South Puget Sound *Forum*

Environmental Quality – Economic Vitality

Indicators Report

Updated July 2006

Making connections and building partnerships to protect the marine waters, streams, and watersheds of Nisqually, Henderson, Budd, Eld and Totten Inlets

The economic vitality of South Puget Sound is intricately linked to the environmental health of the Sound's marine waters, streams, and watersheds. It's hard to imagine the South Sound without annual events on or near the water - Harbor Days Tugboat Races, Wooden Boat Fair, Nisqually Watershed Festival, Swantown BoatSwap and Chowder Challenge, Parade of Lighted Ships – and other activities we prize such as beachcombing, boating, fishing, or simply enjoying a cool breeze at a favorite restaurant or park. South Sound is a haven for relaxation and recreation.

Businesses such as shellfish growers and tribal fisheries, tourism, water recreational boating, marinas, port-related businesses, development and real estate all directly depend on the health of the South Sound. With strong contributions from the South Sound, statewide commercial harvest of shellfish draws in over 100 million dollars each year. Fishing, boating, travel and tourism are all vibrant elements in the region's base economy, with over 80 percent of the state's tourism and travel dollars generated in the Puget Sound Region.

Many other businesses benefit indirectly. Excellent quality of life is an attractor for great employees, and the South Puget Sound has much to offer!

The South Puget Sound Forum, held in Olympia on April 29, 2006, provided an opportunity to rediscover the connections between economic vitality and the health of South Puget Sound, and to take action to protect the valuable resources of the five inlets at the headwaters of the Puget Sound Basin – Totten, Eld, Budd, Henderson, and the Nisqually Reach. This document served as a backdrop for the presentations and discussions at the forum, and now provides a baseline for other ongoing work to protect and restore the health of our valuable water resources.

The information on these six indicators - population, land cover, shoreline armoring, shellfish water quality, freshwater quality and marine water quality - provides a valuable snapshot of current conditions and recent trends. The report also provides baseline data against which future assessments can be compared to gauge changes over time as well as the effect of related managment actions. Do you part, get involved and stay tuned for future updates and forums addressing these issues.

PUGET SOUND ACTION TEAM
Office of the Governor, State of Washington

TRPC
Thurston Regional Planning Council

Population

The South Sound is one of the fastest growing areas in the state, exceeding the State's growth rate consistently since the 1960s. Twenty-five years ago there were around 125,000 people living in Thurston County. By 2005 the number had risen to 225,000 – a gain of 100,000 people. We're expecting another 150,000 people within the next 25 years. Our growth rate is high because of our stable economy, high quality of life, and lower cost of living compared to the Central Puget Sound region. The story is much the same for other areas of South Puget Sound.

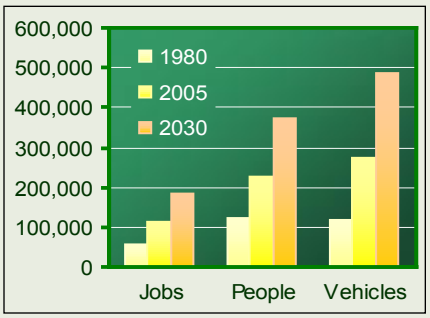


Figure 1. Recent and projected growth in jobs, people and vehicles in Thurston County.

Approximately 75 percent of the population growth is from people moving here – only a quarter of the growth is from births. We expect 63,000 new jobs to be created in Thurston County alone by the year 2030, and these jobs will attract workers and their families. We're also expecting an increasing number of people to move to the South Sound to commute to jobs in the Central Puget Sound region.

This means that one-third of the jobs and 40 percent of the homes that will exist in 2030 will be created between now and then.

New home construction.

The only thing growing faster than population is cars. Twenty five years ago there were around 120,000 vehicles registered in Thurston County. By 2004 there were around 275,000. Using state-wide population to vehicle ratios, this number could increase to nearly 400,000 by the year 2030 (Figure 1).

Challenges

One of the biggest challenges facing our community is how to plan for expected growth in people and businesses and at the same time keep our streams, water bodies, and Puget Sound healthy. People move here because it's a great place to live, but more people, more cars, more asphalt, more pollution, and less natural areas – these are challenges that we face as growth comes to the region. It's truly a balancing act.

Boardwalk apartments in downtown Olympia.

Growth impacts all aspects of marine health – and indicators such as impervious area and stormwater runoff, miles of armored marine shoreline, stream and marine water quality, and shellfish and fish health provide insight into how well we're balancing economic prosperity, managing growth, and protecting the environment. Monitoring these indicators of marine health allow us to take a step back and look at the effects of everyone working together to preserve the jewel of the South Sound – our Puget Sound.

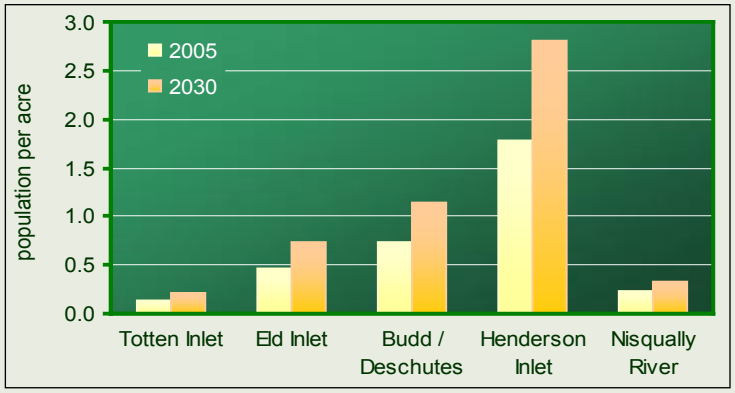


Figure 2. Current and projected population per acre in South Sound watersheds.

Opportunities

Much of the growth will be clustered around Puget Sound's Inlets, or near and around streams that feed into Puget Sound. The cities of Olympia, Lacey, and Tumwater all lie at the headwaters of the Puget Sound – the South Puget Sound. Of the five South Sound watersheds, Henderson Inlet and Budd/Deschutes watersheds will experience the most growth (Figure 2). Most of this growth will be concentrated in the cities of Lacey, Tumwater and Olympia.

Construction of new mixed office and residential building.

With growth comes many opportunities to reshape our community. During the 1970s and 1980s development spread out at suburban densities. By the 1990s a more compact pattern of development began to take shape with the help of growth management. This opened opportunities for infilling, redeveloping existing properties, and strengthening the city centers in Olympia, Tumwater and Lacey.

Compact development also creates more choices for alternate ways to travel – increasing the efficiency of buses, and making walking and biking more convenient. Compact development leaves more land available for natural areas, parks and open spaces, preserves productive resource lands and related industries in rural areas, supports affordable infrastructure and services, and protects healthy water resources.

All of this leads to healthy, vibrant communities, the type of community that businesses want to be located in, keeping the South Sound a desirable place to live, work, and play.

South Puget Sound watersheds.

For More Information:
Thurston Regional Planning Council. 2005. *The Profile.*
www.trpc.org/programs/estimates+and+forecasts/demographics/the+profile.htm

Land Cover and Land Use

Western Washington is prized for its lush evergreen forests, but in the Puget Sound region these forest lands are giving way to cities and urbanized areas at a fairly rapid rate. Between 1985 and 2000, around 32,500 acres of forested lands, agricultural lands, or shrub lands were converted to residential subdivisions and other urban land uses in Thurston County – representing around 7 percent of the total land area. Forest cover decreased by 13,000 acres during this time – or by 5 percent – and the amount of impervious surfaces – like parking lots, roof tops, and roads – increased by 5,500 acres, an increase of around 30 percent. In contrast, population increased by around 45 percent during the same time (Figure 1).

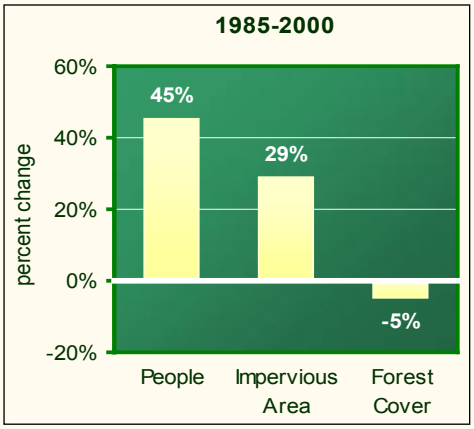


Figure 1. Change in people, impervious area, and forest cover in Thurston County between 1985 and 2000.

Impervious Area

Among other variables, studies have found a strong relationship between the amount of impervious surface and forest cover in a basin or watershed, and the health of streams and other water resources. The greater the amount of impervious area and the corresponding loss of forest cover, the less water that is absorbed into the ground – being filtered naturally and slowly returning to our ground water or stream systems. Increased surface runoff leads to more pollution in our streams and inlets, to higher and increased numbers of flood events, and to degradation of our streams and stream beds.

Research shows that as development increases, as measured in changes in impervious cover, impacts to streams tend to progress. As a guide, natural resource managers use generalized breakpoints at approximately 10 and 25-30 percent impervious cover to reflect potentially important transitions in stream health based on an array of stream-health indicators.

The stormwater utilities of Thurston County, Olympia, Lacey and Tumwater have partnered with Thurston Regional Planning Council (TRPC) to develop estimates of future impervious area based on TRPC's population and employment forecast distributions, today's land use patterns and zoning. Estimating future conditions is critical in making decisions today.

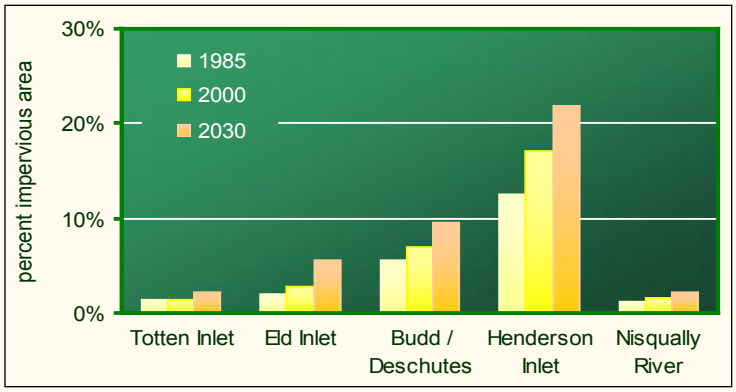


Figure 2. Estimated impervious area conditions in South Sound watersheds, 1985, 2000, and 2030.

Preliminary estimates, which at this time only take into account forecast residential growth, show that while the increasing percentage of impervious area is of concern throughout the South Sound, the Henderson Inlet and Budd/ Deschutes watersheds have, and will continue to have, the greatest surface area in impervious surface cover (Figure 2).

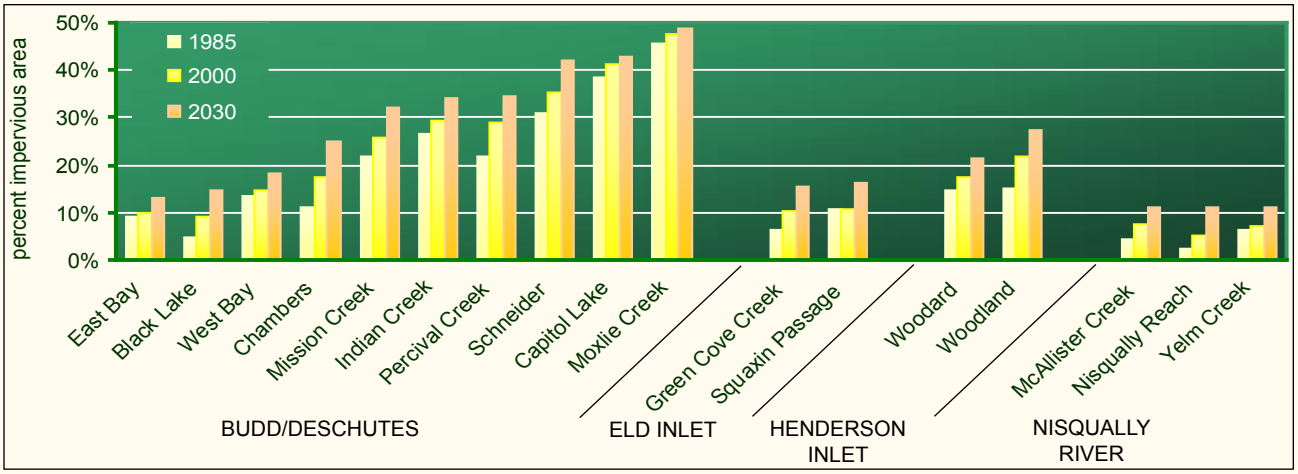
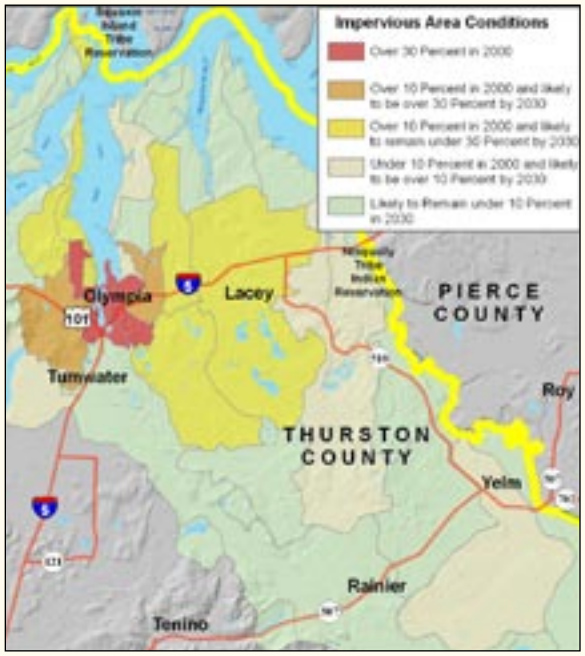


Figure 3. Estimated impervious area conditions in select Thurston County basins, 1985, 2000, and 2030.



Select Thurston County basins categorized by current and future percentage of impervious area.

Many basins within Thurston County watersheds are likely to have more than 10 percent impervious cover in coming years (Figure 3). In the late 1990s, Green Cove Creek Basin, in Eld Inlet Watershed, was identified as having around 10 percent impervious area cover, which raised concerns over stream and water quality health in the future. Joint planning efforts by the City of Olympia and Thurston County resulted in changes in zoning and development regulations in this basin. Much of the unincorporated area was downzoned to rural densities, and a new low impact development (LID) zoning district was created for the area of the basin within city limits. The hope is that the impact of future development will be less in this basin than it would have been under previous regulations. The broader hope is that we can use this information and perhaps some of the same approaches to more effectively protect and restore water resources in other areas of the South Sound.

Forest Cover

Studies have shown that watersheds with high forest cover are less likely to have degraded stream health. Budd/Deschutes, Eld Inlet and Henderson Inlet watersheds have experienced the greatest loss of forest cover due to urbanization over the last 15 years (Figure 4).

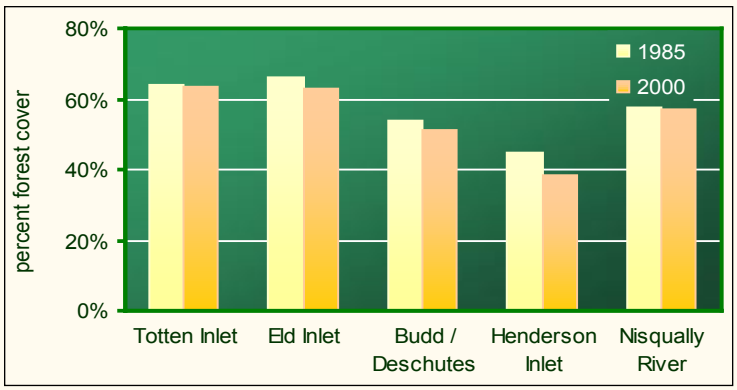


Figure 4. Estimated loss in forest cover due to urbanization in South Sound watersheds.

Land Use and Density

There are things we can all do to minimize the impacts of development and lessen our stormwater problems. One of the less obvious ones is to support compact growth. Compact growth offers many benefits, including low maintenance homes and lawns (and less water usage), nearby shopping, biking, walking, and transit opportunities, and nearby parks and open spaces to enjoy. While many people are used to thinking of compact or dense development producing a greater amount of impervious surfaces, the opposite is true.

Unit for unit – compact development is far more effective at reducing impervious surfaces. Let's take those 150,000 people we are expecting in Thurston County, they will require around 70,000 new homes.

Take a look at the chart to the side. As building densities increase, the total amount of impervious surfaces generated by growth decreases – and at the watershed or basin level – the decrease is astounding.

Land Needed to Accommodate 70,000 Homes and Resulting Impervious Surface

Density	Acres of Land	Percent Impervious Surface	Acres of Impervious Surface
1 du/acre	700,000	20%	140,000
2 du/acre	350,000	25%	87,500
4 du/acre	175,000	40%	70,000
8 du/acre	84,000	65%	54,600
100 du/acre	7,000	85%	5,950

For More Information:

Thurston Regional Planning Council. 2001. *Land Cover Mapping of Thurston County.* www.trpc.org/programs/estimates+and+forecasts/development/land+cover+mapping.htm

Thurston Regional Planning Council. *The Rate of Urbanization and Forest Harvest in Thurston County, 1985-2000.* www.trpc.org/programs/estimates+and+forecasts/development/land+cover+change.htm

NOAA Coastal Change Analysis Program. www.csc.noaa.gov/crs/lca/ccap.html

Stormwater Manager's Resource Center. *Monitor/Assess - Tools for assessing stream quality* www.stormwatercenter.net

Shoreline Armoring

Beaches along the South Puget Sound provide essential habitat for many forms of marine life, including many species that are an important part of the food chain such as forage or bait fish. These small fish are the main source of food for salmon in certain stages of their life cycle, and are as essential to salmon survival as clean water and spawning habitat.

Over time this nearshore habitat has been altered by human activity. Of the almost 130 miles of marine shoreline in Thurston County, 37 percent, or 47.5 miles has been modified in some fashion (Figure 1).

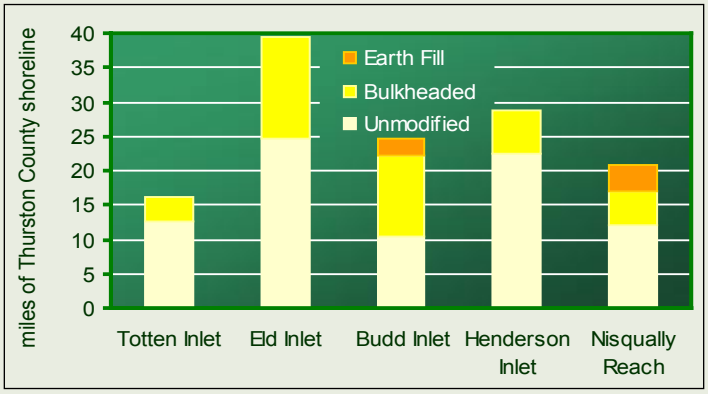


Figure 1. Thurston County shoreline modification status (in miles), 2003.

In urban areas such as downtown Olympia and West Bay Drive, large portions of the nearshore environment have been filled with earth, representing over 10 percent of the Budd Inlet shoreline, or over 2.5 miles of shoreline. Other areas such as portions of the Nisqually Delta were diked for farming, with almost 5 miles of shoreline modified by earth fill. Although this land is now a national wildlife refuge, the dike and fill remain, modifying over 18 percent of the shoreline of the Nisqually Reach.

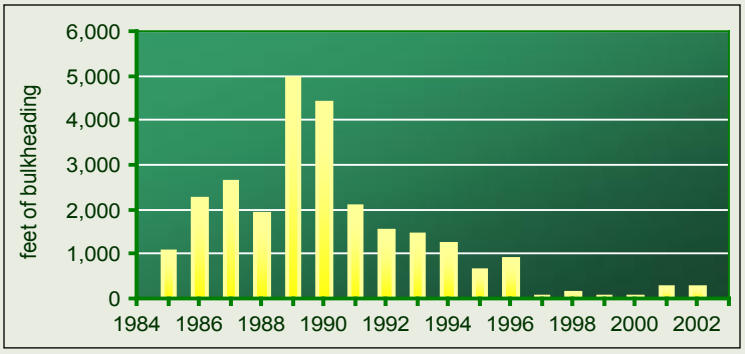


Figure 2. Feet of new bulkheading permitted in Thurston County between 1983 and 2002. Note: does not include City of Olympia.

Bulkheading is another way that the natural shoreline has been modified. Waterfront property owners often add a bulkhead along the shoreline to protect their house and yard from shoreline erosion. Bulkheads are typically constructed of logs, concrete, wood, rip rap (large rocks), or other means of hardening or armoring the shoreline. The amount of bulkedheaded shoreline varies by inlet in Thurston County, a result of both topography and urbanization.

Locations with the highest amount of bulkheading or shoreline armoring are:

- West side of Budd Inlet along Cooper Point Peninsula,
- Olympia shoreline (Budd Inlet), and;
- Squaxin Passage.

Areas with the lowest amount of bulkheading are:

- Totten Inlet,
- West shore of Henderson Inlet, and
- East shore of Budd Inlet.

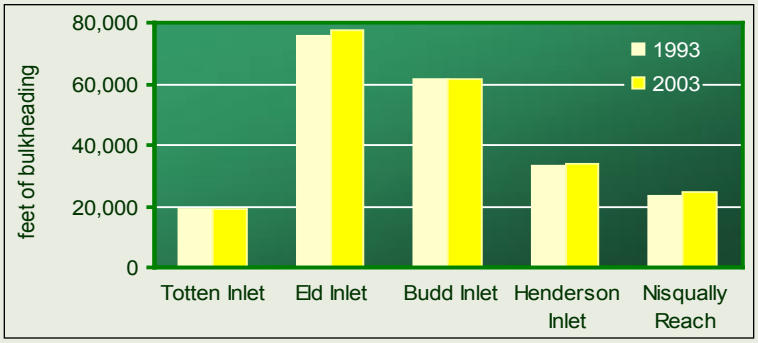
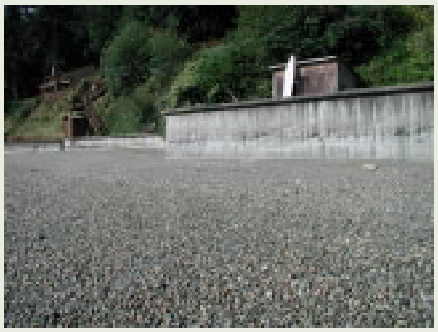


Figure 3. Cumulative feet of bulkheading on Thurston County shorelines, by inlet, 1993 and 2003. Assumes no new bulkheads added within Olympia city limits during this time period.

The amount of new bulkheading permitted in Thurston County has decreased in the last decade, from a high of nearly 5,000 feet in 1989, to less than 50 feet per year in the late 1990s (Figure 2). The largest amount of new armoring has been in Eld Inlet and along the Nisqually Reach (Figure 3).

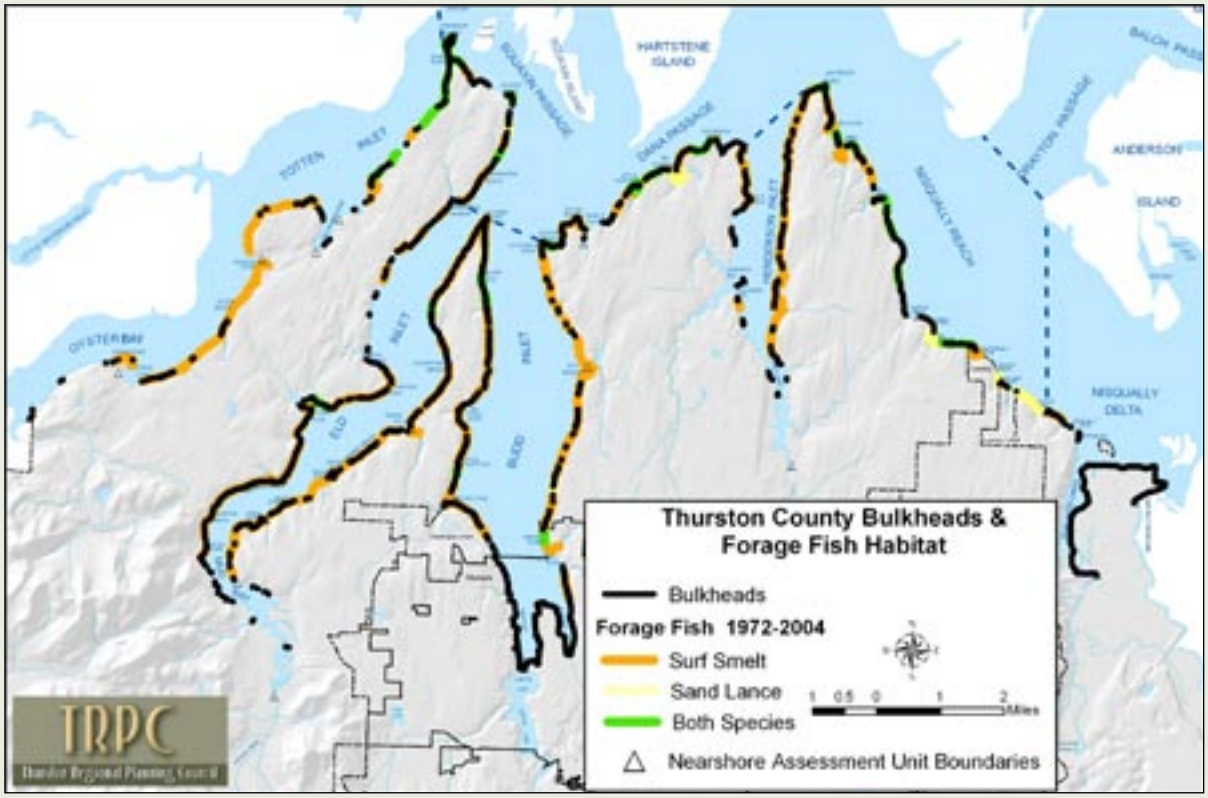
How does Shoreline Modification Impact Forage Fish?

The Salmon Recovery Funding Board, Thurston Regional Planning Council, Port of Olympia, City of Olympia, and Thurston County joined together to fund a study of the marine shoreline in Thurston County. This study explored the impacts of shoreline armoring (bulkheading) on forage fish such as surf smelt and sand lance. Paired beach transects were used to compare armored and unarmored shorelines. The study found that many bulkheads were built in the upper beach zone (rather than close to the toe of the slope), narrowing the total amount of beach available for habitat. This filling of the upper beach ranged from 4 to 21 feet, depending upon the location. Since forage fish spawn on these beaches, this represented a cumulative habitat loss of over 52 acres, or 0.4 of an acre per mile of shoreline. The study also found that there was a 74 percent reduction of stable accumulations of large wood debris in armored sites versus unmodified sites. Large woody debris is important to help prevent erosion and provide diverse habitat.



Concrete bulkheads along Cooper Point.

Most beaches with suitable forage fish spawning habitat were located along the northern parts of Thurston County's inlets, where beach sediment was suitable for spawning. Overall, Thurston County has almost 55 miles of marine shoreline that supports forage fish habitat.



Thurston County forage fish habitat and marine shoreline armoring.

For More information:

Herrera Environmental Consultants, Inc. *2005. Marine Shoreline Sediment Survey and Assessment, Thurston County.*
www.trpc.org/programs/environment/water/nearshore.htm

SHORELINE ARMORING

Shellfish Water Quality

The cool, clean waters of South Puget Sound provide some of the finest shellfish habitat in the world and present an array of recreational, commercial and tribal harvest opportunities. Commercial production of oysters, clams and mussels from these waters and tidelands contribute significantly to Washington's position as the nation's leading producer of farmed bivalve shellfish, generating nearly $97 million in 2005. The commercial shellfish industry is thriving, demand is expanding in markets worldwide, and clean water is the essential catalyst for continued success.

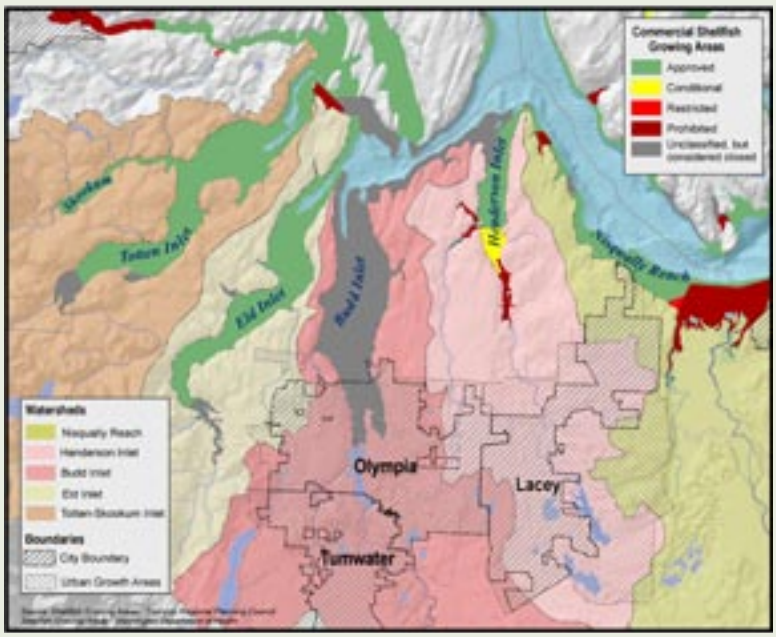


Figure 1. Commercial shellfish classifications for Totten Inlet, Eld Inlet, Budd Inlet, Henderson Inlet and Nisqually Reach (DOH 2005).

Shellfish Classifications

The Washington Department of Health (DOH) monitors levels of fecal coliform bacteria in the marine waters to determine suitability for shellfish harvesting. The department also periodically surveys shorelines and drainages to look for pollution problems that might affect the growing areas.

Four of the five South Sound inlets are classified for commercial shellfish harvesting, and the classification of these areas tends to correlate with population and development levels in the adjacent watersheds (Figure 1). Budd Inlet, with the most developed of the five watersheds, has been closed to shellfish harvesting for decades. In contrast, Totten Inlet, with the least developed watershed, has never been closed due to fecal pollution. DOH closed a portion of Eld Inlet in the early 1980s because of fecal pollution, then reopened much of the area in 1998 following successful control of the pollution sources and improvements in water quality (see accompany case study of Eld Inlet). The work in Henderson Inlet has been more challenging due largely to the scale and complexity of the pollution problems and continued population growth and urbanization in the watershed. In Nisqually Reach, the story has been more mixed, with both downgrades and upgrades over the past 15 years, but with some notable successes in recent years due to targeted cleanup efforts (Figure 2).

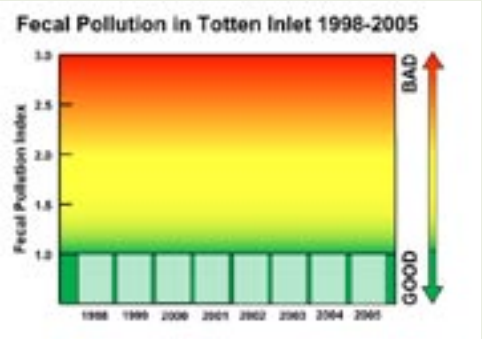
Area	Year	Acreage	Classification Change
Totten Inlet	*no classification changes – approved for commercial harvest*		
Eld Inlet	1983	690 acres	↓ downgraded from Approved to Conditional
	1998	450 acres	↑ upgraded from Conditional to Approved
Budd Inlet	*no classification changes -- prohibited for commercial harvest*		
Henderson Inlet	1984	180 acres	↓ downgraded from Approved to Conditional
	1985	120 acres	↓ downgraded from Conditional to Prohibited
	2000	8 acres	↓ downgraded from Conditional to Restricted
	2001	300 acres	↓ downgraded from Approved to Conditional
	2005	49 acres	↓ downgraded from Conditional to Prohibited
Nisqually Reach	1992	1000 acres	↓ downgraded from Approved to Conditional
	2000	74 acres	↓ downgraded from Conditional to Restricted
	2000	20 acres	↑ upgraded from Conditional to Approved
	2002	900 acres	↑ upgraded from Conditional to Approved
	2002	60 acres	↑ upgraded from Restricted to Approved

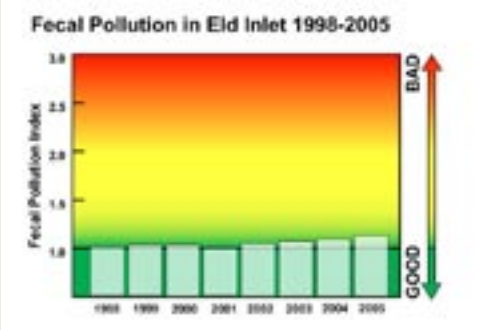
Figure 2. Classification changes in the five inlets over the past 25 years (DOH 2005).

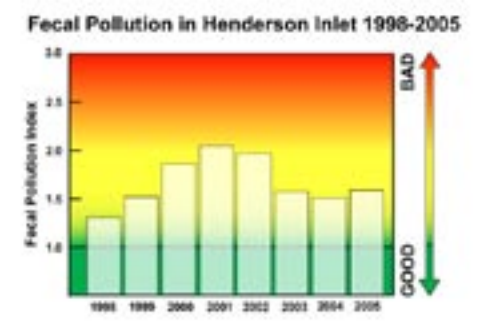
DOH also oversees an early warning system to help identify and respond to declining conditions in shellfish growing areas. Since the system was first instituted in 1997, Totten Inlet has not yet appeared on the annual list of "threatened shellfish growing areas," while at least a portion of Eld Inlet has been listed four times, Nisqually Reach four times, and Henderson Inlet nine times through 2005.

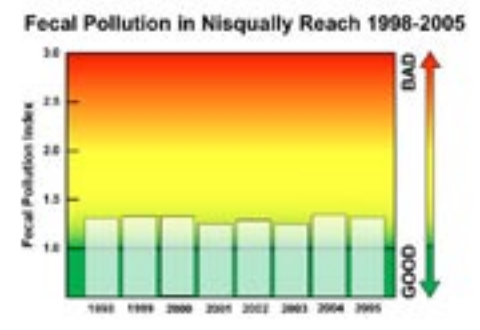
Fecal Pollution Index

Another measure of shellfish water quality is the "Fecal Pollution Index" (FPI) developed by DOH to compare pollution levels and to track changes over time. The index is a weighted calculation based on the fraction of samples in each growing area that are classified as good, fair or bad (the weightings are 1 for good, 2 for fair, 3 for bad). The best possible score is 1, meaning that 100 percent of the samples were classified as good, and the worst possible rating is 3, meaning that 100 percent of the samples were classified as bad (see DOH 2003, Atlas of Fecal Pollution in Puget Sound, for more explanation).









As with the other measures, the results of the FPI calculations for the four inlets tend to correlate with development levels and the closure activity in the respective watersheds. Totten Inlet continues to maintain perfect scores based on very good water quality monitoring results. Eld Inlet's results have also been quite good but show a modest upward trend. Henderson Inlet's are the highest and most volatile of the four watersheds. Nisqually Reach's scores show a measurable degree of impact but the scores have been relatively stable.

For More Information:

Washington Department of Health. 2005. *Annual Inventory of Commercial and Recreational Shellfish Areas of Washington State.* www.doh.wa.gov/ehp/sf/Pubs/2004annualinventory.pdf

Washington Department of Health. 2003. *Atlas of Fecal Coliform Pollution in Puget Sound, Year 2001.* *www.doh.wa.gov/ehp/sf/Pubs/fecalreport01.pdf*

Thurston County Shellfish Protection Web Site for Henderson Inlet and Nisqually Reach. www.co.thurston.wa.us/shellfish

Puget Sound Action Team. 2004. *Literature Review and Analysis: Coastal Urbanization and Microbial Contamination of Shellfish Growing Areas.* www.psat.wa.gov/Programs/shellfish/sf_lit_review0604.pdf

Freshwater Quality

The health of our streams and other freshwater resources are a direct reflection of the condition of the surrounding landscapes. In short, healthy watersheds are the key to healthy streams, wetlands, lakes and groundwater. In the same way, the health of our marine waters and habitats reflect the condition of the streams and watersheds that drain to our inlets. The influences are significant and often long-lasting, and they take on added importance when you consider that the streams and watersheds of South Sound mark the beginning of our great estuary, the headwaters of Puget Sound.

Stream Health

Our water courses have long been recognized as some of the finest in the world – cool, clean meandering streams that support vibrant salmon runs and other valued resources. These waters and the corridors they flow through, especially the lowland areas adjacent to the marine waters, are also prized areas for development. As development has intensified and spread across the Puget Sound region over the past century, the health of our stream systems has diminished as a direct consequence.

Stream health is monitored using a suite of measures, including stream flow, temperature, bug populations, nutrients, dissolved oxygen, fecal bacteria and more. Extensive research has been conducted around the world and in the Puget Sound region showing that stream health correlates strongly with land uses and human activities in the adjacent basin or watershed. As development increases, stream health tends to decline as gauged by a number of measures, but the type and degree of impacts are not always the same and can be prevented or lessened by applying a number of land conservation practices. These include practices that retain forest cover, minimize and disconnect impervious surfaces, and preserve mature, native vegetation in corridors adjacent to streams, shorelines and other water bodies.

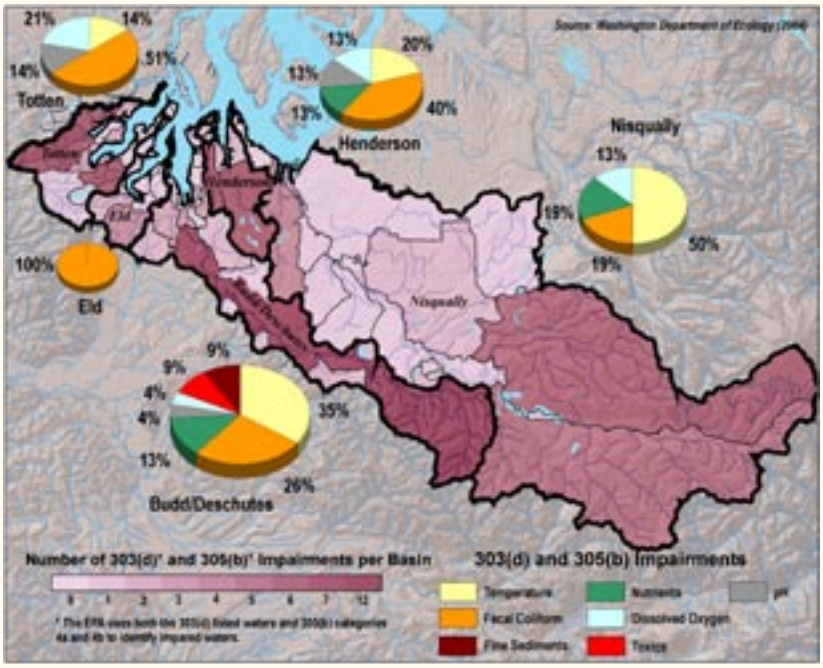


Figure 1. Freshwater impairments in Totten, Eld, Budd, Henderson and Nisqually watersheds as listed by the Washington Department of Ecology (Ecology 2004).

Figure 1 shows violations of state water quality standards (also known as impairments) that have been documented in the five watersheds and that appear in the Washington Department of Ecology's most recent list of polluted water bodies. The list totals 69 freshwater impairments: 57 stream and 12 lake violations. The information in the figure is organized to show different aspects of the freshwater problem: (1) the pie charts are sized to show the relative number of violations in each watershed; (2) the pie charts are segmented to show the percentage of different types of problems; and (3) the map is shaded to show the number of violations in each basin. The figure does not show the listed impairments for the marine waters, which include 7 dissolved oxygen and 5 toxics for Budd Inlet; 5 fecal coliform for Henderson Inlet; and 6 fecal coliform for Nisqually Reach.

Staff from the Department of Ecology work with various interests to develop and implement water cleanup plans to address and correct these problems, and such work is currently underway in all five watersheds. In the Totten Inlet and Eld Inlet Watersheds, efforts are focusing mainly on fecal bacteria violations in Pierre, Burns, Kennedy, Schneider, McLane, Perry and Skookum creeks. In the other three watersheds the problems involve work on both the freshwater and marine water problems. In the Budd/Deschutes Watershed the violations include fecal coliform bacteria, dissolved oxygen, fine sediments, temperature and pH. In Henderson Inlet Watershed the studies and cleanup efforts are focusing mainly on fecal coliform bacteria, dissolved oxygen, temperature and pH. In the Nisqually River Watershed the work is concentrating on fecal coliform violations in Ohop, Red Salmon and McAllister creeks. There are also low oxygen levels and high nitrogen levels in McAllister Creek, but there is some uncertainty about the cause and the potential to correct these problems.

Stream Monitoring

Local streams are monitored by many governments and organizations, including the well-coordinated stream team programs, and the results are reported using a variety of means. Figure 2 gives an example of the type of information that is collected to track stream health and to inform efforts aimed at protecting and restoring these waters. Much of the information in these sample profiles can be accessed at the Thurston GeoData Center at www.geodata.org. This type of data is also published periodically in water resources monitoring reports produced by local, tribal and state government agencies.

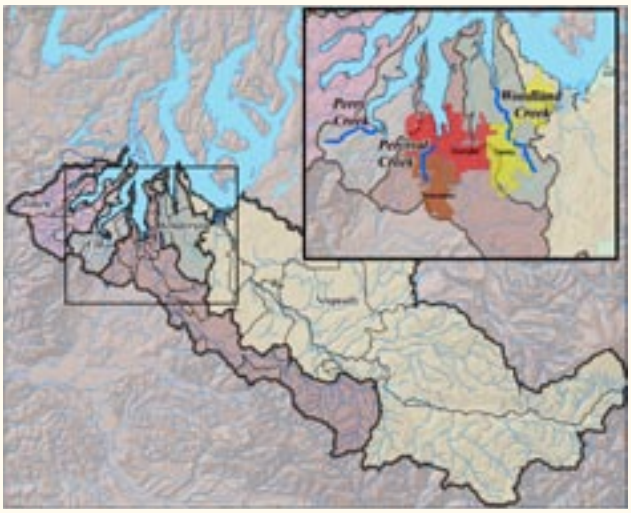
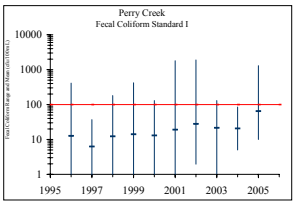
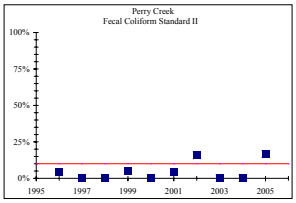


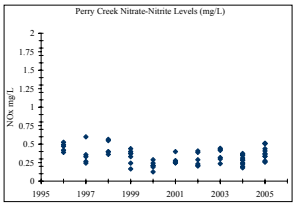
Figure 2. Profile of selected monitoring data and land use information for three streams: Perry, Percival and Woodland Creeks (Thurston County 2004,TRPC 2001).

Perry Creek

Watershed: *Eld*
Basin Size: *4,064 acres*
Land Uses: *Rural residential, forestry, agriculture*
Basin Urban Cover: *2%*
Basin Forest Cover: *73%*
150' Riparian Zone Forest Cover: *76%*
General Water Quality: *Excellent*
Stream Biological Health: *High*

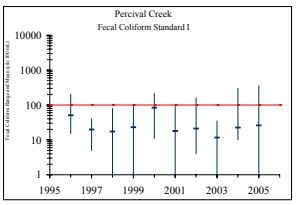


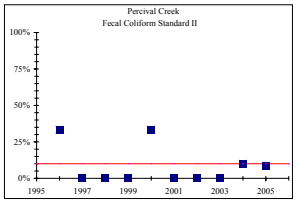


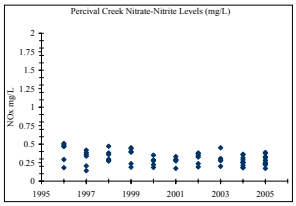


Percival Creek

Watershed: *Budd*
Basin Size: *5,300 acres*
Land Uses: *Suburban residential, urban, commercial*
Basin Impervious Cover: *28 %*
Basin Forest Cover: *28%*
150' Riparian Zone Forest Cover: *44%*
General Water Quality: *Good*
Stream Biological Health: *Moderate*

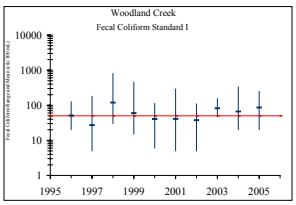


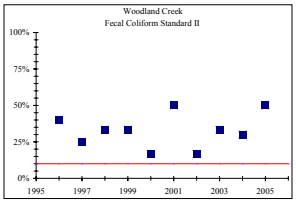


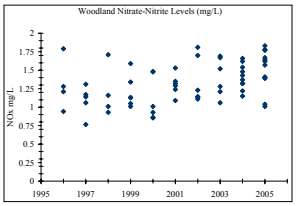


Woodland Creek

Watershed: *Henderson*
Basin Size: *18,900 acres*
Land Uses: *Urban and rural residential, commercial*
Basin Impervious Cover: *21%*
Basin Forest Cover: *30%*
150' Riparian Zone Forest Cover: *54%*
General Water Quality: *Fair*
Stream Biological Health: *Moderate*







For More Information:

Thurston County. 2004. *Thurston County Water Resources Monitoring Report 2002-2003 Water Year.* www.co.thurston.wa.us/monitoring/Water%20Quality%20Monitoring%20Report/water_quality_monitoring_report.htm

Thurston Regional Planning Council. 2001. *Land Cover Mapping of Thurston County, Methodology and Applications.* www.trpc.org/resources/landcoverreport02_02_05.pdf

Washington Department of Ecology. 2004. *Washington State's Water Quality Assessment [303(d) and 305(b) Report].* www.ecy.wa.gov/programs/wq/303d/2002/2002-index.html

Washington Department of Ecology. 2006. *Tributaries to Totten, Eld, and Little Skookum Inlets—Fecal Coliform Bacteria and Temperature Total Maximum Daily Load: Water Quality Improvement Report.* www.ecy.wa.gov/biblio/0603007.html

Washington Department of Ecology. 2006. *Henderson Inlet Watershed Fecal Coliform Bacteria, Dissolved Oxygen, pH and Temperature Total Maximum Daily Load Study.* www.ecy.wa.gov/biblio/0603012.html

Washington Department of Ecology. 2005. *Nisqually River Basin Fecal Coliform Bacteria and Dissolved Oxygen Total Maximum Daily Load Study.* www.ecy.wa.gov/biblio/0503002.html

Marine Water Quality

South Puget Sound consists of an intricate network of waterways and habitats that define the essential character of the region. This marine ecosystem – or more accurately this estuarine system where land and sea meet and fresh and marine waters mix – provide important food staples such as salmon and shellfish, support valued uses such as transportation and recreation, and serve essential ecosystem functions such as nutrient cycling, habitat protection and climate control. The system is complex and beautiful. The system is also vulnerable to the effects of human development due to a combination of natural factors and the region's large and fast growing population.

The health of marine waters is monitored using a variety of measures, including dissolved oxygen, nutrients, water clarity, fecal coliform bacteria, and changes in the composition and distribution of marine species. While the different measures help us understand and track the overall health of the system, perhaps the most significant vital sign is dissolved oxygen – the amount of oxygen that is dissolved in the water column that sustains virtually all marine life.

Dissolved Oxygen

The south basin of Puget Sound—the area south of the Tacoma Narrows – differs from other parts of the Sound, especially the main basin, with its relatively shallow depth (bathymetry), unique shape (morphology) and relatively long residence time of the marine waters. Scientists tell us that, because of these characteristics, South Sound is highly sensitive to the process of enrichment from high nutrient inputs, a process known as eutrophication, and related impacts such as reduced oxygen levels in the water. They also tell us that the situation can be exacerbated by factors such as highly stratified waters (meaning there are periods when the marine water layers don't mix well) and high primary production (meaning there can be fast growth of phytoplankton when nutrients are available).

As a result, the waters of South Sound can be readily influenced by additional inputs of nutrients that can fuel short-term blooms of plankton and result in longer-term enrichment of the system. The decomposition of plankton and other organic material consumes oxygen and can reduce the amount of oxygen in the water to levels that affect the health and survival of marine life.

Figure 1 shows dissolved oxygen levels in near-bottom waters of South Sound measured in fall 2003 by the Department of Ecology. As a benchmark, minimum state water quality standards for dissolved oxygen are generally 6.0 to 7.0 milligrams per liter (mg/l) for marine waters, and 8.0 to 9.5 mg/l for freshwater streams. Dissolved oxygen levels below 5 mg/l are considered to be a significant concern for fish and some other organisms.

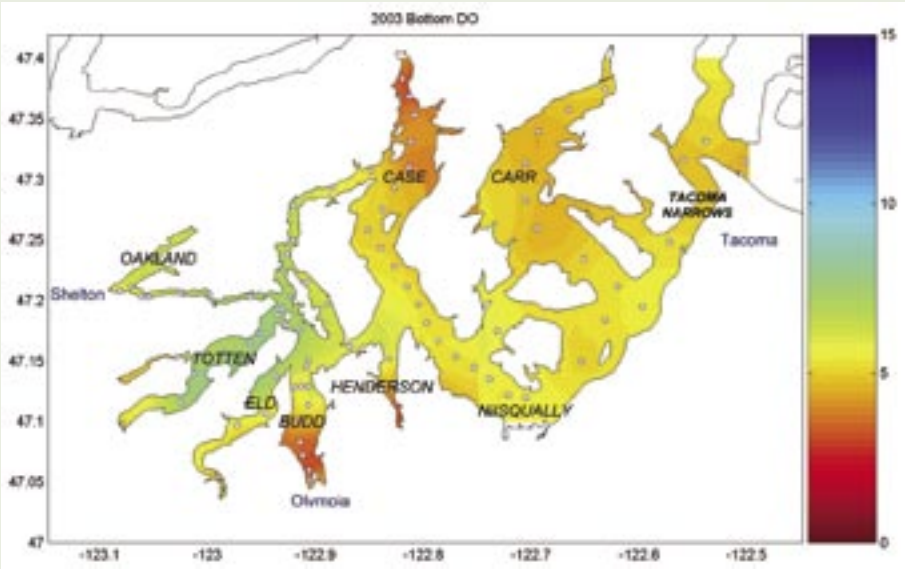


Figure 1. South Sound near-bottom dissolved oxygen levels in milligrams per liter (mg/l) measured in fall 2003 by the Washington Department of Ecology.

The shallow, dead-end inlets of South Sound are most susceptible to low oxygen levels. Ecology has reported that Case, Carr and Budd Inlets "appear to have the lowest dissolved oxygen levels within South Puget Sound, and may be the most sensitive areas to increased nutrient loads" (Ecology 2002). Other South Sound inlets may be similarly vulnerable. For example, researchers at the Pacific Shellfish Institute have been monitoring dissolved oxygen levels in Totten and Eld Inlets since the late 1990s and have documented low oxygen levels that stress organisms and that have resulted in late-summer mortality of shellfish.

Nutrient Sources and Loads

Nutrients enter the marine system from a variety of sources and land uses, most notably nutrients associated with fertilizers, animal wastes and human sewage. With the region's steadily increasing population it's reasonable to conclude that nutrient loads to South Sound are likely greater today than they were in the past, and will likely continue to increase in the future.

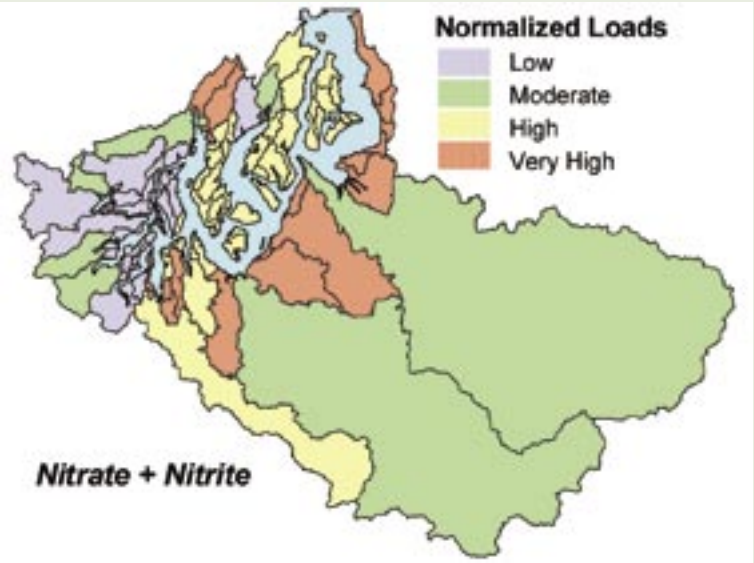


Figure 2. Estimated watershed loads of nitrogen to South Sound that have been normalized to show relative loadings on a per-area basis (Roberts and Pelletier, 2001).

Like other pollution problems, nutrients come from many dispersed sources, not just large "point source" discharges. As a result, strategies to control and prevent nutrient pollution must engage people and change all kinds of behaviors. Illustrating the breadth and depth of the problem, Figure 2 shows estimated nitrogen loads that have been normalized to show relative loadings on a per-area basis. Larger watersheds generally contribute higher total loads due in part to their higher flows, but developed areas tend to contribute more concentrated loads on a per-area basis (Roberts and Pelletier, 2001).

While the people of the region have made significant investments over the years in programs and practices to control and prevent pollution, nutrient contamination has received relatively little attention in South Sound with the exception of Budd Inlet and the LOTT wastewater treatment plant.

An upgrade of the LOTT wastewater treatment plant in the 1990s dramatically reduced nitrogen discharges from the facility and lessened impacts on Budd Inlet. In addition, new enhancements to the system will recycle almost 20 percent of the flows as reclaimed water and groundwater recharge starting in 2006, and new permit requirements adopted in 2005 give added flexibility to seasonally adjust the treatment process and better control wastewater discharges. These changes enhance not only the overall protection of the inlet, but also the efficient use of our precious freshwater resources.

For More Information:

Washington Department of Ecology. 2002. *South Puget Sound Water Quality Study: Phase 1.* www.ecy.wa.gov/pubs/0203021.pdf

Washington Department of Ecology. 2002. *Summary of South Puget Sound Water Quality Study.* http://ecystage.ecy.wa.gov/pubs/0203020.pdf

Roberts, Mindy and Greg Pelletier. 2001. *Estimating Loads of Nutrients, Bacteria, DO and TSS from 71 Watersheds Tributary to South Puget Sound. Proceedings of the Puget Sound Research Conference 2001.* www.psat.wa.gov/Publications/01_proceedings/sessions/oral/1c_rober.pdf

LOTT Alliance. 2006. *State of the Utility Report 2006.* www.lottonline.org/PDF/SUR2006Web.pdf

10 Keys to Preserving Healthy Waters, Healthy Watersheds

1. **Preserve Forest Cover:** Preserve forest cover, soils and other native land cover. Replant trees and restore areas that have been cleared or damaged. The functions provided by native vegetation and soils are irreplaceable.
2. **Preserve Natural Drainages:** Preserve and restore wetland systems and other natural drainage features that hold, absorb and slowly release water. These features are a key part of nature's system for regulating the movement of water and breaking down pollutants.
3. **Preserve Riparian Areas:** Preserve continuous riparian zones with mature, native vegetation to protect and buffer streams, shorelines and other water bodies.
4. **Minimize Impervious Surfaces:** Minimize impervious surfaces such as rooftops, concrete and pavement. Disconnect impervious surfaces and use alternative materials that promote infiltration and prevent stormwater runoff.
5. **Limit Shoreline Armoring.** Explore and use alternative or "soft" armoring techniques to minimize changes in the sensitive shoreline environment. Before doing anything, think twice about whether you need to armor and explore ways to avoid the alterations altogether.
6. **Prevent Pollution:** Pollution is so hard to control and clean up, so do your best to prevent it before it becomes a problem. Avoid and limit the use of toxic chemicals in your businesses and homes, pick up pet wastes, inspect and maintain septic systems, use sewage pumpout stations for boat wastes, and properly manage manure from farm animals.
7. **Manage Growth:** Direct development to urban growth areas. Limit development densities in sensitive watersheds and rural areas to preserve the value and integrity of these areas and the industries they support.
8. **Plan for Protection:** Determine land uses based on long-term protection and use of water resources. Use sub-area planning and other tools to tailor development policies and standards to local conditions to preserve water quality and watershed functions.
9. **Rethink Stormwater:** Use the principles and practices of low impact development and other "soft" stormwater infrastructure wherever feasible, to mimic natural watershed hydrology and to treat runoff.
10. **Manage Wastewater:** Tailor sewage infrastructure to land uses and development densities (centralized systems in urban areas, decentralized systems in rural areas), manage all parts of the infrastructure, and capitalize on opportunities to reclaim and reuse treated water.

Portions of this project were produced with support from the Puget Sound Action Team, the U.S. Environmental Protection Agency, Region 10, and Thurston Regional Planning Council

Acknowledgements

Layout and Design: Sarah Morley
Writing: Stuart Glasoe, Veena Tabbutt and Steven W. Morrison
GIS Support: Scott Carte, Jeff Holcomb and Tim Strickler

Special Thanks To:
Sue Davis, Karla Fowler, Tim Determan, Bob Woolrich, Mindy Roberts, Brian Grantham, Chris Hempleman, Duane Fagergren and Doug Myers

Front Photo Credits:
Jill Williams, Duane Fagergren, Puget Sound Action Team