oxygen concentrations at Ecology's PSAMP stations between 1999 and 2008.

Legend

Relative ranking

- Low
- Medium
- High

Note: Low represents 25th percentile.
Medium represents inner quartile range.
High represents 75th percentile.

N

0 7.5 15 30
Miles

HERRERA

Coordinates: NAD83 Wahington State Plane North (feet)

Produced By: GIS ( )
Project: K:\Projects\11-05217-000\Project\ndz\ambient-do.mxd (4/10/2012)

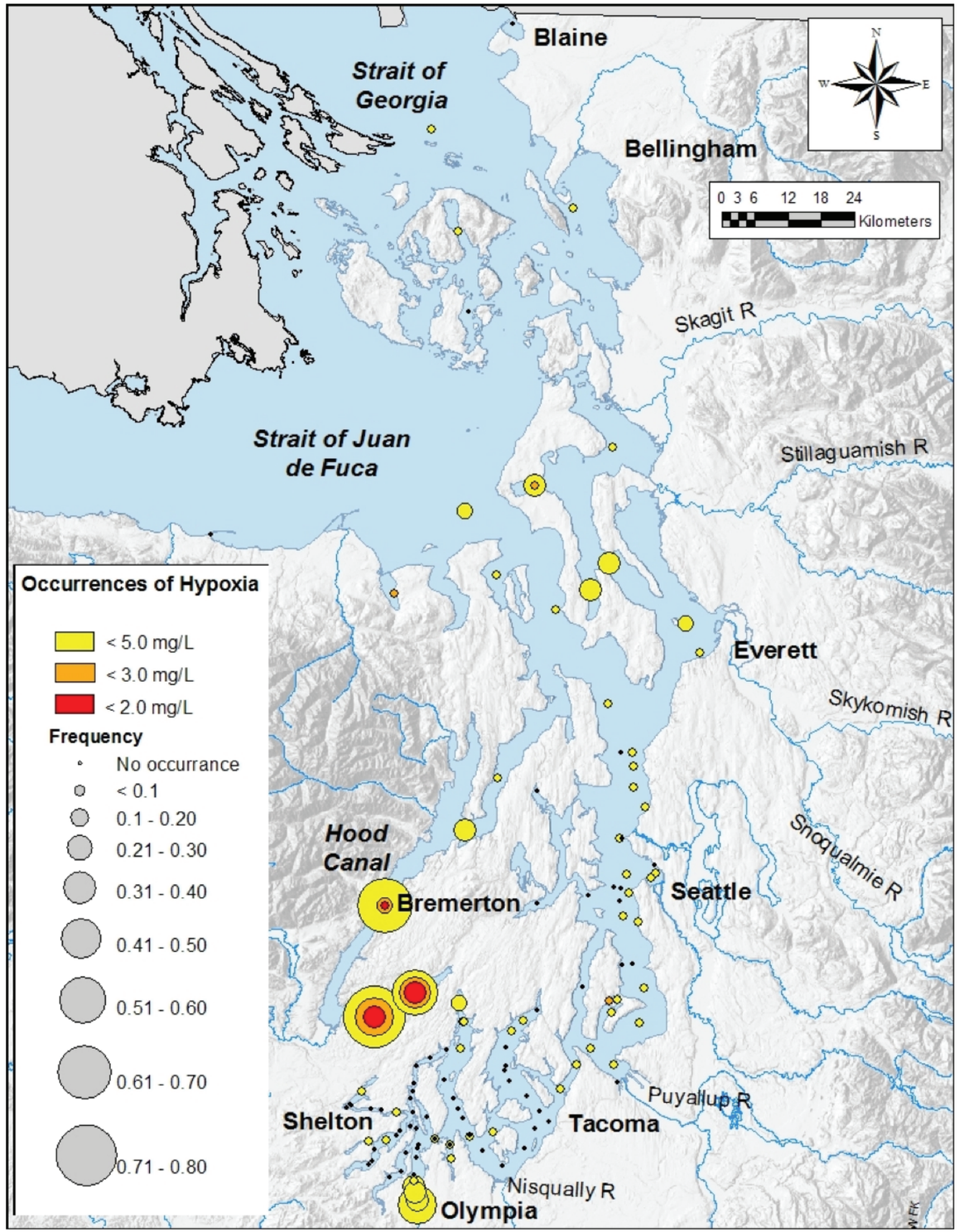

Figure 11.
Spatial patterns of chronic low oxygen concentration.
(Excerpted from PSP 2009)

Legend

See legend details contained within the figure.

N

HERRERA

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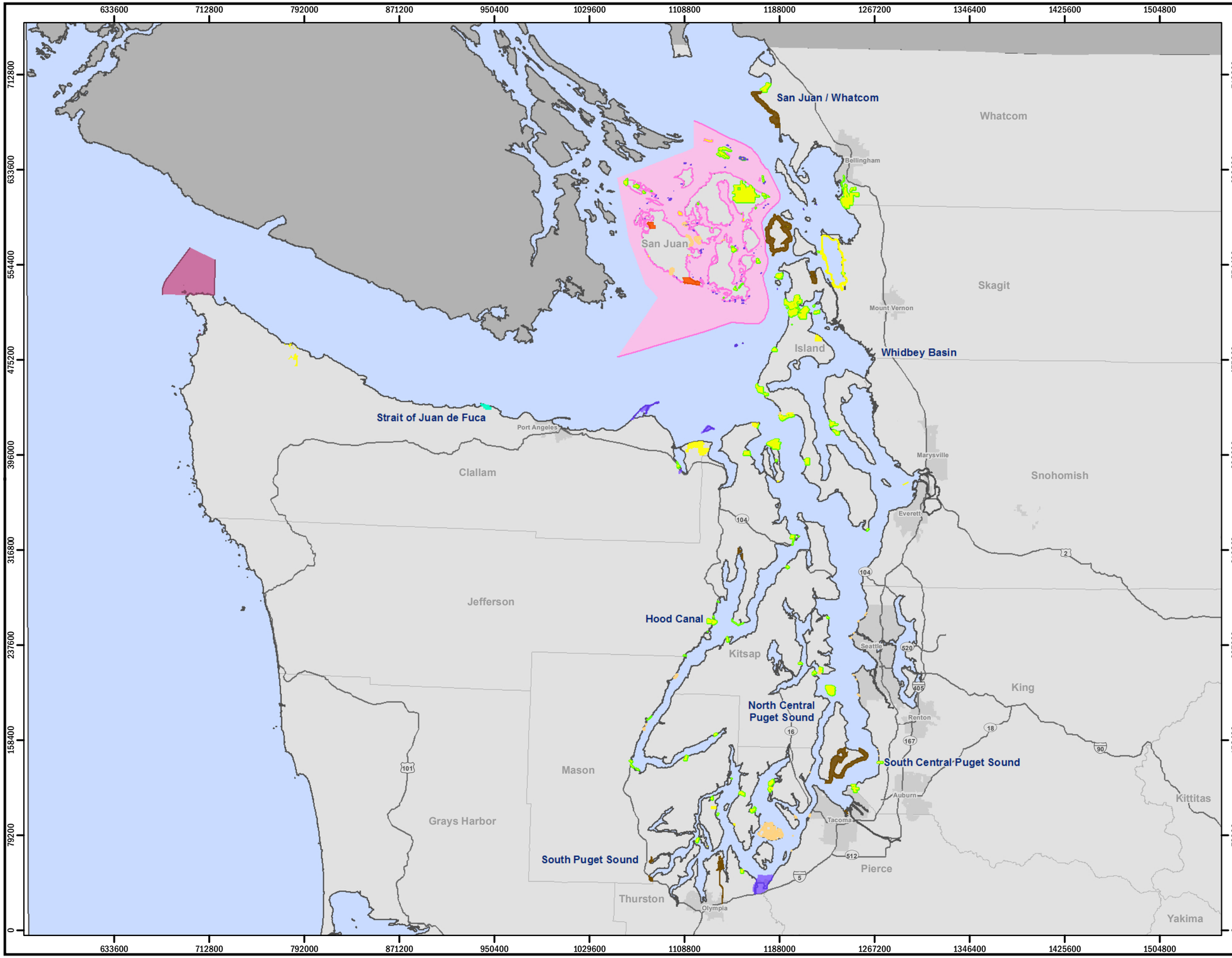

Figure 12.
Proposed marine protected areas in Puget Sound.

Legend

Managing agency

- NPS
- NOAA
- USF&WS
- WDFW
- WDNR
- WDOE
- WP&RC
- UW/FHL
- County

N

0 7.5 15 30

Miles

HERRERA

Coordinates: NAD83 Wahington State Plane North (feet)

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Aquatic Reserves

The Washington Department of Natural Resources (WDNR) manages seven aquatic reserves. Altogether, these seven reserves cover about 142 square miles of marine habitat. The reserves are on state-owned land, and were created to promote the preservation and restoration of aquatic lands that are of special educational, scientific, or environmental interest (WDNR 2012). These seven reserves (Figure 13) were chosen and designated based on selection criteria described in Palazzi and Bloch (2006). These criteria ensure the selection of sites that: protect and provide a diversity of habitat, exhibit high ecological quality, sustain viable populations, and promote habitat connectivity and biodiversity.

Important Species and Habitats

Many important nearshore habitats of Puget Sound support endangered, protected, and economically valuable species that live and reproduce in the waters of Puget Sound. While the creation of an NDZ indirectly relates to the protection of habitat, it is nonetheless worthwhile to catalog sensitive species and critical habitats because documenting the value of the resource is an important component of the NDZ petition.

Forage Fish

Pacific herring, and Pacific surf smelt, are forage fish that are a critical prey species for Puget Sound Salmon. Puget Sound forage fish stocks are not classified as threatened or endangered, though there is not adequate data to assess accurately the status of their populations (Pentilla 2007). Forage fish require intact nearshore habitat in the intertidal zone for successful spawning. Shoreline modifications that result in the disturbance of sediment and the loss of eelgrass are detrimental to the success of forage fish. Because the majority of Puget Sound Shorelines are privately owned, it is difficult to ensure the protection of forage fish spawning habitat. While some legislation can help to prevent further losses to forage fish spawning habitat, education and the actions of individual landowners will be critical to the enhancement of shoreline habitats and forage fish stock recovery (Pentilla 2007). Figure 14 shows the locations of forage fish spawning areas in Puget Sound.

Endangered Species

Several endangered and threatened species are dependent on the ecological integrity of Puget Sound for their survival. The species that garner the most attention are orca whale, chum and Chinook salmon, and steelhead trout. Of 148 distinct salmon stocks reviewed in 1993, 11 stocks of Puget Sound Chinook, chum and steelhead were in danger of extinction (Ecology 2012b). The fate of orca whales and salmon are linked. Salmon comprise a significant portion of the orca's diet; up to 96 percent at certain times of year (USBR 2008). Therefore, declining salmon stocks pose a substantial risk to orca whale populations. Salmon require a diversity of marine habitats throughout their lifecycle. Orca whale habitat covers all open water of Puget Sound.

Critical Habitat

Kelp and eelgrass provide critical habitat for juvenile salmon. The plant beds provide protection from predators, but also provide habitat for crustaceans and smaller forage fish on which the salmon rely as a food source. The areal coverage of kelp and eelgrass beds has declined in

Puget Sound. Though the specific causes of the declines are uncertain, it is thought that reduced light availability, due to suspended sediments and algae, may be among the more significant causes (Thom et al. 2011). PSP has set a management target of a 20 percent increase in the areal coverage of eelgrass by 2020 (PSP 2011a). Figures 15 and 16 show the documented coverage of kelp and eelgrass beds in Puget Sound.

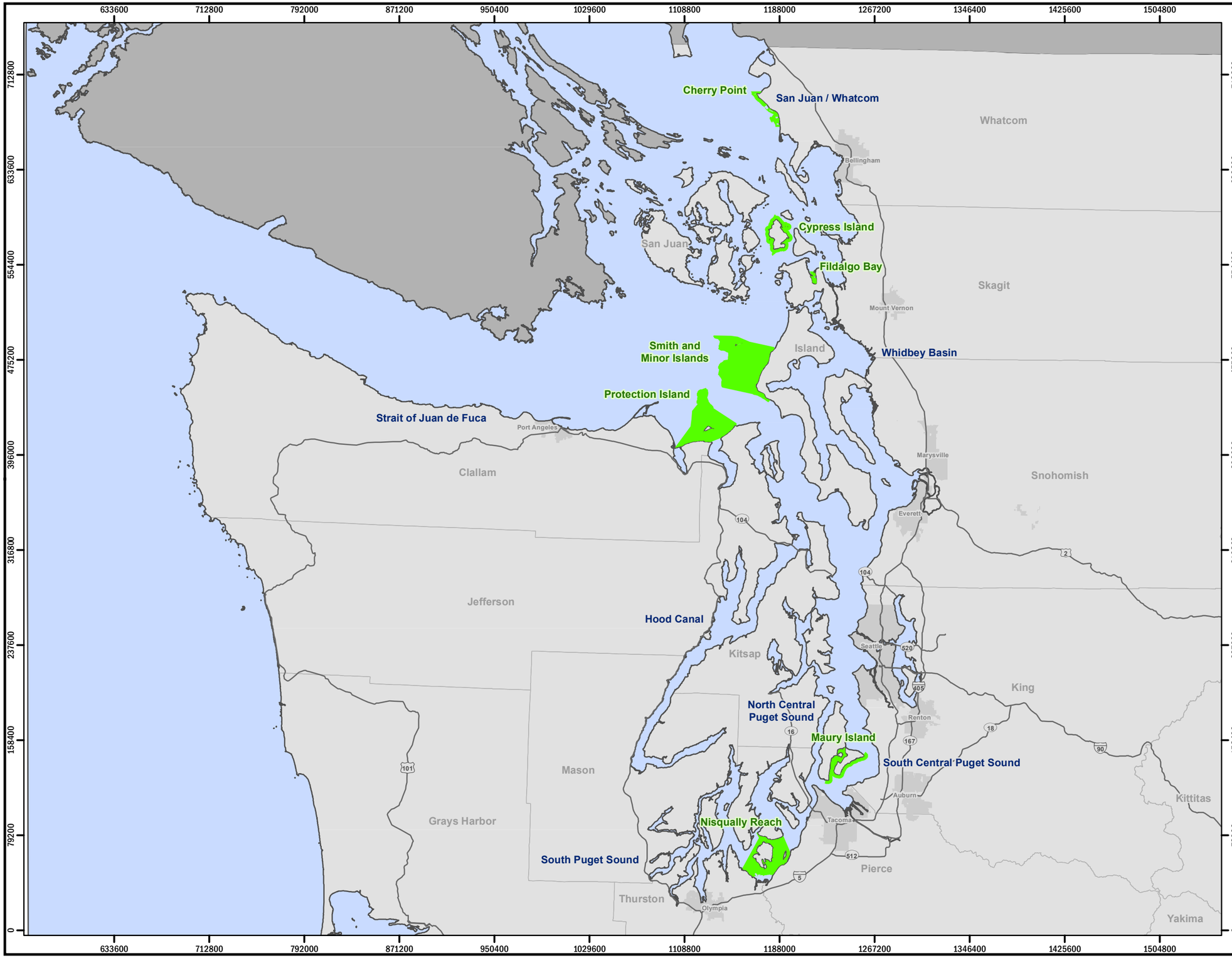

Figure 13.
Aquatic reserves in Puget Sound.

Legend

Aquatic reserve

N

0 7.5 15 30

Miles

HERRERA

Coordinates: NAD83 Wahington
State Plane North (feet)

Produced By: GIS ( )
Project: K:\Projects\11-05217-000\Project\ndz\aquatic_reserve.mxd (4/10/2012)

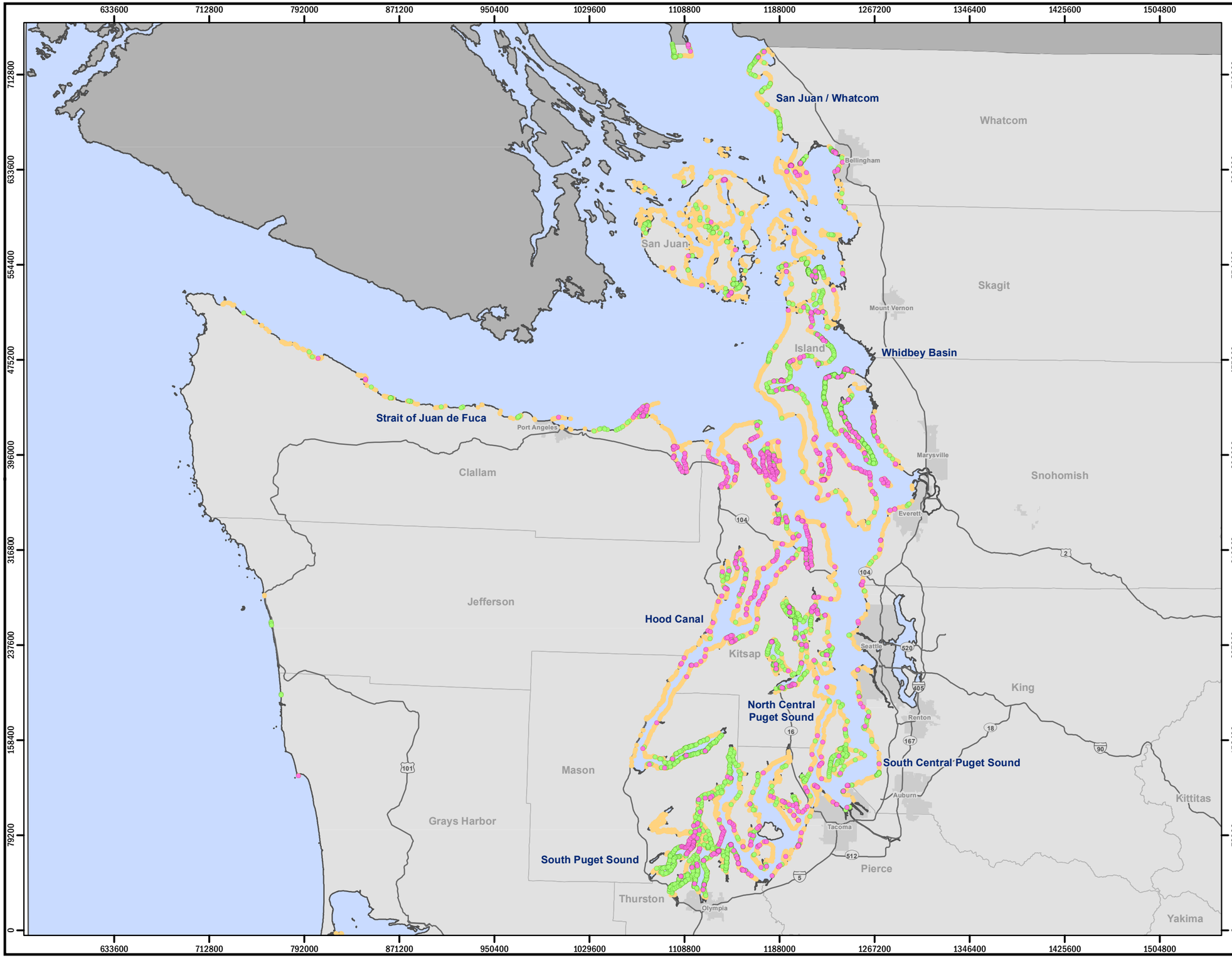

Figure 14.
Forage fish spawning observations in Puget Sound.

Legend

- Sand lance spawning
- Smelt spawning
- No spawning

N

0 7.5 15 30

Miles

HERRERA

Coordinates: NAD83 Wahington State Plane North (feet)

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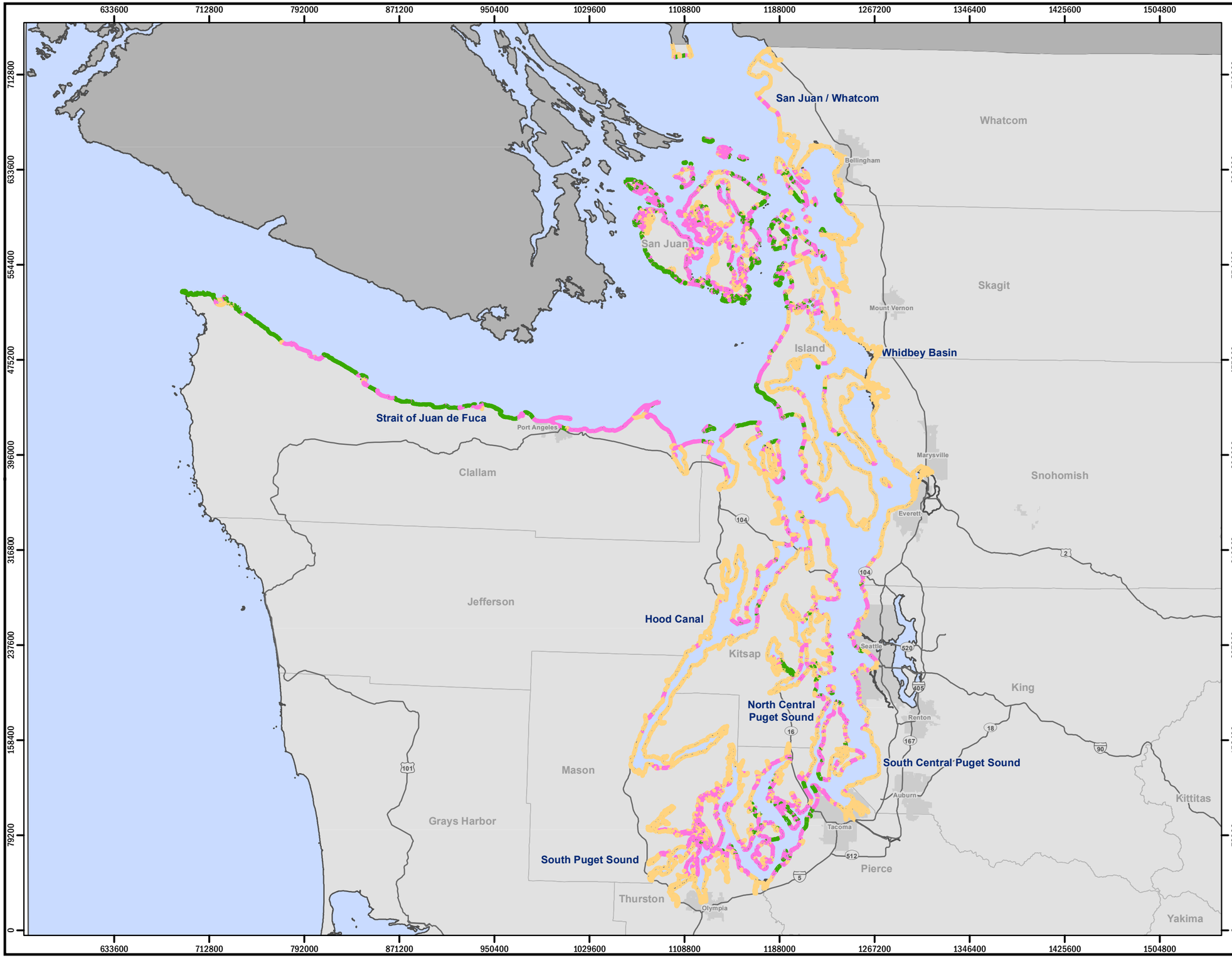

Figure 15.
Kelp observations in Puget Sound.

Legend

Kelp

- Continuous
- Patchy
- Absent

N

0 7.5 15 30

Miles

HERRERA

Coordinates: NAD83 Wahington
State Plane North (feet)

Produced By: GIS ( )
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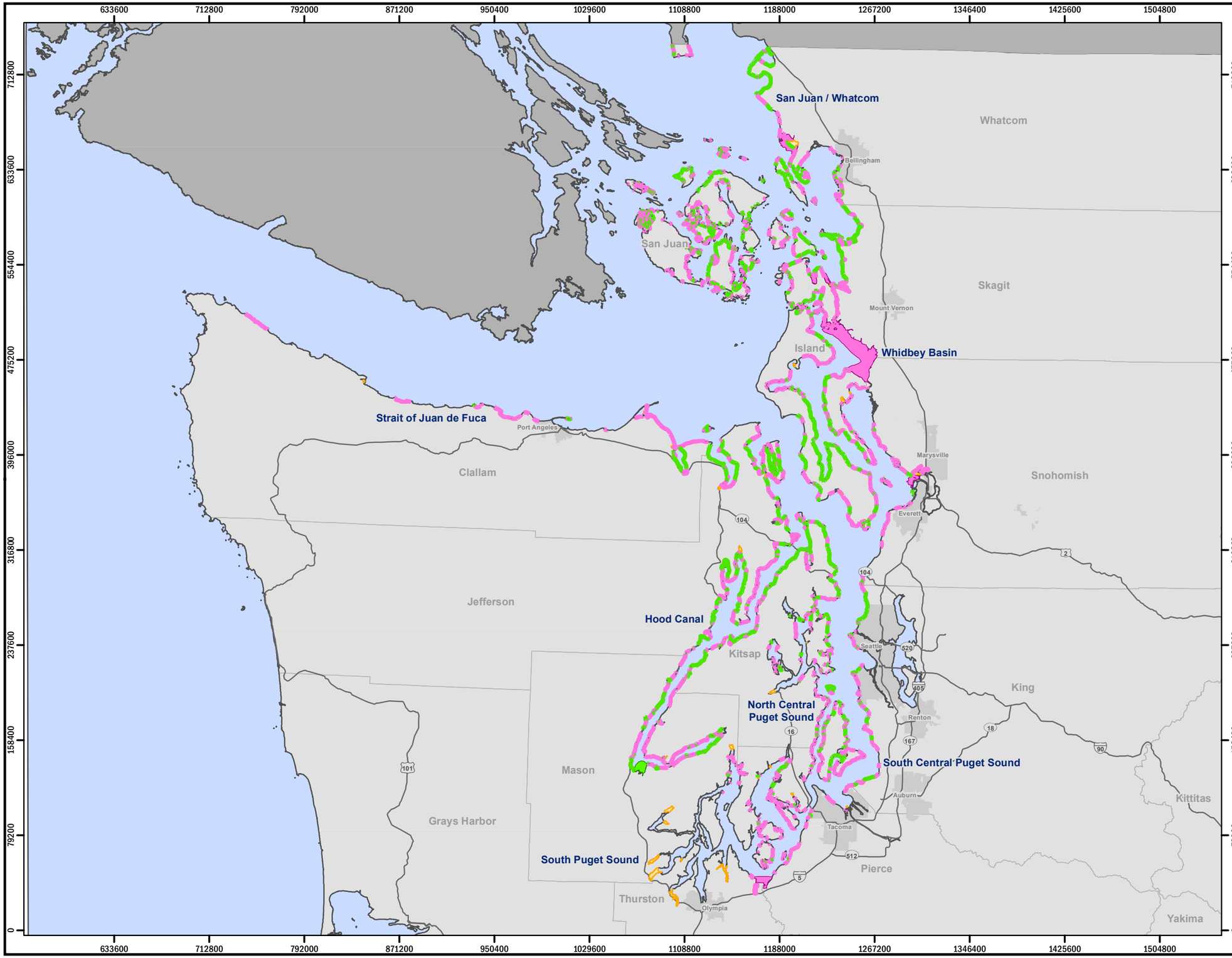

Figure 16.
Eelgrass observations in Puget Sound.

Legend

Eelgrass

- Continuous
- Patchy
- Absent

N

0 7.5 15 30

Miles

HERRERA

Coordinates: NAD83 Wahington
State Plane North (feet)

Produced By: GIS ( )
Project: K:\Projects\11-05217-000\Project\ndz\dnr_eelgrass.mxd (4/10/2012)

VESSEL SEWAGE DISCHARGE

When considering creating new regulations that will control sewage discharges (i.e., establishing a NDZ), it is first necessary to understand: 1) the existing regulations that govern sewage discharges, 2) the quality of the discharges based on vessel type, and 3) the number vessels of different types using Puget Sound. The first two topic areas are addressed in the following subsections. Estimates of vessel number and type will be addressed in a separate report.

In general vessel wastewater is more concentrated than domestic wastewater because people on board vessels use less water for sanitary purposes (California Clean Boating Program, 2011). Therefore, vessel discharges may pose an acute water quality risk at the point of discharge.

Existing Regulations and Agreements

There is an overlapping network of regulatory and voluntary measures governing sewage discharges from vessels in Puget Sound. Internationally, sewage discharges are regulated under the authority of Annex IV of the International Convention for the Prevention of Pollution from Ships. (This agreement is referred to as Marpol for 'marine pollution'.) Marpol is an international convention aimed at reducing many different types of pollution associated with vessel operation. Annex IV which regulates sewage from ships was adopted in 2003 by more than 50 countries. These regulations and revisions require that all vessels over 400 gross tons (GT) or vessels certified to carry more than 15 persons have sewage treatment system; and prohibit discharge of treated sewage within 3 nautical miles (nmi) from shore and untreated sewage within 12 nmi from shore (IMO 2011). Although the United States did not ratify MARPOL Annex IV, it does apply to most foreign-flagged ships (U.S. EPA 2012). U.S. flagged vessels are not subject to MARPOL Annex IV regulations, but they must comply with the CWA, or other state laws when operating in waters within 3 nmi of shore, or within Puget Sound. Table 3 summarizes the regulations governing vessel discharges among the various vessel types that use Puget Sound, as well as the types of MSDs that are typically installed. Marine sanitation devices are discussed further in the following subsection.

The federal government regulates sewage discharges from all vessels, both recreational and commercial under the CWA. Collectively, CWA Section 312 and its implementing regulations require all vessels with toilet facilities to have operable MSDs. Discharges of treated sewage are allowed any distance from shore (except where a no discharge zone has been established). It allows discharges of both treated and untreated sewage beyond 3 nmi from shore. Discharge to a land based pumpout facility is of course also allowed. Standards for discharge from MSDs were developed by the U.S. EPA and are summarized in Table 3 (40 CFR Part 140 and 33 U.S.C. 1322).

Treated sewage discharges are technically required to meet Washington State marine water quality standards (Table 1). However, as will be described in later sections of this report, many MSDs and even Advanced Wastewater Treatment Systems (AWTS) frequently fall short of this

standard. Discharges from MSDs do still occur and are allowed under existing regulations (U.S. EPA 2008, 2010).

Table 3. Regulatory Framework and Marine Sanitation Devices.

Vessel Type	Sanitation Device	Discharge Allowed?	Applicable Regulations/ Agreements	Affected by NDZ Regulation?
Cruise Ships	Advanced Wastewater Treatment System	Yes [a]	NWCCA Memorandum of Understanding	Yes [a]
Cruise Ships	Traditional Type II MSD	No [b]	NWCCA Memorandum of Understanding	No
Commercial (Non-Cruise) Passenger Vessels	Traditional Type II MSD	Yes [c]	CWA Section 312	Yes
State Owned Passenger Vessels (Ferries)	Type III	No [d]	CWA Section 312	No [d]
Large (>79 feet) Domestic Flagged Commercial Vessels	Traditional Type II MSD	Yes [c]	CWA Section 312	Yes
Small (<79 feet) Domestic Flagged Commercial Vessels	Traditional Type II MSD	Yes [c]	CWA Section 312	Yes
Large (>79 feet) Foreign Flagged Commercial Vessels	Traditional Type II MSD	Yes [c]	MARPOL Annex IV	Yes
Recreational Vessels	Type III MSD	No [c]	CWA Section 312	No
Recreational Vessels	Type II MSD	Yes [c]	CWA Section 312	Yes
Recreational Vessels	Type I MSD	Yes [c]	CWA Section 312	Yes
Armed Forces Vessels	Type II MSD	Yes [e]	CWA Section 312	Yes [e]

[a] The overwhelming majority of cruise ships voluntarily practice no-discharge while operating in Puget Sound to comply with the NCCA MOU, so very few vessels would be affected by NDZ regulations.

[b] Under the MOU agreement discharges from Type II MSDs are not allowed under any circumstances.

[c] Regulations governing discharges for United States Flagged Vessel in U.S. waters are described in 40 CFR Part 140 and 33 U.S.C. 1322.

[d] Washington State Ferries voluntarily agree to use holding tanks and pumpout waste at shoreside facilities

[e] Armed forces vessels are not required to comply with an NDZ designation unless certain additional criteria described in 40CFR1700.10 are met.

Large passenger vessels (such as cruise ships) have the potential to discharge large volumes of sewage that may be comparable in volume to a small municipality. Although cruise ships are currently subject to the same rules under the CWA as all other vessels, Ecology and the North West and Canada Cruise Association (NWCCA) have entered into a memorandum of understanding (MOU) which restricts sewage and graywater discharges. Under the MOU, cruise ships must undertake a rigorous monitoring and documentation process proving that their discharges meet specific water quality standards, before they are allowed to discharge into Washington State waters, including Puget Sound. In 2010, two of the 15 cruise vessels that operate in Puget Sound applied for permission to discharge in Washington waters and were approved. (They can only discharge while moving at speeds of greater than 6 knots.) In 2011, the same two vessels applied for and were approved to discharge (Ecology 2010, 2011b).

Marine Sanitation Devices: Performance and Effluent Quality

National and international laws require that for vessels operating within 3 nmi (4 nmi for vessels party to MARPOL Annex IV) from shore, sewage be treated by a MSD prior to discharge into marine waters. There are several different types of MSDs available to vessel operators. MSDs must meet specific performance standards, and not all types of MSDs are allowed on all vessels. Table 4 summarizes the types of MSDs available, and the applicable U.S. Coast Guard (USCG) standards. Although there are performance standards for MSDs, there are no requirements for periodic testing to ensure that they are working properly.

Table 4. Marine Sanitation Device Summary.

MSD Type	Allowable Vessel Installations	Primary Mode of Operation	Discharges Allowed in Washington Waters	USCG Treatment Standards
Type I	Recreational Vessels <69 feet in length	Maceration [a] / Chlorination	Yes	No visible floating solids: A fecal coliform bacteria count not greater than 1,000 per 100 milliliters
Type II	All Vessels	Aeration, Clarification, Disinfection	Yes	A fecal coliform bacteria count not greater than 200 per 100 milliliters No more than 150 milligrams of total suspended solids per liter
Type III	All Vessels	Holding Tank	No	No Performance Standard
AWTS	All Vessels [b]	Biological reactor / UV Sterilization	No	Same as Type II

[a] Maceration refers to the mechanical grinding and liquefying of solid waste.

[b] While AWTS are allowed on any vessel type, they are large and costly; therefore, they are typically only installed on large passenger vessels.

According to data collected under the Clean Vessel Act (CVA 1994), approximately 46 percent of Washington's recreational vessels over 26 feet have Type III MSDs installed. Type III MSDs are basically holding tanks with no treatment capabilities. Discharges from these MSDs are not allowed within 3 nmi from shore, and these vessels must use pumpout stations. Type III MSDs may be installed with a "Y" valve which allows operators to discharge waste overboard from the holding tank when they are outside the 3nmi limit. The remaining 54 percent of recreational vessels presumably have Type I or Traditional Type II MSDs installed. Vessels under 26 feet are assumed to have no toilet facilities. Type I MSDs are typically installed on smaller recreational vessels (>26 to <69 feet) and use maceration and chlorination to liquefy and disinfect waste. USCG performance standards are not very stringent for these devices. The effluent limit for fecal coliform (1,000/100 mL) is 10 times higher than the least stringent Washington State water quality standard. U.S. EPA recently conducted performance evaluations of two popular Type I MSDs, the Electro Scan EST 12 and the Thermopure-2 systems, both of which were previously approved by the USCG.

The Electro Scan in general was highly effective at removing pathogens, and in the majority of samples had no detectible Escherichia coli (*E. coli*) or enterococci bacteria. However, there were some samples collected which had concentrations of *E. coli* and enterococci of 59,000 and >24,000/100 mL respectively, indicating variable and at times inadequate performance. The Thermo Pure that was tested was very ineffective at removing pathogens. *E. coli* counts were

typically in the millions and enterococci were in the hundreds of thousands per 100 mL. Neither unit was effective at removing nutrients, biological oxygen demand (BOD), or total suspended solids (TSS) U.S. EPA 2010.

Traditional Type II Marine Sanitation devices are typically installed on larger vessels, and are required on all vessels over 69 feet with toilet facilities, if they do not have a Type III MSD (Holding Tank). The types of vessels that would typically have Traditional Type II MSDs would be large passenger vessels, cruise ships, freighters, commercial fishing vessels, and tug boats. Some cruise ships, particularly those that operate in Alaska and Washington, frequently have advanced wastewater treatment systems (AWTS), an advanced kind of Type II MSD. Traditional Type II MSDs use a three-stage process consisting of aerobic bacteria digestion, clarification and filtration, and ultimately chlorine disinfection. AWTs generally provide improved screening, biological treatment, solids separation (using filtration or flotation), and disinfection (using ultraviolet light) as compared to traditional Type II MSDs (U.S. EPA 2008). U.S. EPA and the Alaska department of Environmental Conservation (ADEC) evaluated the performance of Traditional Type II MSDs and AWTS installed on cruise ships (U.S. EPA 2008). AWTS generally performed very well and for most parameters results were found to be comparable to land based sewage treatment facilities. The exceptions were dissolved metals and ammonia, which were generally not effectively removed by AWTS (EPA 2008). Traditional Type II MSDs were ineffective at removing fecal coliform, and produced effluents that were high in BOD and TSS (Table 5) (U.S. EPA 2008; ADEC 2004). Traditional Type II MSD also did little to remove metals or ammonia (U.S. EPA 2008).

Table 5. Comparison of Traditional Type II MSD Effluent Concentrations to Untreated Domestic Wastewater.[a]

Parameter	Average Concentration of Cruise Ship Type II MSD Effluent	Concentration in Untreated Domestic Wastewater
Total Suspended Solids (mg/L)	627 ± 94.3	100-350
Biochemical Oxygen demand (5-Day) (mg/L)	133 ± 15.2	110-400
Fecal Coliform MPN/ 100 mL [b]	2,040,000	Not Reported

[a] Table5 adapted from U.S. EPA (2008).
[b] Fecal Coliform concentration was reported in ADEC (2004).

With the exception of AWTS, which generally perform well, Type I and traditional type II MSDs are ineffective or variable at best, at reliably treating sewage to an acceptable level. Despite the treatment standards established by the USCG for marine sanitation devices, several studies have documented that the true operating performance of MSDs rarely approaches these standards. Although many land-based sewage treatment facilities also discharge to Puget Sound, their performance is generally much better for removing contaminants than any available MSD treatment technologies. Therefore, requiring that sewage waste be held on vessels until it is possible to pump it out at a land based facility is currently the best way to minimize pollution impacts to Puget Sound from vessel sewage.

PUGET SOUND NDZ COSTS AND BENEFITS

There are direct and indirect costs and benefits of establishing an NDZ that affect a range of stakeholders. The primary cost to vessel operators is the cost to retrofit vessels that do not have adequate holding capacity. There are also costs associated with the building and maintenance of pumpout facilities. The Clean Vessel Act grant program pays the bulk of the costs associated with recreational pumpouts, but there are no similar programs for commercial pumpouts. There are also indirect costs, which are difficult to quantify, such as the cost in time required navigating to and from pumpout facilities. The following subsections aim to outline some of the costs for various users. The data presented are not intended to serve as a cost estimate; rather the purpose is to highlight the array of potential costs incurred.

Costs to Recreational Vessel Operators

Those vessel operators who already hold their waste and utilize pumpout facilities will not be noticeably affected by NDZ regulations. However those that habitually discharge treated wastes into Puget Sound, or untreated waste beyond 3nmi will have to modify their habits. While out on the Sound for a multiday voyage, there will be time and fuel costs associated with making a detour to a pumpout station.

Those recreational vessel owners that do not have the capacity to store waste will incur retrofit costs. The cost of installing a holding tank is about $500 (USACE 2004) if there is enough room on a boat. There is also a 'sunk' cost to vessel operators who have recently invested in a MSD that could no longer be used for its intended purpose (treatment and discharge) under NDZ regulations.

Costs to Commercial Vessel Operators

Common waste handling practices for commercial vessels in Puget Sound are not well known. Most commercial vessels are large and utilize Type II MSDs. Some vessels may have holding and pumpout capability, however many may not. For example, Chamber of Shipping America supplied the State of California survey data on MSDs on board commercial freight and tank vessels. Of the 634 vessels included in the Chamber of shipping survey, only 330 (52 percent) had the capability to hold sewage (Paul Amato Region 9 EPA, Pers. Comm.).

It can be costly to retrofit large oceangoing vessels. One trade group estimated that the average cost of retrofitting an ocean-going vessel is about $98,000 (Paul Amato, Region 9 EPA, Pers. Comm.) This estimate assumed a vessel with a crew of 20 people and a 1,200-gallon holding tank. Transit time to and from pumpout facilities also needs to be considered when assessing costs to commercial vessel operators. The extra time required to travel to and from pumpouts represents a direct cost to the company in time, wages and expenses for these trips which is why they often perform pumpout operations in conjunction with fueling operations. This factor must be considered when locating commercial vessel pumpout facilities. It is critical that commercial vessel operators do not need to travel far to use a pumpout, otherwise they are

unlikely to use it (Todd Callaghan, Massachusetts Office of Coastal Zone Management, Pers. Comm.).

Costs of Developing Pumpout Facility Infrastructure

Costs associated with establishment of a No Discharge Zone may include constructing and maintaining pumpout stations, recordkeeping, reporting, public education, and enforcement.

The approval of a NDZ is contingent on there being an adequate number of facilities. If it is determined that there are already enough pumpout facilities and they are adequately spaced in reasonable geographic locations, there is no need to establish more stations. In that case there would be little cost for pumpout facilities. Although the State has no obligation to pay for pumpout facilities, if additional facilities are required, the state may choose to seek or provide funding for the construction of additional facilities. The cost of establishing new pumpout facilities is largely dependent on site-specific logistics, and the type of vessels intended to be serviced.

Recreational pumpout facilities are typically funded via the federal CVA grant program. Under this grant program, Washington State can receive, up to 1.5 million dollars annually for the construction, operation and maintenance of pumpout facilities (Al Wolsgel. Washington State Parks Department, Pers. Comm.). This money is dispersed by the State to marina owners and others for eligible projects. The marina owners in turn provide matching funds of 25 percent of the project cost, but there is no limit to how much money a single facility can receive. In 2011, there were 29 projects in Washington that utilized CVA funds. The cost of these projects ranged from approximately $7,000 to $150,000.

Commercial pumpout facilities are not eligible for CVA funds. In Puget Sound, commercial facilities are often located at ports, so the port may be responsible for securing funding for commercial vessel pumpout facilities. In some cases states have assisted with funding for commercial vessel pumpout infrastructure (Todd Callaghan, Massachusetts Office of Coastal Zone Management, Pers. Comm.). The cost of constructing commercial pumpout facilities is comparable to constructing recreational facilities. Five new commercial pumpout facilities were recently constructed in Massachusetts. The cost of these projects ranged from approximately $35,000 to $175,000 (Todd Callaghan, Massachusetts Office of Coastal Zone Management, Pers. Comm.).

There are also recordkeeping costs associated with maintaining a NDZ. U.S. EPA estimates an annualized cost of approximately $108,000 (76 FR 80360). This is the estimated cost for U.S. EPA staff time. Similar estimates for the state's cost are not readily available, but they are likely similar in magnitude.

The cost of enforcing NDZ regulations is difficult to estimate. It is recommended that an enforcement plan be developed as part of the petition process. This plan would address who is responsible for policing and how fines will be levied. Once this has been established, it can be determined what, if any, additional burden there may be to the state or municipalities.

Many states rely on public education and awareness as the primary incentive for compliance. Costs for these programs would be minimal and may include production of publications, signage, and employee time.

The Value of Clean Water

It is difficult to put a monetary value on clean water. However, we do know that clean water is vital for sustaining the economic and social benefits provided by Puget Sound.

In 2008, the Puget Sound commercial shellfish industry was estimated to have generated 44 million dollars in revenue. Shellfish aquaculture has shown steady growth since 1985, with over 20 million pounds harvested in recent years (PSP 2009). On a per acre basis, commercial Pacific oyster beds are estimated to produce between $10,000 and $20,000 per year (Entrix 2010). Therefore the cost of prohibited or restricted commercial acres can be directly estimated. Commercial fishing is valued at 4 million dollars annually (Ecology 2008).

Each year about 390,000 people recreate in the waters or on the beaches of Puget Sound. Thousands of people flock to Puget Sound beaches every weekend to dig for clams and oysters. The value of shellfish harvested recreationally is estimated to be 42 million dollars annually. Recreational fishing is valued at 57 million dollars annually, when peripheral expenses such as fuel and equipment purchases are considered (Ecology 2008).

An additional benefit that cannot be related to a monetary value is protection of traditional tribal fishing and shellfish harvesting areas and the associated treaty rights. These 'usual and accustomed' harvesting areas have been used by the tribes for millennia that and must continue to serve as a natural and cultural resource for generations to come.

Vessel pumpout facilities are a viable strategy for reducing and eliminating vessel sewage discharges into Puget Sound. Beginning in 1996, Washington State Parks has administered the CVA program, which provides funding for recreational boater pumpout facilities. Since its inception there has been a steady increase in usage and the amount of sewage pumped at these facilities. In 2011, over 4 million gallons of sewage was removed from vessels via publically accessible pumpout facilities used by recreational vessels. Over 35 million gallons have been removed from these facilities since the program began (Al Wolsgel, Washington State Parks, Pers. Comm.). It is expected when vessel pumpout is compulsory, rather than voluntary, as it is now, the amount of sewage diverted from Puget Sound and into pumpout stations will substantially increase.

CONCLUSIONS

Puget Sound is a unique and valuable resource that is worth protecting from the potentially harmful effects of vessel sewage discharges. While overall the condition of Puget Sound is good, there are many indications that the condition has declined over past decades and that this trend is continuing. Elevated nutrient levels have the potential to cause harmful algal blooms and exacerbate existing DO problems. Low DO levels and high fecal bacteria concentrations do not meet water quality standards in many areas. High fecal bacteria concentrations have also resulted in the closures of thousands of acres of commercial and recreational shellfish growing and harvesting areas, resulting in significant revenue losses.

Existing regulations governing vessel discharges and the practical performance of most commonly used MSDs are inadequate for treating sewage or for ensuring the protection of Puget Sound. The performance standards for MSDs allow for fecal bacteria concentrations many times higher than Washington States' marine water quality standards. They also release high levels of ammonia, pharmaceuticals and other toxicants. Performance evaluation studies have also documented that under practical usage conditions, some approved MSDs offer little to no treatment benefits. Establishment of an NDZ will ensure that waste discharges from vessels will not continue to contribute to the degradation of Puget Sound.

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