1. STATUS OF THE ECOSYSTEM

PROGRESS TOWARDS 2020

The overall purpose of this chapter is to report on the status of the ecosystem based on the indicators adopted by the Leadership Council and on progress towards meeting the 2020 ecosystem recovery targets.

In the following pages of this chapter, you will find:

- An overview of the development of the 2012 Vital Sign dashboard for indicators and 2020 ecosystem recovery targets.
- Our approach to evaluating the status of indicators and progress towards the 2020 ecosystem recovery targets.
- The synthesis of the status of Vital Signs and progress towards 2020 ecosystem recovery targets.
- Individual technical summaries of each indicator and target.
- Highlights of four cases of high caliber volunteer-driven monitoring programs that collect data in support of Puget Sound recovery.
- Local stories presenting on-the-ground work that is underway to address many of the Vital Signs.
- An evaluation of our current understanding of the ways that climate change will affect ecosystem recovery.

Development of the 2012 Vital Sign Dashboard for Indicators and Targets

In the 2009 State of the Sound, we reported on the health of Puget Sound based on an initial set of ecosystem indicators suggested by the Puget Sound Science Panel and regional experts. These indicators were organized and linked to the six over-arching goals for ecosystem recovery defined in the statute that created the Puget Sound Partnership: 1) human health; 2) human well-being; 3) species and food web; 4) habitat; 5 water quantity; and 6) water quality.

Work to improve the indicators continued, and in 2010 the Puget Sound Partnership Leadership Council formally adopted a slightly modified and refined list of 21 "dashboard" indicators. The dashboard concept was intended to more easily communicate to the public about a small set of ecologically important and socially resonant indicators that collectively reflect the status of the ecosystem and progress towards meeting the statutory goals for ecosystem recovery.

The indicators recommended to the Leadership Council for adoption were based on a variety of scientific sources including the "Environmental Indicators for the Puget Sound Partnership: A Regional Effort to Select Provisional Indicators (Phase 1)(O'Neill et al. 2008), the Puget Sound Science Update 2010, recommendations from an independent team of scientists (Puget Sound Partnership's Indicator Action Team 2010), and recommendations of subject matter experts (referred to as "Indicator Leads").

Then, recruiting the expertise of state, local and federal agencies, Tribes, academic institutions, businesses and non-governmental organizations (NGOs), and following extensive stakeholder engagement and review by both the Science Panel and Ecosystem Coordination Board, the Leadership Council began in 2011 to adopt specific targets for the indicators to reach by the year 2020.

Targets serve as explicit policy statements that articulate the ecosystem conditions desired by 2020, and reflect the region's commitment to and expectations for a measurable path to recovery. In the process of adopting targets, the Leadership Council further refined and added to the 2010 list of indicators. (For a complete list of targets, please refer to the 2012 Action Agenda, or go to: http://www.psp.wa.gov/LC_resolutions.php.) Targets are still under development for some indicators and will be adopted once technical work is completed.

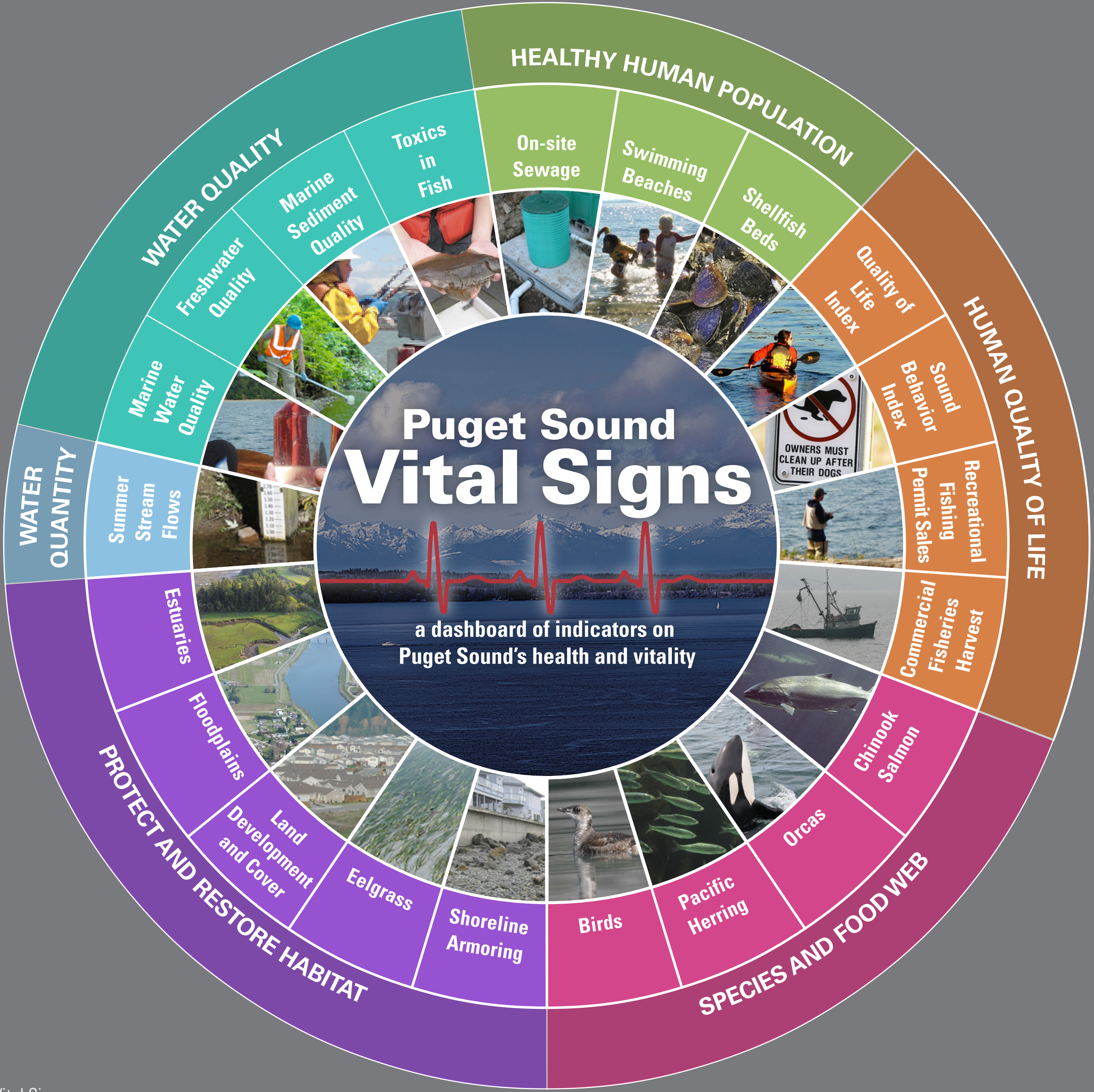

Figure 1. Vital Signs

The Puget Sound Vital Signs

To better advertise and communicate the status of the adopted indicators and 2020 targets, the Partnership created the Puget Sound Vital Signs wheel. The 21 Vital Signs incorporate the complete set of dashboard indicators adopted by the Leadership Council, grouped in segments according to the six broad recovery goals set in statute. (http://www.psp.wa.gov/vitalsigns/index.php; Figure 1).

The Puget Sound Vital Signs dashboard combines selected programmatic and ecosystem indicators to help track and communicate progress in recovering the health of Puget Sound. Most of the ecosystem indicators are measures of the status of specific ecosystem components or impacts to them, such as eelgrass area and number of orcas. Others are measures of the pressures on Puget Sound. For instance, the indicator "amount of shoreline armoring" is a proxy for alterations to shorelines by the construction of seawalls, a practice that is detrimental to ecosystem functions and processes vital to the conditions of shorelines.

One Vital Sign, on-site sewage system, consists of a programmatic measure of key actions to restore the health of Puget Sound, defined as the percent of current on-site sewage system inspections that are current. A number of the Vital Signs combine both environmental and administrative measures, such as swimming beaches, shellfish bed classifications, and freshwater impairments under the Clean Water Act.

Some of the Vital Signs are specific to human dimensions of the ecosystem, as defined by human health and human quality of life. Two of these, the Quality of Life Index and the Sound Behavior Index, are in development. Two others, recreational fishing license sales and commercial fishing harvest, do not have targets but we report on their status and trends.

The Vital Signs were chosen as the most readily available data sets that could be evaluated to assess the longer-term outcomes of the restoration activities in Puget Sound. However, these indicators are also subject to natural drivers such as annual climate conditions, local weather patterns, ocean-climate factors such as El Niño vs La Niña cycles, natural species interactions, and many other factors. Therefore, management actions may not always have a direct and immediate effect on the status and trends of these indicators.

Furthermore, some of the Vital Signs can be slow to respond to changes in the environment. One example is the orca population size, which is due to low reproductive and maturity rates. However, we expect that the Vital Signs will respond in a positive direction towards the targets if management actions are working.

The Vital Signs are not meant to impart a comprehensive understanding of the complexity and dynamics of the Puget Sound ecosystem, as that would require a much more extensive collection of indicators. However, the indicators were chosen deliberately to represent all recovery goals, major ecological domains such as freshwater, marine waters, terrestrial habitats, and key ecological attributes such as population size and condition. Choosing indicators was a challenging task and that is why they will continually be improved and updated as new knowledge and data become available.

Approach To Evaluating The Status Of Indicators And Progress Towards The 2020 Ecosystem Recovery Targets

We focused our reporting on the Vital Signs as defined by their associated indicators and 2020 targets.

For each, we provide answers to two simple questions:

1. Has the 2020 target been met?

2. Is there progress toward the target?

Status provides the most recent estimate of the indicator. For the purposes of this report, we used either the value for year 2011 as the current status or when data were not available for 2011, we used values from previous years. Yet in other cases, the current status was the average of some number of years, particularly when data exhibited a lot of year-to-year variability.

We assessed progress by comparing the estimate for the current status relative to a value defined as the baseline reference. If the estimate of current status was between the target value and the baseline reference, we called that progress. If the estimate of current status was at the baseline or outside the interval between the baseline reference and the target value, we determined that there was no progress.

In many cases, the baseline reference was not specifically defined when the target was adopted. In fact, eelgrass, land development, and floodplains are the only indicators that have specific baseline reference in their target language. In other cases, the target language defines a time period over which to evaluate the progress, including the orca and shoreline armoring indicators. In those cases, we used the first year of that time period as the baseline reference year.

In the remaining cases, we chose a baseline reference year or value based on what made sense for the monitoring programs, the data, and how the target was defined. For instance, the baseline reference chosen for swimming beaches is the first year that the BEACH (Beach Environmental Assessment, Communication & Health) program was launched. In other cases, the baseline was an average of years, such as the herring indicator. In still other cases, there was no baseline data available, such as the on-site sewage and shoreline armoring indicators.

The choice of baseline reference is critical. Because there is annual variability in the data, depending on the year that is chosen, the conclusion may be slight to significant progress or negligible progress. Choosing a range of years can help dampen that effect. Sometimes, there may be no progress over the short-term, but progress over the long-term, as was the case for orcas.

Monitoring

Ecosystem monitoring is inherently complex, difficult, and often confounding. We want to know about everything from phytoplankton to whales, from the chemical toxicity of sediments in deep marine basins to the retreat of glaciers in the high mountains. The basic life history of many key species still eludes us: where do herring migrate? What triggers certain species of algae to produce toxins? Managers struggle to know which actions are most likely to produce desired results—difficult choices when data seem equivocal and predictive models are beset with uncertainty.

We look to monitoring to help answer many important questions. We need pertinent, reliable data focused on the right questions. We need data collected with enough frequency and over long-enough periods of time to account for the large annual differences that can result from simple changes in year-to-year weather patterns. We need standardized, high quality, and well-documented data that can be analyzed and compared across the region. Such data are surprisingly rare.

Monitoring programs are scattered across agencies with limited jurisdiction, often using different methods, focusing on slightly different questions, and managing data in a multitude of different data management systems. Funding decisions around monitoring are left to individual agencies, with the potential for a patchwork of monitoring gaps across the Sound as many local, state, tribal, and federal agencies struggle individually to fund their most important objectives. Without a dedicated purpose, coordination among programs is typically ad hoc and incomplete.

Photo Credit: NWCIF PENDING

What is the Puget Sound Ecosystem Monitoring Program?

The Puget Sound Partnership is leading efforts to develop and implement the Puget Sound Ecosystem Monitoring Program (PSEMP). PSEMP is an independent collaboration of monitoring practitioners, researchers, and data users from across the region. The program is directed by a Steering Committee representing some 23 different state, federal, tribal, and local government agencies; universities; non-governmental organizations; watershed groups; business; and other private and volunteer groups and organizations.

The goal of PSEMP is to create and support a collaborative, inclusive, and transparent approach to regional monitoring and assessment. PSEMP's intent is to work with all of our partners to coordinate monitoring efforts in order to avoid overlaps and duplication in monitoring, and to provide credible, high quality, and accessible monitoring findings for our partners, decision-makers, and ultimately, the public.

PSEMP helps standardize monitoring across jurisdictions, identify monitoring gaps, and propose strategies to effectively address priority needs.

PSEMP partners and indicator leads provided the data for the technical summaries of the indicators and 2020 ecosystem recovery targets reported here, and they have contributed significantly to the evaluation of the progress towards ecosystem recovery goals. The information contained in each technical summary and the synthesis represents a significant collaboration among partner agencies and contributors from across the region, and benefited from input from PSEMP Steering Committee and the Science Panel.

Synthesis of the Status of Vital Signs and Progress Towards 2020 Ecosystem Recovery Targets

Overall, the technical summaries on indicators and targets suggest that progress towards the 2020 goals for recovering the health of Puget Sound remains an ambitious challenge.

Approach

This synthesis was compiled by Partnership staff with guidance from the PSEMP Steering Committee. It presents a compilation of the status and trends of the indicators and the progress made towards the 2020 ecosystem recovery targets drawn from the technical summaries.

Two evaluations, one nested in the other, are presented. The first evaluation summarizes progress towards the 2020 targets for each of the Vital Signs (Table XXXX). The second evaluation of progress is for each of the six overarching ecosystem recovery goals, based on their associated Vital Signs.

Although individual Vital Signs are primarily associated with a particular recovery goal, they are in fact often related to additional goals. For instance, the Marine Sediment Quality Triad Index, an indicator under the Marine Sediment Quality Vital Sign, is an indicator that informs about both water quality and habitat. We related each Vital Sign to one or more statutory goal based on previously published work[1] and the Leadership Council's target resolutions (http://www.psp.wa.gov/LC_resolutions.php). We limited our assignment of Vital Sign to goals where the strength of association between them was strongest.

Progress Towards The 2020 Targets For Each Of The Vital Signs

Six of the 21 indicators show no progress or, in some cases, have actually gotten worse relative to their baseline reference conditions (Table xxx). Five vital signs show mixed progress towards their 2020 target. These five vital signs each have multiple targets and their respective indicators reveal a mix of improving and declining conditions. For example, freshwater quality in major rivers has improved slightly over the past five years (as indicated by the Freshwater Quality Index) while the biological condition of wadeable streams (as measured by the Benthic Index of Biotic Integrity) has declined.

Only two indicators show clear progress: shellfish bed health and estuarine restoration. However, in both cases recent progress is not sufficient to assure they will meet their larger 2020 targets.

Eight of the 21 indicator reports exhibit some degree of incomplete results. Of these:

- Four are still being developed: Quality of Life, Sound Behavior Index, floodplains, and birds, which are examples of how the development of indicators and targets is often complicated by the multiple factors. In the case of the bird indicator, diverse migratory strategies of many species as well as our desire for a quantifiable measure of the way birds uniquely reflect the health and function of the Puget Sound ecosystem.

- Two indicators, land development and shoreline armoring, have enough data to establish current baseline/reference conditions, but not enough to evaluate progress toward their 2020 targets.

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[1] Johnston et al. 2011, Levin et al. 2011

- Two other indicators—commercial fisheries harvest, and sales of recreational fishing licenses—were adopted without setting specific 2020 targets because annual goals are set through separate regulatory processes. These two indicators mark important commercial and cultural aspects of Puget Sound, and reflect our long-standing connection to the Puget Sound food web. These indicators will be fully reported in future editions of the State of the Sound.

Variability of the data

In almost every case, progress (or decline) is rarely uniform across all years, or across all localities within the larger Puget Sound basin. Many indicators show significant year-to-year variability, and some even show possible longer-term (decades or more) fluctuations. Indicators often show short-term improvement in some years but declines in other years, including herring, orcas, shellfish beds, beaches, stream flows, and marine and freshwater quality,

Other indicators show important regional or local variability, such as marine sediment quality and freshwater quality. These short-term variations, combined with local or sub-regional differences, can mask long-term and region-wide trends. Yet this variability may actually be an important, functional characteristic of the ecosystem, which we need to understand and take into consideration when evaluating progress towards ecosystem recovery, and when making local or regional decisions about management actions.

This short-term and local variability greatly complicates our interpretation of the results. For now, the indicator reports focus primarily on the data and factual results, and generally do not hypothesize cause-and-effect relationships, which often require dedicated research efforts to tease out. Observed changes and trends most likely reflect the net effect of a wide range of human activities and management efforts, but also annual climate conditions, local weather patterns, ocean-climate factors such as el nino vs la nina cycles, natural species interactions, and many other factors.

Long-term monitoring is necessary to overcome short-term variability and to gain insight into the causative factors of change. However, long-term ecosystem-scale monitoring is always more efficient and effective when designed for that purpose, and when sufficiently robust and integrated to provide the necessary data for all key factors.

Sensitivity of the indicators to change

The fact that most indicators did not make significant progress towards their 2020 targets is not greatly surprising. Many of the indicators adopted by the Leadership Council were done so knowing they would change slowly over time, including orca whales, shoreline armoring, eelgrass, land development and cover, marine sediment quality, and toxics in fish. These indicators were selected because data were readily available, they represent key aspects of the Puget Sound ecosystem, and policy statements about the future desired state could be articulated (i.e., target defined). However, they may better reflect long-term pressures on the system. Tracking these vital signs over time will provide much insight into our overall progress towards ecosystem recovery.

It is important to recognize that the indicators and many of the targets are complex and technically demanding to measure with needed confidence. In many cases, the only data available were drawn from monitoring programs designed to meet other objectives. For example, water quality is monitored primarily to support state and federal Clean Water Act regulatory actions. Relatively little of the data reported for the vital signs come from monitoring programs specifically designed to characterize the overall, unbiased health of Puget Sound. When monitoring is targeted to known problems, and not representative of the entire Sound, it can take considerable effort—and require excluding much data—to screen, compile, and properly evaluate the datasets. Over time, tracking the indicators could be significantly improved by designing monitoring efforts with assessing the progress of ecosystem recovery as the primary objective.

GOAL-LEVEL SYNTHESIS

HUMAN HEALTH GOAL

Related Vital Signs: shellfish beds, swimming beaches, toxics in fish, and on-site sewage systems.

Vital Signs for the human health goal continued to show evidence of impacts and some risks to human health:

- There is continuing contamination of swimming beaches (12 beaches failed to meet standards in 2011; five of these have chronic bacteria issues), harvest restrictions at commercial shellfish beds (thousands of acres are closed to harvest due to pollution concerns), and contaminants in fish tissue (especially PCB contamination in flat fish from central Sound urban bays and in salmon from south and central Puget Sound).
- Among human health-related vital signs, only restoration of shellfish beds is showing clear progress toward 2020 recovery targets. Thanks to improvements in water quality, there has been a net increase of over 1,300 acres in harvestable shellfish beds – a positive step towards the 2020 target of restoring 7,000 acres.
- It appears that conditions at swimming beaches improved in 2011 compared to 2009 and 2010. However, this is most likely an artifact of the program adding 30 previously unsampled beaches in 2011 rather than bacteria problems being solved. At best, conditions at swimming beaches over the longer-term have not changed much, therefore, progress towards the 2020 target may be very slow.
- The indicator for on-site sewage systems focused on percent of inspections that are current. This is a programmatic indicator rather than an ecosystem indicator, and does not provide any direct information about whether the systems are failing, how much they are contributing to pollution problems, or if on-site septic management programs are reducing pollution. Information on efforts to fix failed systems is anticipated in future reporting

HUMAN QUALITY OF LIFE GOAL

Related Vital Signs: shellfish beds, estuaries, swimming beaches, land development, shoreline armoring, recreational fishing licenses, commercial fishing harvest, floodplains, quality of life index, and sound behavior index.

While robust measures for quality of life and sound behavior are still under development, the Vital Signs do indicate that Puget Sound provides important services that contribute to recreational and commercial fishing. However, these indicators have not increased much over the past decade or kept pace with a growing human population, suggesting that the Puget Sound ecosystem has not improved or been able to keep up with the growing demand for these key services:

- The two indicators that most directly relate to the human quality of life goal are under development: Quality Of Life Index and Sound Behavior Index.
- Many recreational activities continue, including fishing (hundreds of thousands of recreational fishing licenses issued annually) and swimming (dozens of beaches open for swimming),
- Commercial salmon fishing continued at low but fairly steady levels through the 2000s.
- Tens of thousands of acres of shellfish beds are currently open for commercial harvest.

SPECIES AND FOOD WEB GOAL

Related Vital Signs: shellfish beds, Chinook salmon, orcas, pacific herring, eelgrass, toxics in fish, commercial fisheries harvest, and birds.

Vital signs for this goal indicate continuing concerns for the status of Puget Sound species and the integrity of the food web:

- Cherry Point herring biomass remains at critically low levels with no sign of recovery while other stocks show much variability around levels closer to (but still below) those observed historically.
- Puget Sound Chinook continue to face a moderate risk of extinction and their overall abundance remains very low and possibly in decline. Only two of 22 populations show statistical increases in the past five years.
- Orca numbers show slow progress over the longer term but their numbers have dropped in the past couple of years.
- Eelgrass has not increased in extent and is well short of meeting the 2020 target.
- A variety of fish species continue to show contamination by persistent, bioaccumulative toxic chemicals and estrogen disrupting compounds. This points to potential impacts throughout the food chain, especially for apex predators like orca whales and upper food-chain species like salmon and people.

PROTECT AND RESTORE HABITAT GOAL

Related Vital Signs: estuaries, eelgrass, marine water quality, marine sediment quality, summer stream flows, freshwater quality, land development, shoreline armoring, and floodplains.

Some vital sign reports show continuing, even if slow, loss of some habitat types and trending away from the 2020 targets:

- There was a six-mile net increase in shoreline armoring from 2007 to 2010.
- Continuing loss of forest lands to development; more areas losing eelgrass than gaining at sites where change was detected).
- Other habitat measures have shown progress in restoring, recovering, or protecting habitat. For example, 2,300 acres of estuarine habitat restoration projects were completed between 2007-2011, and an increasing proportion of development is occurring within Urban Gowth Areas in central Puget Sound. However, the net sum of habitat losses vs gains is not well measured by the indicators.

WATER QUANTITY GOAL

Related Vital Signs: summer stream flows and land development and cover.

- Low summer stream flows continue to be of concern with no significant progress toward recovery targets. Declining trends for the Deschutes, North Fork Stillaguamish, and Issaquah Creek have not been reversed, and stable flows in the Nooksack River have not been maintained.
- Continuing forest conversion as described in the land development and land cover indicators may cause an increase in stormwater flows from developed lands due to decreased infiltration and loss of water from soil and plants (evapotranspiration).

WATER QUALITY GOAL

Related Vital Signs: shellfish beds, swimming beaches, marine water quality, marine sediment quality, freshwater quality, toxics in fish, on-site sewage, and land development and cover.

Indicator reports indicate on-going marine and fresh water quality issues in the Puget Sound basin, including:

- Toxic contamination in sediments, especially in urban bays
- Marine benthic communities adversely affected by poor sediment conditions, which may be related to toxic chemicals and/or biogeophysical condition of sediments.
- Low dissolved oxygen and increasing eutrophication (nutrient enrichment often leading to low dissolved oxygen) in Hood Canal, areas of Puget Sound where circulation is limited, and also along the main axis of the Sound from the central basin through Admiralty Inlet.
- A variety of fish species continue to show contamination by persistent, bioaccumulative toxic chemicals and endocrine disrupting compounds in urban bays
- A number of routinely monitored rivers consistently fail to achieve goals for fresh water quality, often in more heavily developed watersheds.
- Vital Sign summaries do suggest limited progress toward some water quality related targets. A growing proportion of freshwater sites—up to 30% in 2011—are achieving the target for the Freshwater Quality Index, and 1,400 acres of commercial shellfish beds have had their classifications upgraded in recent years. However, most measures do not show progress.

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Vital Sign	Vital Sign showing progress towards 2020 target?	Basis for decision about progress	Primary goal associated with Vital Sign
Shellfish beds	Yes	1,384 net acres restored between 2007 and 2011	Human Health Human Quality of Life Water Quality Species and Food Webs
Estuaries	Yes	Approximately 2,300 acres of habitat restoration projects were completed from 2007-2011 in the 16 major river delta estuaries.	Habitat Human Quality of Life
Swimming beaches	No	Percent of beaches meeting standards in 2011 was lower than the 2007 baseline reference	Human Health, Human Quality of Life, Water Quality
Chinook salmon	No	The total number of Chinook salmon in Puget Sound declined from 2006-2010, and no regions have yet met their target to improve 2-4 populations	Species and Food Webs
Orcas	No	Fewer whales in August 2012 than in 2010 baseline year	Species and Food Webs
Herring	No	No significant increase of spawning herring in any of the stocks. Cherry Point stock remains severely depressed.	Species and Food Webs
Eelgrass	No	No change in eelgrass area in 2011 relative to baseline reference of 2000-2008	Habitat, Species and Food Webs
Marine water quality	No	The marine water condition index shows a recent declining trend. Data not available yet for the dissolved oxygen target.	Water Quality, Habitat
Marine sediment quality	No	Sediment chemistry index results have not changed from baseline conditions. Chemicals meeting SQS standards, and Sediment Quality Triad Index both show progress towards their target, but most individual SQTI scores have declined compared to the baseline.	Water Quality, Habitat
Summer stream flows	Mixed	Some streams maintained or increased flow (7 of 8 rivers) but others lost ground: stable flows were not maintained where they should have been maintained (1 of 3 rivers); flows were not restored where they should have been restored (3 of 4 rivers); (1975-2011)	Water Quantity
Freshwater quality	Mixed	Fresh water quality in 2007-2011 was slightly better than 2003-2007 baseline conditions, but there was a net decline in B-IBI scores for wadeable streams. Although the total number of impaired waters was down in 2008-2010, the trend is expected to reverse in the next round of assessments	Water Quality, Habitat
Toxics in fish	Mixed	Concentrations of PBDEs and PAHs in fish appear to be dropping. PCB's are holding steady, while endocrine disrupting compounds are on the rise in certain areas of the Sound.	Water Quality, Species and Food Webs, Human Health

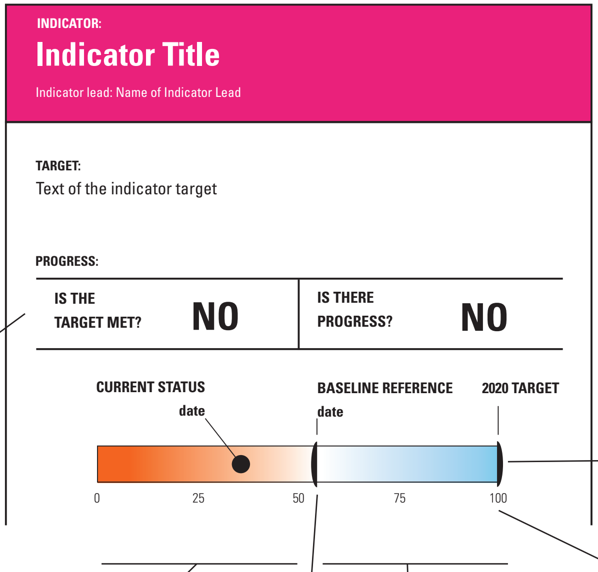
Vital Sign	Vital Sign showing progress towards 2020 target?	Basis for decision about progress	Primary goal associated with Vital Sign
Land development and cover	?	The number of systems inventoried and the percent of systems current with inspections have both increased. Data for the other targets are under development	Habitat, Water Quantity
Onsite sewage systems	?	The number of systems inventoried and the percent of systems current with inspections have both increased. Data for the other targets are under development.	Water Quality, Human Health
Shoreline armoring	n/a	Data for the net change in armoring from 2011-2020 is not yet available. Two other targets still in development.	Habitat
Recreational fishing license sales	n/a	This indicator is tracked, but no 2020 targets has been set.	Human Quality of Life
Commercial fisheries harvest	n/a	This indicator is tracked, but no 2020 targets has been set.	Human Quality of Life
Floodplains	n/a	Indicator is under development	Habitat
Quality of Life Index	n/a	Indicator is under development	Human Quality of Life
Sound behavior index	n/a	Indicator is under development	Human Quality of Life
Birds	n/a	Indicator is under development	Species and Food Webs

Puget Sound Vital Signs

How to read the State of the Sound target bars

The data that we used to track indicators and targets are often complex and variable over time. Yet, there is a desire for simple and clear messages. To this end, we distilled this complex information down with the aid a diagram that we refer to as target bars.

Our objective was for the reader to quickly grasp whether there was progress, and how close the current status estimate is to the target. The advantage of our distillation is that it is easy to read and gets a simple message across. The disadvantage is that the nuances and variability are absent. We strongly encourage readers to continue reading to get a better picture and more comprehensive understanding of health of Puget Sound and challenges ahead.



Target and progress questions: Yes or no answers.

Brackets define the baseline reference and 2020 target values

Target bar axis; units and scales vary

If the dot is inside the bracks there is progress

If dot is to the left of the baseline bracket in the orange area, no progress made and furthermore, the indicator is losing ground

If the dot is overlapping baseline bracket, no progress

On-site Sewage

On-site sewage systems, commonly known as septic systems, are widely used around Puget Sound on properties not served by municipal sewers. These systems safeguard public health and water quality, and allow people to flexibly live and work in all parts of the region. There are more than a half million systems in the Puget Sound region.

Systems that receive good use and care will provide very good treatment of sewage. However, when homeowners don't take care of their systems through regular inspections and repair—including pumping as needed—the systems can break down, leaking sewage into the groundwater and putting people and water resources at risk. Inadequately treated sewage can contaminate marine and fresh waters and impact drinking water supplies, swimming beaches, and shellfish beds for recreational and commercial uses.

All on-site systems need periodic inspections and good operation and maintenance to ensure effective, ongoing treatment.

On-site Sewage

INDICATOR:

On-site Sewage Inspection, Repair, and Maintenance

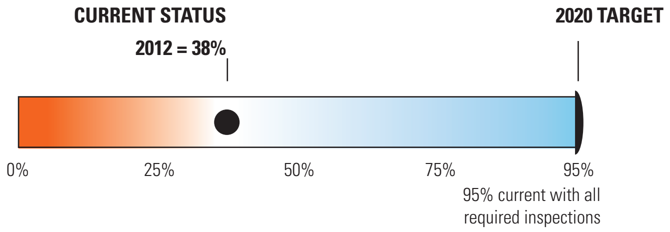
Indicator lead: Stuart Glasoe, Washington State Department of Health

TARGET:
Part 1: inventory on-site sewage systems and fix all failures in Marine Recovery Areas and other specially designated areas, and to be current with inspections at 95%.

Part 2: Phase in an extension of this program to cover 90% of Puget Sound's unsewered marine shoreline.

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**Part 1** **YES**	**Part 2** **NO**



As of July 1, 2012, inspections were current on 38% of on-site sewage systems in Marine Recovery Areas and other specially designated areas. The total number of systems inventoried was nearly 60,000 and the percent documented was 91%. Reporting on the percent of failed systems fixed or mitigated will be phased in.

Progress towards 2020 target

The target has not been met. This is a relatively new target in the state's existing performance management programs. The twelve Puget Sound local health jurisdictions (LHJs) report data semiannually to the Washington State Department of Health (DOH). Only three reporting cycles have been completed so far.

The results of the first three cycles show an increase in the percent of systems current with inspections from 33% to 38%. During this same period, the total number of systems inventoried increased by about 7,000 and the percent of systems documented rose from 86% to 91%.

The interim inspection target is 60% by January 2015. The designated areas currently cover about 10% of the region's on-site systems. This coverage will continue to expand as more areas and on-site systems are designated for enhanced management, resulting in more systems to inventory and inspect.

The second target will be phased in, and the implementing agencies will need to develop a system to measure and report results. DOH estimates that the existing designated areas cover approximately 450 miles of unsewered Puget Sound shoreline. This represents roughly 20% of Puget Sound's unsewered shorelines, compared to the 90% target for 2020.

Number of On-site Sewage Systems Inventoried and Inspected in Designated[1] Areas
Semi Annual Figures 2011-2012

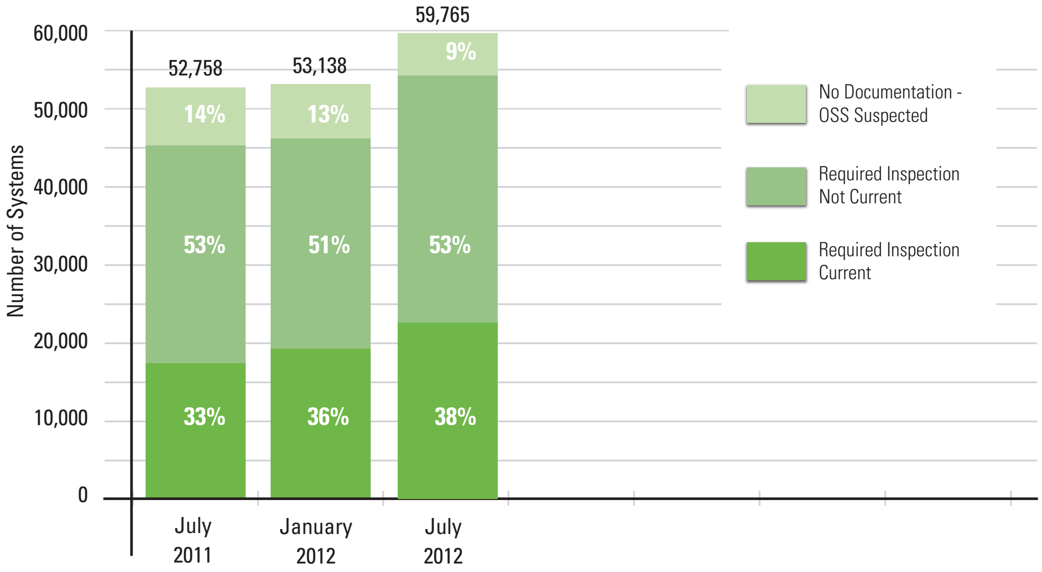


Figure1. Caption forthcoming
Source: Washington State Department of Health, Office of Shellfish and Water Protection

What is this indicator?

The goal of this indicator is to track and advance the proper use and care of on-site sewage systems in sensitive and high-risk areas of Puget Sound to protect public health and water quality.

State rules require all homeowners to regularly inspect and maintain their on-site sewage systems. However, in marine recovery areas and other designated areas, LHJs engage more directly with homeowners to help ensure systems are inspected and maintained to reduce public health risks.

All 12 Puget Sound LHJs have adopted comprehensive management plans for on-site sewage systems under the state on-site sewage rule. The management plans frame the local Operation and Maintenance (O&M) programs. The local O&M programs share a set of common elements but they are all uniquely designed and implemented. DOH oversees the statewide on-site sewage rule and collects and interprets data for the Puget Sound targets.

Interpretation of Data

The LHJs are currently working to adapt and align their programs to fit with these ambitious regional targets.

The Puget Sound O&M programs are inherently complex and costly to implement. They all work from the same rule requirements and core elements, but are all tailored to local conditions, budgets, and ways of doing business. They require significant planning, infrastructure, personnel, public education, political support, community buy-in, financial resources, and smart execution.

At all levels of government, funding for decentralized wastewater programs and infrastructure dramatically lags behind public investment in centralized sewer systems. State financial support for the Puget Sound O&M programs has never materialized at a scale originally envisioned when the state on-site sewage and MRA laws were enacted. Most O&M program costs are covered locally and are complemented by state and federal grants. In 2009 the Puget Sound counties conservatively estimated unmet needs at approximately $4 million annually. State pass-through funds and federal EPA

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[1] Designated areas include Marine Recovery Areas and other areas with comparable requirements.

On-site Sewage

On-site Sewage Program Tineline

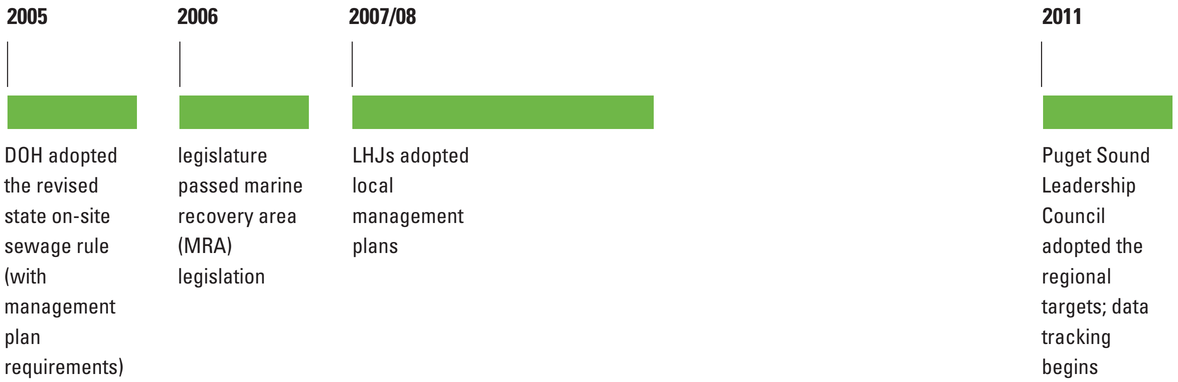


Figure 2. Several key milestones have been achieved for the On-Site Sewage Program

Pathogen Funds administered by DOH help augment this shortfall, adding about $4 million to work by the Puget Sound counties in the 2011-2013 biennium.

The targets provide a small window into the workings of the local O&M programs. These programs include such diverse activities as financial lending for system repairs, code enforcement, homeowner inspection training, data management, certification of O&M professionals, homeowner notification and reporting, and community outreach.

"Management"—characterized here as O&M—has long been recognized as the weak link in the widespread use of on-site sewages systems when compared to centralized sewers. This picture is gradually changing in the Puget Sound region as local O&M programs take root, but it will continue to take significant investments and smart thinking to effectively design and deliver these utility-style programs and services on an ever-expanding scale.

Homeowners and elected officials alike are increasingly seeing the need for and benefits of these programs. The Action Agenda and regional targets will continue to shape and guide these efforts.

Swimming Beaches

On a warm day, the waters of Puget Sound present an alluring invitation to wade, swim, or SCUBA dive. Although many of our beaches meet high standards for water quality, every year beaches are closed to the public because of high bacteria counts.

In 2011, one quarter of our monitored beaches were unsafe for swimming because they failed to meet water quality standards. Swimming in contaminated waters can result in a variety of illnesses and other unpleasant outcomes.

As our region grows in population, we can expect both an increase in the demand for recreational swimming opportunities, and in the sources of contamination from wastewater and stormwater runoff.

Clean water, free of harmful bacteria or chemicals, is an important goal in our efforts to restore and protect the Sound. We want the water to be as clean as possible so that we can enjoy the Sound without worrying about our health.

Photo Credit: Jon Bridgman, Puget Sound Partnership

Swimming Beaches

INDICATOR:

Conditions of Swimming Beaches

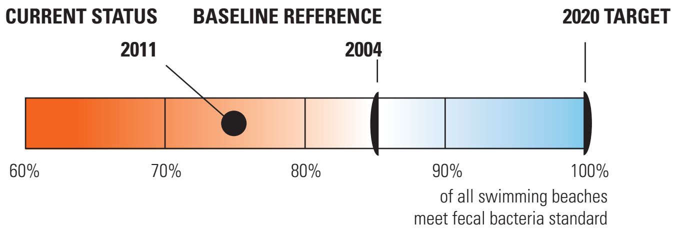
Indicator lead: Julie Lowe, Washington Department of Ecology

TARGET:

To have all monitored beaches in Puget Sound meet standards for what is called *enterococcus*, a type of fecal bacteria.

PROGRESS:

IS THE TARGET MET? **NO**	**IS THERE PROGRESS?** **NO**



In 2011, 75% of all monitored swimming beaches met fecal bacteria standards, which is down 12% from the 2004 baseline reference of 85%.

Progress towards 2020 target

Statewide monitoring of water quality at marine recreational beaches was initiated in 2004 by the Washington State's BEACH (Beach Environment Assessment, Communication, and Health) program. The target of 100% of all monitored swimming beaches meeting the EPA standards has not been met to date. Furthermore, no progress has been made relative to the 2004 baseline. In fact, the percent of core swimming beaches meeting standards initially improved, but has subsequently declined during the same time period, indicating that the conditions at swimming beaches have somewhat worsened.

What is this indicator?

The swimming beaches indicator reflects marine water quality conditions in areas heavily used for recreation. Conditions are measured using the percent of monitored Puget Sound swimming beaches that meet EPA water quality standards for the fecal bacteria enterococcus. Swimming beaches not meeting enterococci water quality standards indicate poor water quality that can result in negative human health outcomes such as gastrointestinal illnesses, respiratory illnesses, and skin infections.

Washington's BEACH Program was launched in 2003 in response to the BEACH Act, which amended the US Clean Water Act in 2000. A collaboration between the Department of Ecology and Department of Health, the program monitors high use/high risk beaches throughout the Puget Sound and Washington's coast.

The number of monitored beaches varied from year to year (Table 1). However, a total of approximately 47 core swimming beaches are monitored every year. Core beaches are those that are heavily used by the public and also present a higher risk to human health. A certain number of additional swimming beaches are monitored every year depending on funding, public input, and local health jurisdiction feedback.

For the purposes of this indicator, a beach is considered to meet EPA standards for a particular year if the beach has only one or less instance of a weekly result greater than or equal to 104 cfu/100mL.

The output of the indicator goal may not adequately reflect a long-term outlook for the quality of our beaches, since the number of beaches monitored changes from year to year.

Interpretation of data

Status and trend

Overall, the majority of monitored swimming beaches met enterococcus standards every year since 2004, the first year when the program was in full operation (Table 1). However, the number of beaches meeting the standards has varied from year to year ranging from a low of 74% in 2010 to a high of 88% in 2005 (Table 1). Monitored swimming beaches that did not meet standards in 2011 are scattered throughout Central and North Puget Sound (Figure 1).

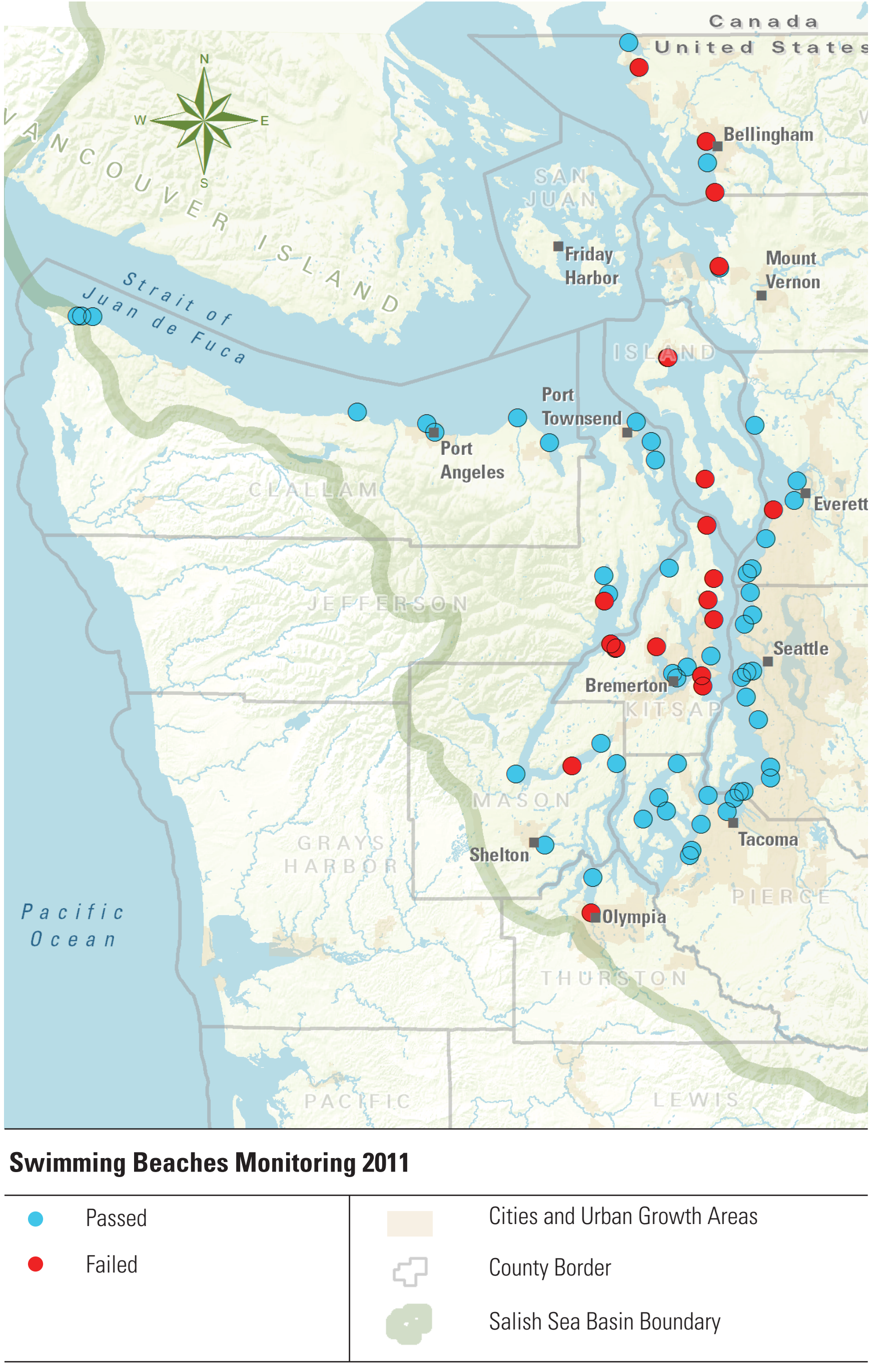


Figure 1. Distribution of all monitored swimming beaches, categorized by whether they passed or failed to meet water quality standards during the 2011 swimming season.
Source: Washington Department of Ecology, BEACH program

Swimming Beaches

Furthermore, some swimming beaches have had multiple violations since 2004. Five of the 19 swimming beaches that failed to meet standards in 2011 are considered beaches with chronic bacteria issues, namely:

- Freeland County Park, Holmes Harbor
- Larrabee State Park, Wildcat Cove
- Pomeroy Park, Manchester Beach
- Silverdale Waterfront Park
- Windjammer Park

The remaining 14 Puget Sound beaches that did not meet standards failed to do so during routine weekly sampling; however, they have met the standard on most occasions.

When the sample size is reduced to just the core beaches and tracked over time, the number of beaches meeting standards has slightly decreased since 2004, although numbers have varied from year to year (Figure 2).

Core Puget Sound Swimming Beaches Meeting Enterococcus Standards
Annual, 2004-2011

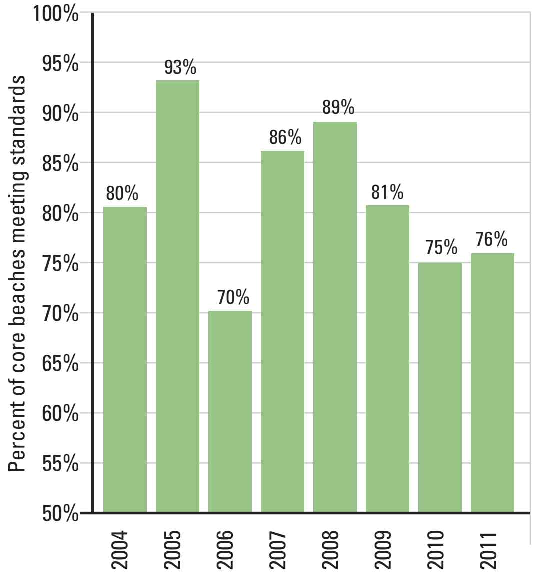


Figure 2. The percentage of core Puget Sound swimming beaches meeting enterococcus standards every year since 2004.
Source: Washington Department of Ecology, BEACH program

Monitoring results for conditions at all monitored swimming beaches in Puget Sound.

	2004	2005	2006	2007	2008	2009	2010	2011
Number of swimming beaches sampled	68	67	71	62	53	68	46	75
Percentage of swimming beaches failing to meet standards	15%	12%	20%	12%	13%	22%	26%	25%
Percentage of swimming beaches meeting standards	85%	88%	80%	87%	87%	78%	74%	75%

Table 1. Monitoring results for conditions at swimming beaches in Puget Sound.
Source: Washington Departmewnt of Ecology, BEACH program

Shellfish Beds

At low tide, the waters of Puget Sound reveal an amazing abundance of oysters, clams, mussels, and more – a bounty unparalleled elsewhere. Gathering shellfish is a time-honored tradition for the public, and today it is an industry that supports thousands of jobs and brings millions of dollars into the region.

Around Puget Sound, there are an estimated 190,000 acres of classified commercial and recreational shellfish beds. However, about 36,000 acres of shellfish beds—approximately 19%—are closed due to pollution, most of which comes from fecal bacteria from humans, livestock, and pets. When fecal bacteria and other contaminants get into the water, they threaten the areas where these prized oysters, clams, and other bivalve shellfish grow.

Photo Credit: Taylor Shellfish

Shellfish Beds

INDICATOR:

Acres of harvestable shellfish beds

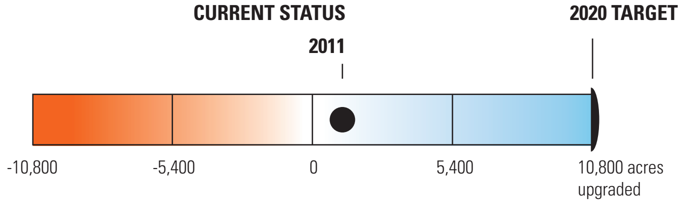
Indicator lead: Scott Berbells, Washington State Department of Health

TARGET:

A net increase of 10,800 harvestable shellfish acres, including 7,000 acres where harvest had been prohibited, between 2007 to 2020.

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**YES**



Since 2007, some shellfish harvest areas were upgraded while others were downgraded. The net result was an increase of 1,384 acres of shellfish beds open for harvest.

Progress towards 2020 target

The 2020 target has not been reached yet, but there has been some progress. Shellfish beds are considered harvestable when their status is upgraded. Between 2007 and 2011, more acres of shellfish beds were upgraded than downgraded across all classifications, resulting in a net increase of 1,384 acres of harvestable shellfish beds. A net 3,290 acres of shellfish beds were upgraded from the prohibited classification (3,437 acres upgraded minus 147 acres downgraded to prohibited).

However, these upgrades in growing area classifications from 2007 through 2011 were dramatically offset by the recent downgrade of the Samish Bay shellfish growing area (4,037 acres), impacting the overall net acreage gained since 2007 and slowing progress toward the 2020 goal.

What is this indicator?

The shellfish harvest area classification process is defined in federal rules and adopted in state regulations. The Department of Health (DOH) implements the rules at the state level. The purpose of the DOH program is to assure that harvested shellfish are safe to consume. This also includes making certain that pollution sources are continually assessed and marine water quality monitored around every classified harvest area. The data collected for the classification process not only represent the conditions that dictate shellfish harvest, but their trends can also indicate a healthier Puget Sound.

Classification	Definition	Acreage in 2011
Approved: commercial harvest for direct marketing allowed	Sanitary survey shows the area is not subject to contamination that presents an actual or potential public health hazard.	141,081
Conditionally approved: opened or closed for predictable periods of time	Meets approved criteria some of the time, but not during predictable periods. The length of closure is based on data that show the amount of time it takes for water quality to recover before the area can be reopened.	11,384
Restricted: cannot be marketed directly and must be transplanted to Approved growing areas for a specified amount of time	Meets standards for Approved criteria, but the sanitary survey indicates a limited degree of pollution from non-human sources. Harvest must be transplanted to Approved growing areas to allow shellfish to naturally cleanse themselves of contaminants before they can be marketed.	307
Prohibited: closed to commercial and recreational harvest	When the sanitary survey indicates that harmful substances may be present in concentrations that pose a health risk. Growing areas that have not undergone a sanitary survey are also classified as Prohibited.	35,683

Table 1. Classification of shellfish areas in Puget Sound.

DOH classifies 91 different shellfish growing areas in Puget Sound, covering roughly 190,000 acres. Sites are classified as "approved," "conditionally approved," "restricted," or "prohibited" (Table 1). Upgrades in classification mean that water quality has improved, allowing for fewer restrictions on shellfish harvest. Downgrades mean there are either more restrictions on when shellfish may be harvested or no harvest allowed at any time. Downgrades are generally caused by fecal bacteria or other pollutants in the water that make the shellfish unsafe to eat. The "acres of harvestable shellfish beds" indicator refers to those shellfish harvest areas that are upgraded.

DOH samples over 1,200 marine water stations between six and 12 times each year for fecal coliform bacteria, salinity, and temperature. Between 2.5 to five years of bacteria sampling data are used in the classification of each marine water station. In addition, shoreline pollution sources, including wastewater treatment plants, individual on-site sewage systems, marinas, farms, and any other activity with the potential to impact the shellfish area, are evaluated periodically and results are integrated in the classification process.

Shellfish Beds

Interpretation of data

Status and trend

Of the total harvest area classified in 2011, 81% was approved or conditionally approved for harvest. Thus, shellfish harvest is possible in most of the areas under DOH jurisdiction, and these areas are distributed across all sub-basins of Puget Sound (Figure 2).

In contrast, over 35,000 acres (19%) of shellfish harvest areas were classified as prohibited due to the proximity of pollution sources or poor water quality (Table 1). Over 60% of this acreage is prohibited because of a nearby wastewater treatment plant outfall, 29% because of nonpoint pollution sources, 8% because of marinas, and 2% because of other factors that could impact public health.

From 2007 through 2011 improved sanitary conditions resulted in net upgrades in classifications totaling 1,384 acres (Figure 1). A classification downgrade in April 2011 within the Samish Bay shellfish growing area (4,037 acres) dramatically impacted the net acreage gained since 2007.

The DOH predicted that 8,738 acres could potentially be upgraded between 2012 and 2020. This analysis incorporates information

Acres of Upgraded and Downgraded Shellfish Beds in Puget Sound

2000–2020

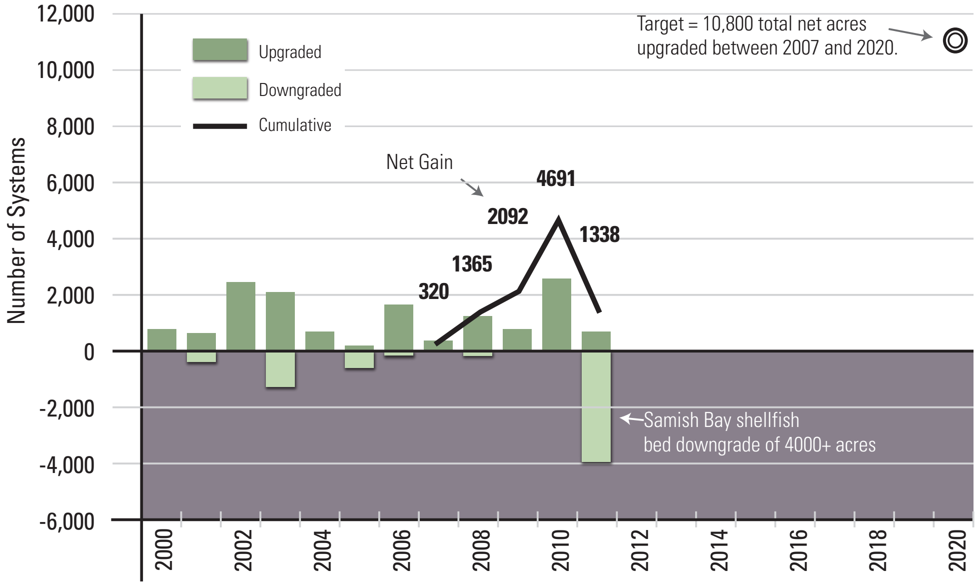


Figure 1. Number of acres in Puget Sound by annual harvest area classification changes from 2000

about the known or suspected causes of harvest restrictions and an area-by-area evaluation of the current activities and water quality trends. These projections, coupled with the current 2007 through 2011 net acreage increase (1,384 acres) results in a predicted increase of 10,122 acres by 2020, just short of the 10,800 acres target value. However, downgrades are almost certain to occur during the same timeframe, thereby counteracting the upgrades and further widening the gap to the target value.

Although the sound-wide trend in improvement is positive, many factors affect the long-term ability to reach the target. Intensive efforts to restore growing efforts, such as in the Samish harvest area, are counter-balanced by shoreline development and polluted runoff from stormwater, onsite septic systems, and farms near existing open areas. Unless there are aggressive actions to improve wastewater treatment plant outfall locations, onsite septic system operation and maintenance, and agricultural best management practices, the 2020 target will likely not be met.

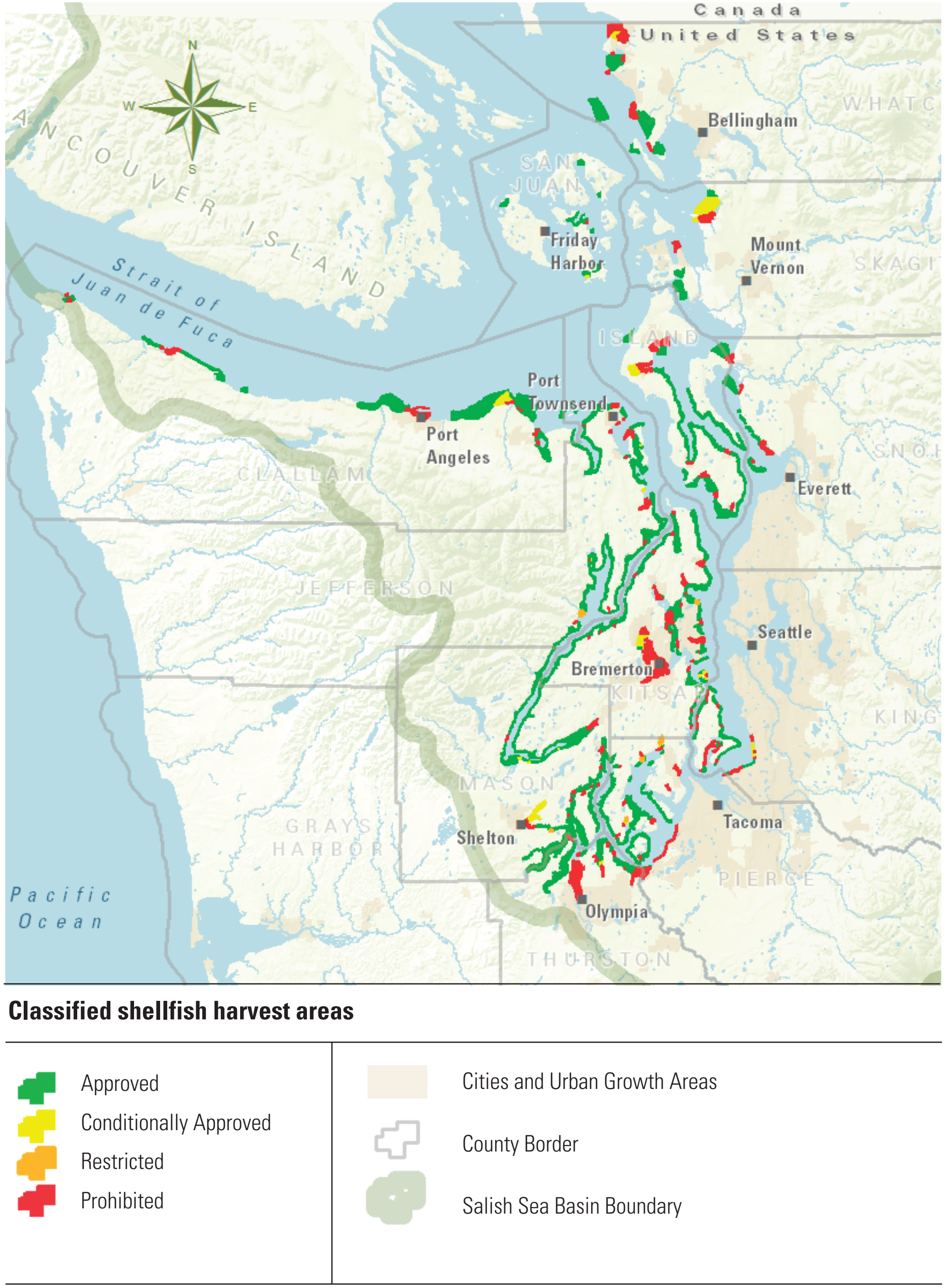
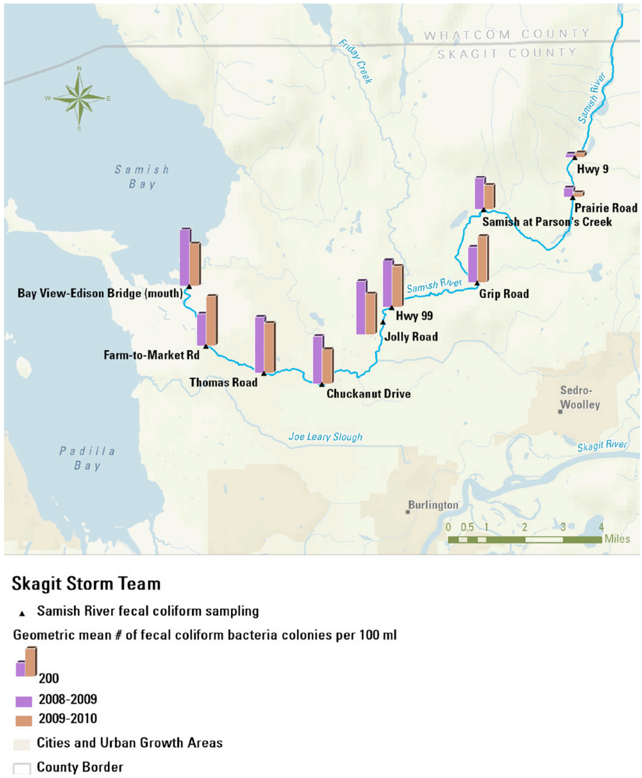


Figure 2. Distribution of classified shellfish harvest areas in Puget Sound.
Source: Washington Department of Health, Office of Shellfish and Water Protection

Skagit Stream Team and Storm Team

Sponsored by the Skagit Conservation District in partnership with the Padilla Bay National Estuarine Research Reserve, the cities of Mount Vernon, Anacortes, Burlington, Sedro-Woolley, and Skagit County, the Skagit Stream Team began in 1998 with a mission to educate and involve local citizens in the protection and stewardship of local streams. Currently, 70 dedicated Stream Team volunteers regularly measure water quality in ten watersheds in Skagit County.



STORM TEAM

A high fecal coliform result during a heavy rain event in 2008 in the Samish watershed, an important commercial shellfish growing area, raised concerns and led to the creation of the Storm Team. Although Samish Bay usually has good water quality, tests showed that during storms large volumes of pollutants wash off the landscape into local streams and rivers and contaminate the bay.

The Storm Team is a dedicated core of volunteers that head out in the middle of rainstorms as streams and rivers are rising to collect water samples for fecal coliform bacteria testing. Testing during high flow conditions is an important complement to the Stream Team's regular ambient monitoring, and it has been instrumental in identifying priority areas for clean up efforts.

Initial Storm Team efforts in the Samish watershed helped establish baseline data for the river during storm events for the Washington State Department of Health (DOH) Office of Shellfish & Water Protection, which regulates the commercial shellfish industry. DOH uses fecal coliform loading to determine when to issue a pollution closure.

As a result of Storm Team and Skagit County sampling, DOH changed the classification of most of Samish Bay from Approved to Conditionally Approved in 2011. Samish Bay commercial shellfish growing areas are now closed automatically when the river reaches 4.7 trillion fecal coliform colonies per day—a level determined to pose a risk for shellfish consumption.

Storm Team sampling efforts were critical in documenting fecal coliform contamination problems in the Samish watershed. The Clean Samish Initiative (CSI), a partnership of local, state, and federal agencies and organizations, was launched in 2010 by Skagit County with funding from the US Environmental Protection Agency. The CSI effort was put together to identify sources of fecal contamination and to find ways to correct them. With increased County sampling efforts under the CSI, the Skagit Storm Team has been able to redirect efforts over the last two years to the Bay View and No Name Slough drainages in the Padilla Bay watershed.

More information about the Skagit Stream Team and Storm Team can be found at www.skagitcd.org/stream_team

Information about the Clean Samish Initiative can be found at skagitcounty.net/cleanwater

Puget Sound Quality of Life Index

Recovering the Puget Sound ecosystem will reap many benefits—both tangible and intangible—for all of our residents. Whether we are employed in a marine industry, celebrating our cultural traditions, boating, or simply enjoying the scenic views, we receive gifts from Puget Sound that are part of the reason that we want to live here. A healthy Puget Sound includes a thriving natural world, a vibrant economy, and a high quality of life for people.

The Puget Sound Partnership and the Science Panel's Social Science Committee are working on a region-wide Quality of Life Index that will assign a numeric value to these intangible benefits, combining attributes related to aesthetics, culture, recreation, and the economy. Work on defining the specific items to be included in the Quality of Life Index isunderway and will seek input from a number of interest groups, as well as be informed by related efforts taking place at the local level. The Quality of Life Index will be presented to the Leadership Council in 2013, and its targets will be identified soon after.

Sound Behavior Index

Many of our common day-to-day behaviors and practices may seem benign on their own, but when multiplied by 4.5 million residents, their cumulative effects can harm Puget Sound. A crucial step in Puget Sound's recovery is fostering beneficial behaviors and reducing harmful ones in order to reverse negative trends influenced by human actions.

The Puget Sound Partnership has recently developed a Sound Behavior Index that is based on a survey that will be conducted every two years among a scientifically selected sample of Puget Sound residents. The survey asks them about specific, measurable, repetitive behaviors that affect water quality and aquatic health. This index also measures social capital—the bonds that bring people together and signify a society's ability to solve complex issues such as environmental problems.

The Sound Behavior Index will distill the region's environmental performance into a single score, which can be tracked across time. By measuring long-term shifts in behaviors and practices across the Puget Sound region, the index gives policy makers a tool to set priorities for regional and local programs. Data for the Index will be available in late 2012.

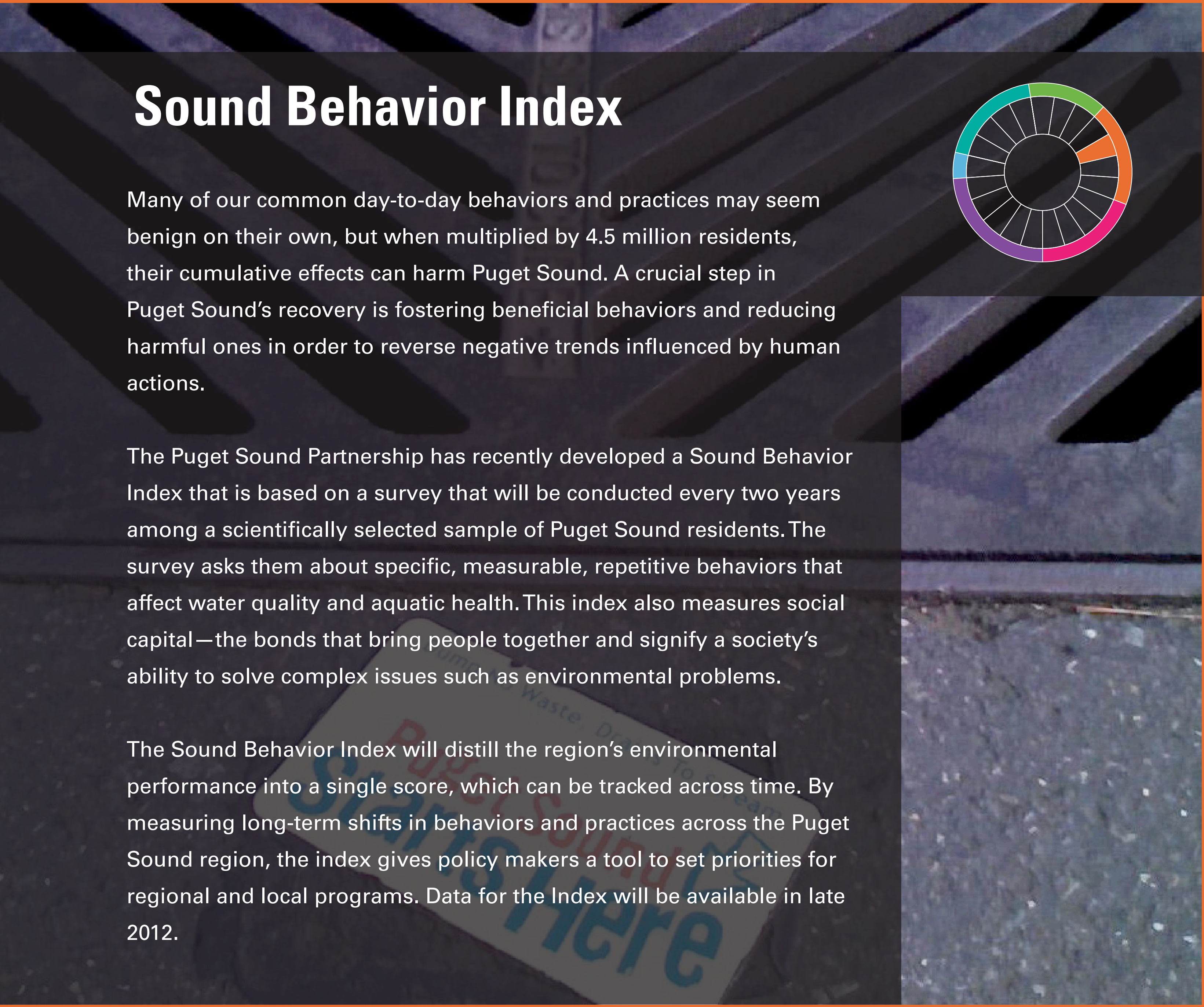


Photo Credit: Kurt Clark

Recreational Fishing Permits

Recreational fishing is part of the lifestyle of Puget Sound. For generations, residents of Puget Sound and our many visitors have enjoyed fishing in the Sound and along its numerous rivers and streams. Recreational fishing provides an opportunity to enjoy the outdoors and is part of the lifestyle of Puget Sound. Today, because of the decline in some populations of fish, recreational fishing is closely managed to allow recreational fishing without harming individual species or stocks that need protection. Our long term vision, as recovery proceeds, is to restore the ecosystem and health of Puget Sound to ensure sustainable, ongoing recreational fishing.

Photo Credit: WSDOT

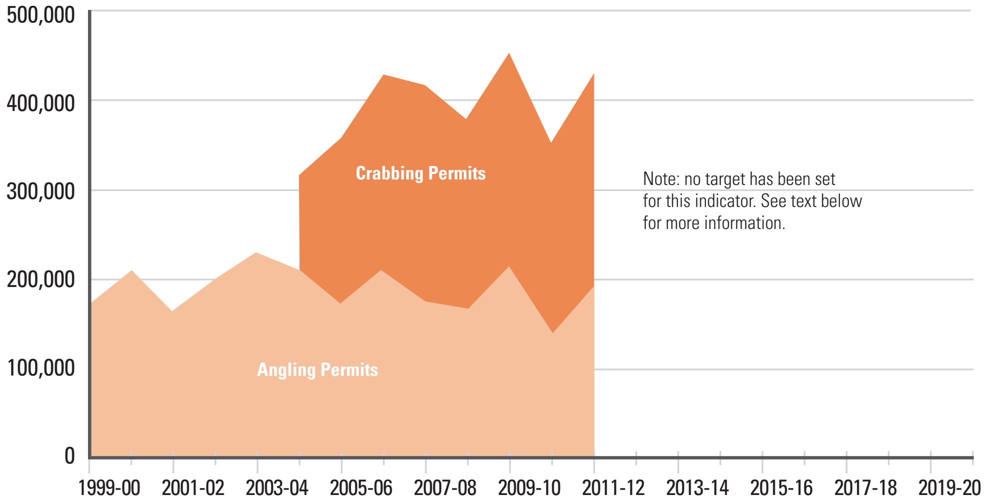
Recreational Fishing License

Recreational fishing license sales are being tracked as an indicator of Puget Sound's overall health, and the prosperity and quality of life for the people in the region. There are currently no 2020 targets for recreational fishing license sales, because the Leadership Council chose not to set a target for recreational fishing licenses at this time.

Staff are considering including this parameter in the Quality of Life Index that is under development.

Recreational Fishing and Crabbing Permits for the Puget Sound

1999-2000 Season through 2019-2020 Season



Note: no target has been set for this indicator. See text below for more information.

Figure1. Fishing licenses: Number of saltwater or combination license holders that fished or intended to fish in Puget Sound, as estimated by the Dedicated Funds telephone survey conducted after the end of the license year. License years run April 1 through March 31.

Crabbing licenses: Number of shellfish-only license holders that purchased a Puget Sound Crab endorsement. Available since 2004-05, when the Washington State Legislature created the Puget Sound Dungeness crab endorsement, which allows data to be collected.

Source: Catch Record Card Data, Washington State Department of Fish and Wildlife, Washington Interactive License Database (WILD) Dedicated Fund Telephone Survey

Commercial Fisheries Harvest

Commercial fishing is a key industry in Puget Sound. Millions of dollars of revenue are generated annually from fish sales. The 17 federally-recognized tribes in Puget Sound, along with Washington State, jointly manage the fish and shellfish resources. By treaty, tribal fishers collectively and non-tribal fishers collectively are each entitled to up to one half of the harvestable amount. Every year, limits are set based upon a complicated set of factors that are used to predict how many fish will be available for harvest, taking into account the status of protected and non-protected stocks. Overall harvest limits are set to ensure that harvests are sustainable and there will be adequate salmon resources into the future. Then this must be divided into commercial, recreational, subsistence, and ceremonial harvest. Our long-term vision, as recovery proceeds is to restore the ecosystem and health of Puget Sound to ensure sustainable ongoing fishing, including commercial..

Photo Credit: Canopic@flickr

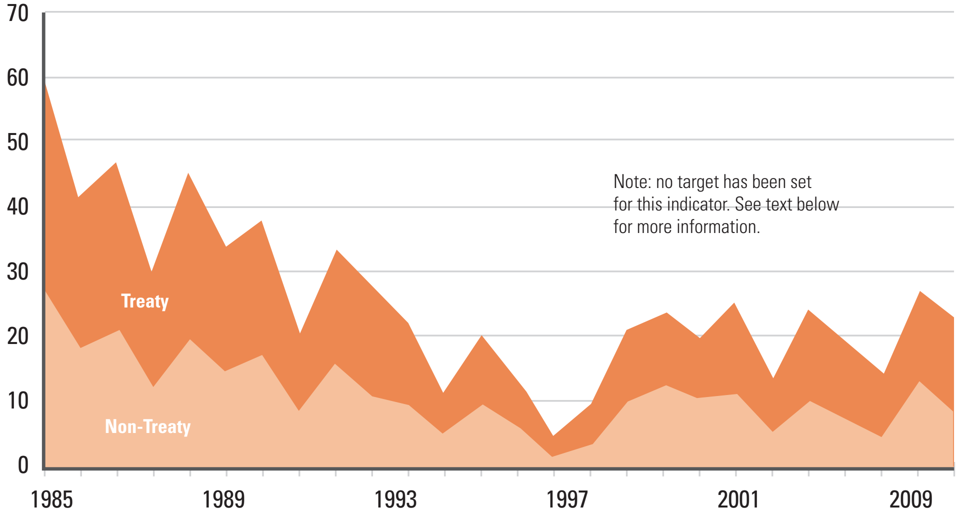
Commercial Fisheries Harvest

2020 Target: There are currently no targets for commercial fishing

As in the case of recreational fishing permits, the governing board of the Puget Sound Partnership, the Leadership Council, chose not to set a target for commercial fisheries harvest at this time.

Staff are considering including this parameter in the Quality of Life Index, which is under development.

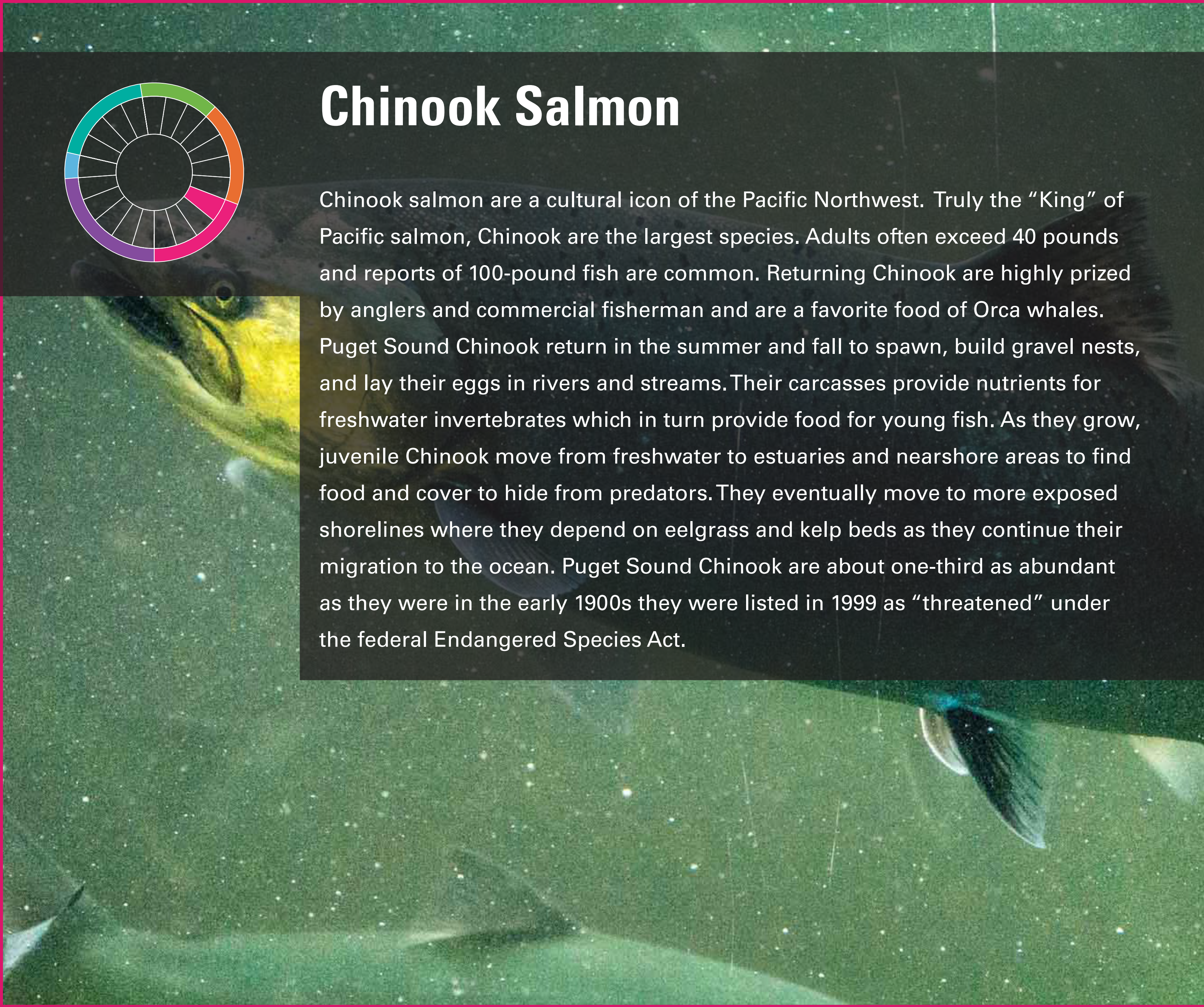
Pounds of All Salmon Caught in Puget Sound Commercial Harvest
In Millions, 2000-2020



Note: no target has been set for this indicator. See text below for more information.

Figure1. The graph shows the pounds (in millions) of all salmon sold in commercial fisheries. Additional commercial benefit accrues from secondary businesses (e.g. restaurant sales) and recreational fisheries as well (not shown here). Note that commercial harvest also does not represent all harvest impacts on a species (e.g. unsold by-catch or gear-related mortalities). The treaty/non-treaty breakout shown here does not reflect allocation balance for a number of reasons.

Source: Historic Catch and Landing System (HCLS) and TOCAS and LIFT systems, jointly maintained by the treaty tribes and the Washington Department of Fish and Wildlife.



Chinook Salmon

Chinook salmon are a cultural icon of the Pacific Northwest. Truly the “King” of Pacific salmon, Chinook are the largest species. Adults often exceed 40 pounds and reports of 100-pound fish are common. Returning Chinook are highly prized by anglers and commercial fisherman and are a favorite food of Orca whales. Puget Sound Chinook return in the summer and fall to spawn, build gravel nests, and lay their eggs in rivers and streams. Their carcasses provide nutrients for freshwater invertebrates which in turn provide food for young fish. As they grow, juvenile Chinook move from freshwater to estuaries and nearshore areas to find food and cover to hide from predators. They eventually move to more exposed shorelines where they depend on eelgrass and kelp beds as they continue their migration to the ocean. Puget Sound Chinook are about one-third as abundant as they were in the early 1900s they were listed in 1999 as “threatened” under the federal Endangered Species Act.

Photo Credit: Ingrid Taylar

Chinook Salmon

INDICATOR:

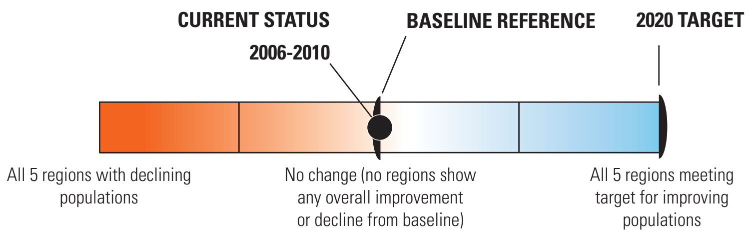
Chinook Salmon Population Abundance as measured by spawning escapement

TARGET:

2020 Target: stop the overall decline and start seeing improvements in wild Chinook abundance in 2-4 populations in each biogeographic region. (note: for the purposes of tracking this target, we report abundance as the number of natural spawners)

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**NO**



From 2006-2010, most Chinook populations showed large annual variability in abundance but no discernable increasing or decreasing trends. Overall, only two populations showed a clear improving trend, and 1 population showed a declining trend. None of the 5 regions have yet met their targets for improving population abundance.

Progress towards target

For the 22 remaining populations of Puget Sound Chinook salmon, two increased and one declined in abundance from 2006 to 2010 (Table 1). Thus, none of the five regions are currently meeting their target of improving trends in 2-4 populations in each region.

After remaining between 30,000 – 40,000 between 1985 and 1991, the total number of Puget Sound Chinook spawners dropped to just over 20,000 in 1993 before beginning an overall upward series of ups and downs to a high of 60,000 in 2004. Numbers have declined since then to just over 20,000 in 2009 (Figure 1; NOAA Status Review Update, 2011).

Numbers of Chinook salmon have not increased, and most populations remain well short of their recovery goals. Nonetheless, the fact that we have any natural-origin Chinook left is testament to the success of our restoration and harvest reduction work so far.

What is this indicator?

Population abundance of Chinook salmon is represented by spawning escapement numbers, which are typically estimated by counting the number of redds (gravel nests) in a river. Redds are counted by walking the stream or from a boat or aircraft. There are 22 populations of Chinook that return to specific watersheds in the Puget Sound Region. Historically, there is evidence of additional populations of Chinook that are now extinct.

Natural spawners are reported here and include both natural origin spawners and hatchery origin spawners. The percent of the total spawners that are hatchery-origin varies across populations from 0 to 78%. The proportion of spawners that were natural or hatchery origin is estimated based on composition of carcasses, which may or may not be equal to the percentage of spawners that were actually natural or hatchery origin.

Chinook Salmon

〰 Rivers having Chinook salmon populations

▢ County Border

🟩 Salish Sea Basin Boundary

▨ Cities and Urban Growth Areas

Source: National Hydrography Dataset

Chinook Salmon

Interpretation of data

Status and trend

- Chinook salmon populations in Puget Sound exhibit large annual variations in abundance, and possibly long-term (10 or more year) fluctuations that confuse simple evaluations of short or long-term "trends" in numbers (Fig 1).
- All Puget Sound Chinook populations are currently well below abundance levels (planning ranges) identified as required for recovery to low extinction risk in the recovery plan
- Looking at just the most recent 5-year period for which we have consistent data, most populations do not exhibit any statistically significant trends. Only two populations show an increasing trend, and 1 population shows a decreasing trend ($p<0.05$; Table 1).
- Although total spawner abundance has not changed significantly over the period from 1985-2009, the total number of natural origin recruits and overall productivity has declined according to NOAA.
- Long-term spawner abundance numbers have shown little progress towards the target, with numbers declining since the early 2000's. However, in their recent 5-year Status Review (Ford 2011), NOAA determined that the available information does not suggest that a change in biological risk category (i.e. "likely to become endangered") is likely for Chinook salmon in Puget Sound, and they continue be listed as "Threatened" under the Endangered Species Act.

Abundance of Chinook spawners in Puget Sound
1990 - 2010

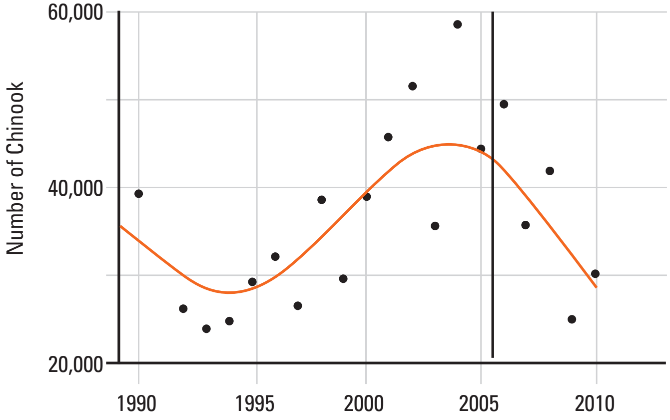


Figure1. Total natural spawners of Chinook salmon observed in Puget Sound watersheds. Included in the counts are natural-origin and hatchery-origin spawners. Shown are natural spawners for each year (points) and a fitted line derived from locally weighted scatterplot smoothing tables.
Source: NOAA A&P tables

Table 1.(opposite) Puget Sound Salmon Populations.
Data Sources: Washington Department of Fish and Wildlife. NOAA's Salmon Population Summary (SPS) Database. NOAA's Abundance and Productivity Tables. Unpublished, Personal communication, Mindy Rowse.Ford, M. J. (ed.). 2011. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwest. U.S. Department of Commerce, NOAA Technical Memo.

[1] Recovery Plan for the Puget Sound Chinook Salmon (National Marine Fisheries Service, 2006).

[2] NOAA's Abundance and Productivity tables. Trends are significant at the 95% confidence level.

[3] Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act (Ford [ed.], 2011, NOAA).

Puget Sound Chinook Spawner abundance and trends

Region/Population	Recovery Goal[1]	5-yr average[2]	% of average recovery goal	Trend[3] (1999-2008)	Trend [2] (2006-2010)
Strait of Georgia					
N Fk Nooksack	3,800 -16,000	1,530	15%	Increasing	Increasing
S Fk Nooksack	2,000-9,100	460	8%		
Strait of Juan de Fuca					
Elwha	6,900-17,000	1478	12%		
Dungeness	1,200-4,700	340	12%		
Hood Canal					
Skokomish	Unknown	1001			
Mid-Hood Canal	1,300-5,200	91	3%		
Whidbey Basin					
Suiattle	160-610	226	59%		
N Fk Stillaquamish	4,000-18,000	903	8%		
S Fk Stillaquamish	3,600-15,000	73	1%	Declining	
Cascade	290-1,200	320	43%		
Upper Sauk	750-3,030	606	32%		
Lower Sauk	1,400-5,600	458	13%		
Skykomish	8,700-39,000	3152	13%		
Snoqualmie	5,500-25,000	1702	11%		
Upper Skagit	5,380-26,000	8,606	55%		Declining
Lower Skagit	3,900-16,000	1,708	17%		
Central/South Puget Sound					
White R	unknown	1,629		Increasing	
Green/Duwamish	27,000	2,964	11%		
Sammamish	1,000-4,000	379	15%		Increasing
Cedar	2,000-8,200	921	118%	Increasing	
Nisqually	3,400-13,000	1,876	23%		
Puyallup	5,300-18,000	2,117	18%		

Local Story - Elwha

Orcas

Killer whales, also called orcas, are among Puget Sound's most distinctive and charismatic inhabitants. They occupy an important niche at the top of the food web and support a multi-million dollar whale watching industry.

A unique population of orcas lives in and around the Salish Sea, which includes Puget Sound, the Strait of Juan de Fuca, and the Strait of Georgia. Called the Southern Resident Killer Whales, the community once numbered around 200 whales. In the past decade, the population totaled fewer than 90 individuals.

While other orca populations prey heavily on marine mammals, resident pods primarily eat fish, relying on Chinook salmon for a large part of their diet.

In the late-1990s, Southern Resident Killer Whales experienced a dramatic decline in population size. As a consequence, they were listed as Endangered under the Endangered Species Act in 2006.

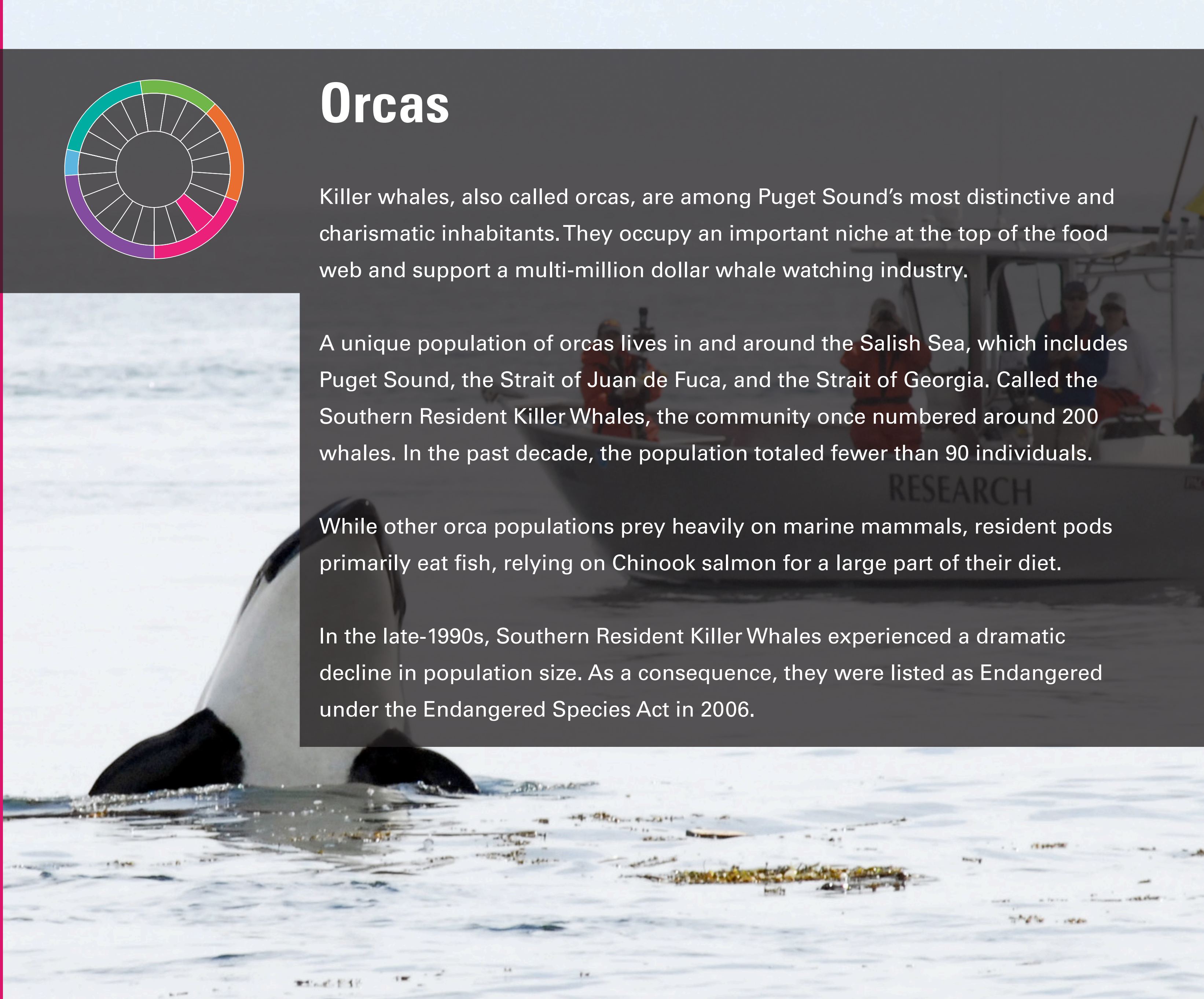


Photo Credit: NOAA Photo Library

Orcas

INDICATOR:

Number of Southern Resident Killer Whales

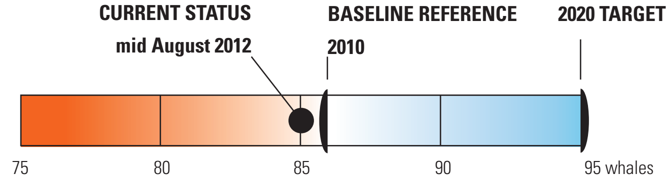
Indicator lead: Ken Balcomb, Center for Whale Research

TARGET:

By 2020, achieve an end of year census of Southern Resident Killer Whales of 95 individuals, which would represent a 1% annual average growth rate from 2010 to 2020

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	NO



There were a total of 85 Southern Resident Killer Whales as of mid-August 2012. This was one less whale than the baseline reference of 86 whales.

Progress towards 2020 target

The 2020 target of reaching 95 whales has not been met, and in the short-term there has been no progress. Since 2010, the Southern Resident Killer Whale population has never been larger than 88 whales. Furthermore, as of August 2012, the size of the population was smaller by one whale relative to the 2010 baseline reference of 86 whales.

Although there has been no progress made since 2010, the population has been growing, albeit slowly at about 1% per year, over the longer term (1979 to 2010). This population growth trend is consistent with the 2020 target. However, trends could easily be reversed, as the Southern Resident Killer Whale population is very vulnerable to a variety of factors, making progress towards the 2020 target tenuous at best.

What is this indicator?

The Southern Resident Killer Whale population in Puget Sound is actually a large extended family, or clan, comprised of three pods: J, K, and L pods. Although they can be seen throughout the year in Puget Sound, they are most often seen during the summer, especially in Haro Strait west of San Juan Island, the Strait of Juan de Fuca, and in the Strait of Georgia near the Fraser River.

Threats to Southern Resident Killer Whales include contaminants, prey availability, vessels, and noise pollution. Additional human activities, such as underwater military activities, have been identified as a potential concern for killer whales, particularly on the outer coast, although this issue has not been fully evaluated. Their small population size and social structure put them at risk for a catastrophic event, such as an oil spill, or a disease outbreak, that could impact the entire population.

Resident orcas were chosen as an indicator because they are top-level predators, spend a portion of the year in Puget Sound to feed and socialize, and are threatened by some of the pressures on the Sound, such as pollution and declining salmon and herring runs. Although a robust orca population is an important recovery goal both at the state and federal level, there may be limits to how much the orca indicator tells us about the overall health of Puget Sound. The Southern Resident Killer Whale population migrates in and out of the area, and thus is not entirely dependent on Puget Sound and its resources.

Interpretation of data

Current Status and Trend

The census of the Southern Resident Killer Whale population, conducted annually by the Center for Whale Research, is an important method by which to assess the status and trends of this endangered population. The entire population is counted with a high degree of certainty using photo identification techniques. Sighting networks throughout Puget Sound support the census. Two of these networks are showcased elsewhere in this report (please see "Volunteers Gather Important Data on Orcas" on page 55.

Other populations of whales, such as Transients and Northern Resident Killer Whales, also frequent the Salish Sea, but their numbers are not reported here because the indicator and target focus only on Southern Resident Killer Whales.

The population size of Southern Resident Killer Whales changes temporarily throughout the year as whales are born and die. For example, as of the end of 2011 there were 88 Southern Resident Killer Whales in total, with 26 in J pod, 20 in K pod and 42 in L pod (Figure 1). Since December 2011 four whales have gone missing (J30, K40, L5, L12) and are presumed dead. A fifth missing whale (L112), drifted ashore dead in February on the outer coast of Washington. However, two new calves (J49, L119) have been seen since the beginning of 2012 such that, at the time of publication, there were 85 Southern Resident Killer Whales in Puget Sound.

Thus, abundance did not change significantly in the last decade (Figure 1). However, although there has been no progress in the short term, analysis of historic data shows modest growth.

Historic trends

Since data became available in 1973, the Southern Resident Killer Whale population has by turns declined and grown. Despite year-to-year variability, total population size grew over the past four decades by about 1% per year: there were fewer than 70 whales in the early 1970s, and an annual average of 85 whales in the 2000s (Figure 1). Yet, compared to the Northern Resident Killer Whale population living in the Strait of Georgia, the Southern Resident Killer Whale population is smaller and has been growing more slowly overall.

At the pod level, the long-term population growth rate (from 1979 and 2010) is slightly higher for J and K pods combined (~1.02) than for L pod (~1.01). L pod is the largest of all pods. However, this pod has been in decline since the early 1990s.

The other two pods, J and K, are roughly the same size. Both J and K pods are growing, with J pod increasing more rapidly than K pod. This is likely due to the limited reproductive potential in K and L pods. Indeed, the sex ratio of K and L pods is skewed toward males. The lack of reproductive females, poor survival of calves, and factors associated with small population sizes such as inbreeding, along with human-caused threats, are a concern for the viability of this population.

Orcas

J pod is also the pod that spends the most time in Puget Sound compared to the other two. The fact that Southern Resident Killer Whales only spend part of their lives in Puget Sound, and that the pod that spends the least time in Puget Sound has the steepest decline, suggests that the whales are impacted by conditions outside of Puget Sound.

Although the Southern Resident Killer Whale population's long-term trend for population growth meets the PSP growth rate target, the population growth rate does not meet the legal recovery criteria to delist the Southern Resident Killer Whales from the Endangered list (i.e., meeting an average growth rate of 2.3% per year for 28 years).

Restoration of this population of long-lived, slow-reproducing killer whales is a long-term effort that requires cooperation and coordination of West Coast communities from California to British Columbia. It will take many years to fill key data gaps and assess the effectiveness of ongoing recovery actions for the whales, salmon, and their habitat, and to observe significant increases in the Southern Resident population.

Number of Southern Resident Killer Whales in Puget Sound

Annual, 1972-2011

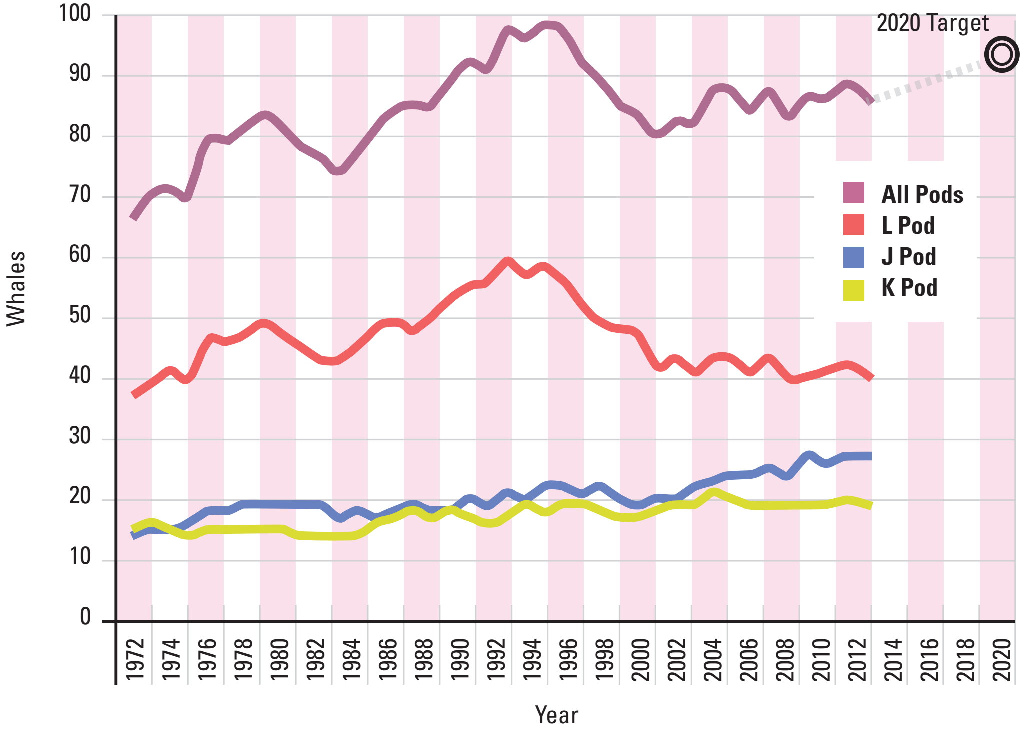


Figure 1. Number of Southern Resident Killer Whales in Puget Sound each year between 1972 and 2011.

Source: Center for Whale Research

Volunteers Gather Important Data on Orcas

Salish Sea Hydrophone Network and Orca Network

The Salish Sea Hydrophone Network and Orca Network are two citizen science projects dedicated to furthering our understanding of abundance, distribution, behavior, and habitat use by the endangered population of Southern Resident Killer Whales, also called orcas. The Hydrophone Network lets the public listen for orcas through their computers, while the Orca Network gathers and disseminates sightings of orcas as they move between Puget Sound, the Fraser River, and the Pacific Ocean.

Listening in on Orcas

The Salish Sea Hydrophone Network started in 2007 and now includes five hydrophones (underwater microphones): two on San Juan Island, and one each at Port Townsend Marine Science Center, the Seattle Aquarium, and Neah Bay. By monitoring the sounds streaming live on orcasound.net, scientists, educators, and the public can help detect loud calls and clicks made by orcas as they communicate and hunt. Listeners can also help detect noise pollution caused by Naval sonar and vessel traffic.

For orcas and other whales, the underwater sound environment is critical to their sensory experience and behavior. Orcas communicate with each other over short and long distances with a variety of clicks, chirps, squeaks, and whistles. They also use echolocation to locate prey and to navigate.

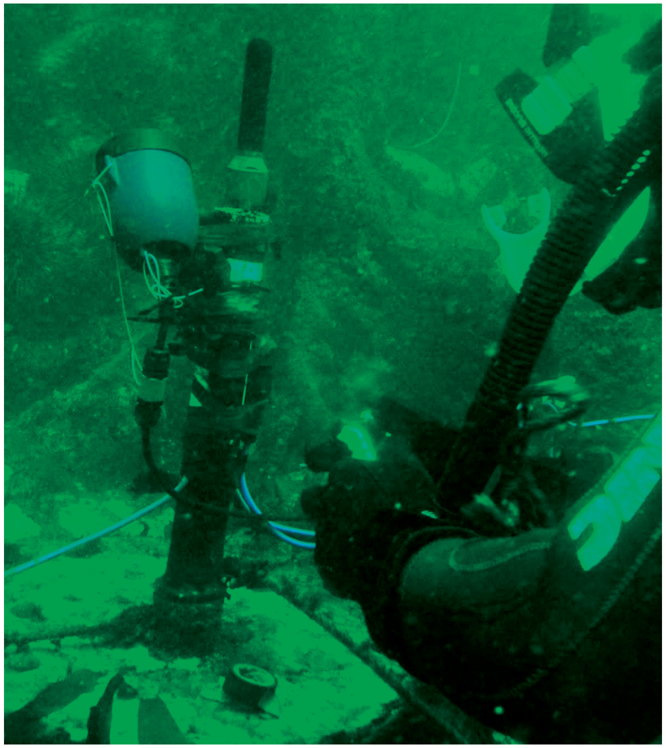
Hydrophone Network volunteers log their observations on a collaborative Google spreadsheet online or report detections via email. Volunteer observations help to direct field research, including prey sampling studies that revealed the orcas strong preference Chinook salmon and fecal sampling studies that show orcas may be prey limited. In addition, the hydrophone network enabled early detection of a new orca calf in 2009.

The Network allows friendly competition and collaboration between volunteer listeners and computers. In detecting when orcas passed by a proposed tidal turbine site near Port Townsend, human listeners heard the orcas 10 of the 22 times they passed by (45%) while auto-detection software detected them 14 times (64%). When both approaches, were combined, orcas were detected 17 times (77%).

The number of orcasound.net visitors per day rises from a mid-winter low of about ten to a summertime average of approximately 100, with occasional spikes to 200-350. Listeners are predominantly from the U.S. (75%) and Canada (13%), so observers from distant time zones are sought to boost nighttime detection rates.

Watching for Orcas

Given the wide-ranging travels of the Southern Resident Killer Whales and other whales in the Salish Sea, it is impossible for the few whale researchers to track all the individuals on a regular basis.



Lime Kiln Hydrophone. Photo Courtesy of Dave Howitt

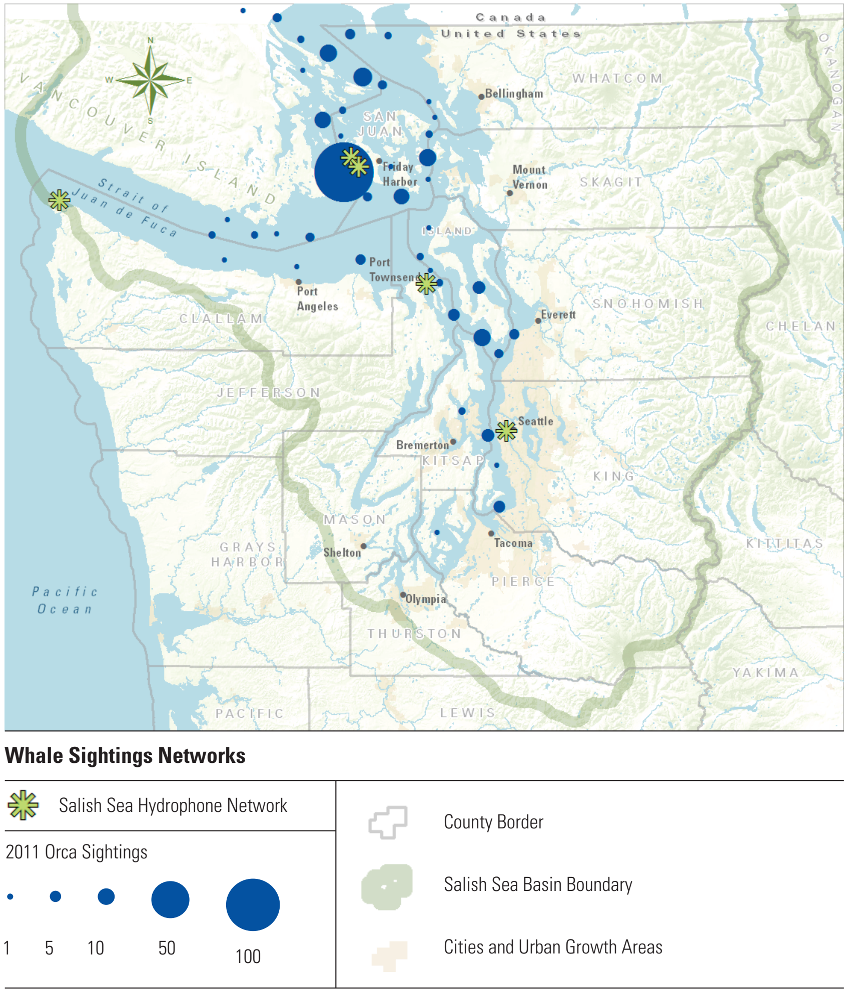


Figure. Salish Sea Hydrophone Network locations and 2011 orca sightings from the Orca Network Whale Sightings Network. Orca sightings data were compiled from monthly sighting maps and include only orca (resident or unknown) reports and only one report per location per day (although it is possible that the Network received more than one report per location per day). *Source: Salish Sea Hydrophone Network and Orca Network*

Orca Network's Whale Sighting Network was started in 2001 to provide more information on Southern Resident Killer Whale travels in inland and coastal waters. In addition, the network also raises awareness, educates the public, and provides a networking and communication system for researchers, educators, and the public. There are currently more than 7,000 participants on the Sighting Network email list, and more than 14,000 subscribers to the Facebook page.

With more than 15,000 sightings reported to date by the hundreds of participants in the Sighting Network, Orca Network harnesses broad public interest in whales to provide researchers with critical information for tracking these endangered whales.

Through the Sighting Network, volunteers report sightings of whales, which provide valuable information on habitat use, social and foraging patterns, and behaviors for researchers managing the recovery of Southern Resident Killer Whales. Reports are compiled and sent to researchers, natural resource managers, and educators and are available on the Orca Network website, Facebook page, and Twitter feed.

The Sighting Network also provides an important communication and tracking tool during emergency situations such as oil spills and entangled whales. It also helps identify orcas out of their usual habitat, such as Springer, the Northern Resident orca calf who was reported through the Sighting Network in Swinomish Channel, then off Edmonds, before showing up off Vashon Island. She was relocated to her home in Canadian waters in 2002.

More information about the Salish Sea Hydrophone Network and the Orca Network's Whale Sighting Network can be found at:

www.orcasound.net | www.orcanetwork.org

Photo Credit: Anne Shaffer

Pacific Herring

Pacific Herring are one of the most abundant forage fish species in Puget Sound. These small, schooling fish play a unique role in the food web: they are an essential source of food for larger fish, seabirds, and marine mammals, and as such, transfer energy from their plankton prey to these higher-level consumers.

Because they are a vital component of the marine food web, Pacific Herring are one key indicator of the overall health of Puget Sound. Herring stocks require clean water and natural shorelines, so their continued survival depends on maintaining links between nearshore and open-water habitats.

Although the number of herring in Central and Southern Puget Sound, while variable, has shown little trend over the past 40 years, the population of this genetically unique stock of Pacific Herring, the spring spawning Cherry Point stock in North Puget Sound, has declined by 90% since 1973.

Pacific Herring

INDICATOR:

Biomass of Spawning Pacific Herring

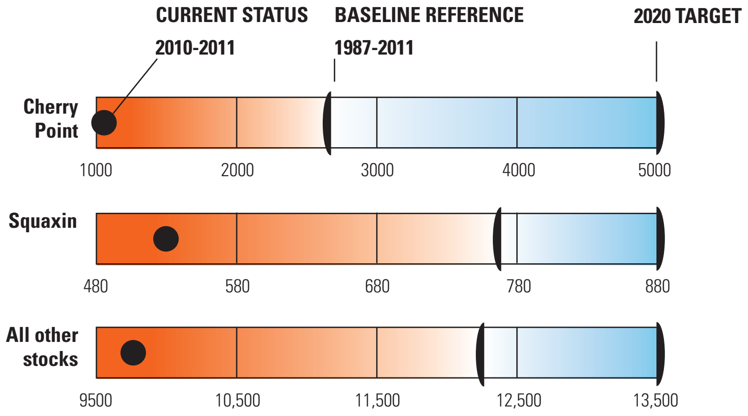
Indicator lead: Kurt Stick, Washington Department of Fish and Wildlife

TARGET:

Increase the overall amount of spawning herring throughout Puget Sound to about 19,000 tons. For each stock, the targets are: Cherry Point: 5000 tons; Squaxin Pass: 880 tons; all other stocks: 13,500 tons.

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**NO**



Please note the different scales for each stock

The spawning biomass of all herring stocks remain below their target values as well as their baseline reference, which is defined as the 25-year mean from 1987 to 2011.

Progress towards 2020 target

None of the 2020 target values for individual Pacific herring stocks or groups of stocks are met, and no progress has been made. Instead, the current spawning biomass of all stocks are below both their 25-year mean baseline reference and their 2020 target values (Figure 1).

The Cherry Point herring stock in North Puget Sound, once the largest stock in the Sound, has declined by 90% since the earliest sampling date in 1973 and shows little sign of recovery.

The Squaxin Pass and other Puget Sound stocks do not exhibit the sharp decline seen in the Cherry Point stock. Although they show broad annual fluctuations, these stocks are relatively closer to their target values. In fact, in some years, these stocks have gone above their target values. However, these stocks are currently at biomass levels below their target values (Figure 1).

Predicting the future condition of herring spawning biomass is difficult. Owing simply to natural fluctuations in abundance, the Squaxin and other Puget Sound stocks in Central and South Puget Sound may reach their respective target values again over the next eight years. However, there is no evidence to suggest that herring spawning biomass at Cherry Point will increase and reach its target value by 2020, or that the biomass of all other stocks will be sustained at or above their target values. Although potential threats have been identified, there is no consensus on which threats limit the stocks or how best to manage these stocks to achieve the 2020 target.

What is this indicator?

The spawning biomass of Pacific herring is the estimated annual tonnage of spawning herring in Puget Sound. Herring spawning biomass is currently based on spawn deposition surveys conducted by the Washington Department of Fish and Wildlife (WDFW) to estimate the quantity of eggs deposited by herring on marine vegetation. Egg abundance is then converted to the estimated biomass of spawning herring.

Reflecting genetic studies that have identified three separate groupings of Puget Sound herring stocks (Figure 2), the Partnership has established three separate targets for Cherry Point, Squaxin Pass and all other stocks combined. Estimates of spawning biomass have been attempted for all known Puget Sound herring stocks by WDFW annually since 1996, and for Cherry Point herring since the early 1970s. The baseline references, the 25-year mean biomass for each stock (1987 – 2011), are intended to provide perspective for the current status of each stock (the 2-year mean of 2010 and 2011) and the targets. The baseline reference and evaluation of current stock status reported here are not based on a conventional fishery stock assessment, which takes into account growth, maturity, fecundity, and mortalities.

Spawning biomass of Pacific Herring stocks in Puget Sound

In tons, 1973 - 2011

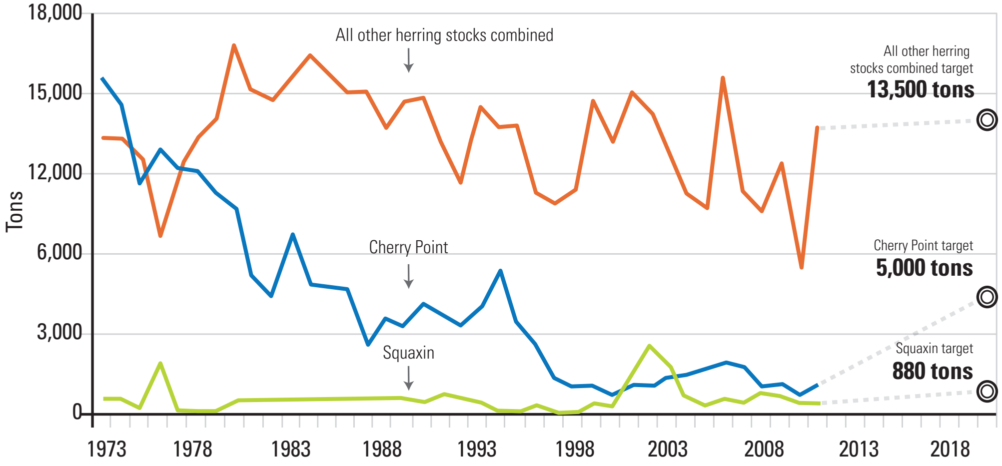


Figure 1. Annual estimates of Puget Sound herring spawning biomass, by genetic grouping (1973 to 2011) with associated targets.

Source: Washington Department of Fish and Wildlife, Fish Program

Pacific Herring

Interpretation of data

The Puget Sound herring data are characterized by broad year-to-year fluctuations, which is typical of Pacific herring populations and likely reflects natural environmental and demographic variability. Indeed, in Puget Sound the bulk of the biomass of the "all other stocks" grouping is contributed by different stocks in different years, further implicating the role of site-specific variability.

The exact causes of the Cherry Point decline are unknown, but it has been variously attributed to many potential factors such as chronic pollution (e.g., PCB and PAH contaminants), oil spills, overfishing, parasites, disease and changes in abundance of predators or prey. Changes to the natural shoreline, including nearby industrial construction and operation, also may play a role. Finally, the extent to which food-web interactions may limit herring populations, and how such interactions are mediated by the effects of climate change, are not well understood. Further studies are needed to elucidate the effect of these possible pressures.

Several factors contribute to difficulties in understanding Cherry Point stock declines and in the trends of other herring stocks, including survey methods and exploitation rate analysis.

Since 1973 at Cherry Point and 1986 for the rest of the stocks, WDFW has conducted a combination of spawn deposition surveys and Acoustic-Trawl (AT) surveys to estimate herring spawning biomass. Until 1996, the spawning biomass of the larger Puget Sound stocks typically was assessed by both methods each year while the smaller stocks were surveyed by spawn deposition surveys every three-years. Since 1996, the spatial coverage of both survey methods has been progressively reduced until the AT surveys were finally discontinued in 2009 due to budget reductions. Spawn deposition surveys and AT surveys each have their advantages depending on the size and type of substrate for eggs, therefore work at their best when used together.

In addition to spawning biomass, biological samples used to estimate growth, mortality, and recruitment were obtained from the AT surveys. These data which, are not currently being collected, are useful for assessing the stocks' population dynamics and capacity to meet the targets, and to understand the mechanisms driving these trends.

For example, for the Cherry Point and most other Puget Sound stocks, there has been a shift in the age structure of the population since the late 1970s and early 1980s towards younger fish, which probably affected their productivity and slowed down their recovery.

As mentioned above, not all spawning grounds/stocks have been surveyed every year. To complete the time series depicted in Figure 1, data gaps were filled in with the long-term average for the stocks with missing data. Given the importance of this indicator to the recovery of the Sound, monitoring methods and analysis should be reviewed and improved to more completely and accurately report status and trends.

Commercial exploitation of Puget Sound herring is limited to a bait fishery, which is allowed to take up to 10% of the cumulative Puget Sound spawning biomass of Central and South Puget Sound stocks. Landings in the past 10 years have ranged from 3 to 5% of this total and are not expected to increase significantly in the near future. This is a conservative exploitation rate, compared to a typical global exploitation rate of 20%. Although a 10% exploitation rate is precautionary, a more rigorous analysis of an appropriate exploitation rate, that accounts for current population dynamics (including age composition) and ecosystem needs (e.g., the extent of predator dependency on forage fish), is desirable to ensure sustainability of the Puget Sound herring stock.

Figure 2. Distribution of Pacific herring spawning grounds in Puget Sound.
Source: Washington Department of Fish and Wildlife, Fish Program.

Birds

A large community of aquatic and terrestrial bird species depend on Puget Sound's watershed for survival. Walk along the shores of Boundary Bay in any season, and you'll see an ever-changing cast of birds. Thousands of seabirds, seaducks, and waterfowl migrate from all directions to converge in the relatively calm and food-rich waters of Puget Sound each winter. In summer, colonies of seabirds are busy attending their young. In spring and fall, the shorelines are full of shorebirds that stop to feed and rest during migration.

Birds serve as useful indicators of ecosystem change and ecosystem health. The Partnership is currently working with the Washington Department of Fish and Wildlife, U.S. Geological Survey, and the Puget Sound Ecosystem Monitoring Program's Birds & Mammals workgroup to develop a meaningful marine and terrestrial bird indicator and potential targets to help achieve its recovery goal of healthy and sustaining populations of native species. Upon completion later this year, the Science Panel and Leadership Council will review the recommendations and make final decisions on the indicators and targets.

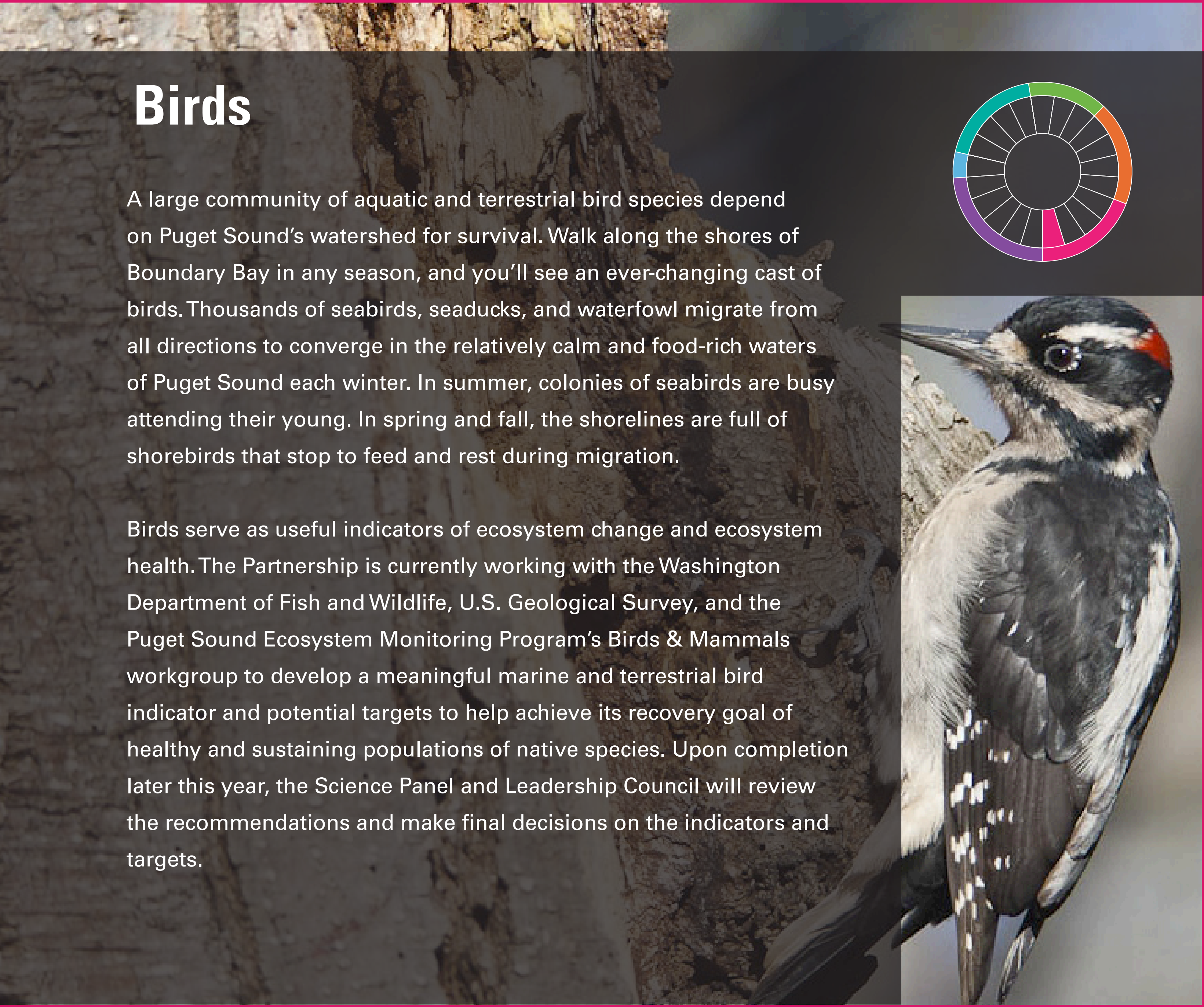
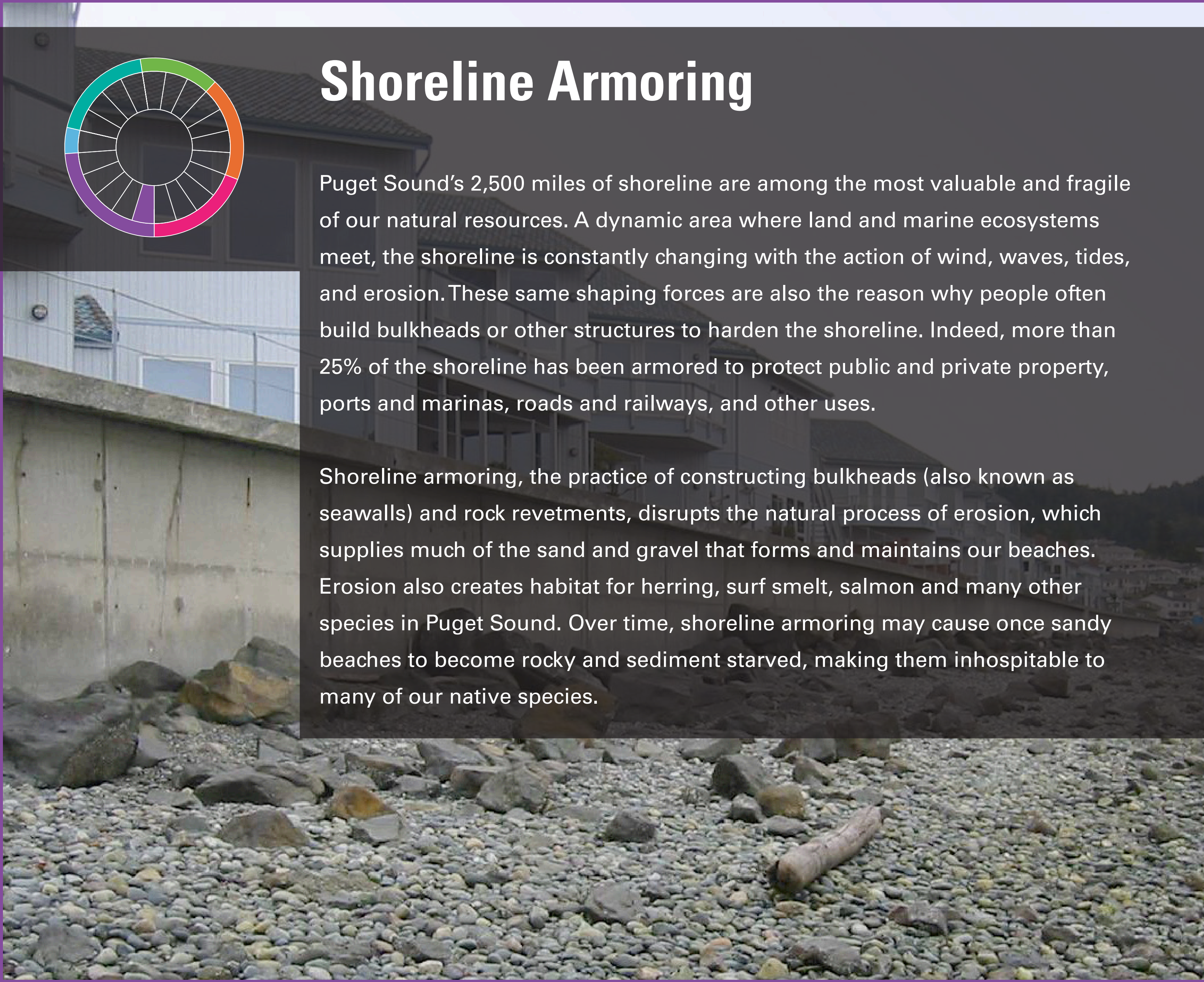


Photo Credit: Tom Talbot



Shoreline Armoring

Puget Sound's 2,500 miles of shoreline are among the most valuable and fragile of our natural resources. A dynamic area where land and marine ecosystems meet, the shoreline is constantly changing with the action of wind, waves, tides, and erosion. These same shaping forces are also the reason why people often build bulkheads or other structures to harden the shoreline. Indeed, more than 25% of the shoreline has been armored to protect public and private property, ports and marinas, roads and railways, and other uses.

Shoreline armoring, the practice of constructing bulkheads (also known as seawalls) and rock revetments, disrupts the natural process of erosion, which supplies much of the sand and gravel that forms and maintains our beaches. Erosion also creates habitat for herring, surf smelt, salmon and many other species in Puget Sound. Over time, shoreline armoring may cause once sandy beaches to become rocky and sediment starved, making them inhospitable to many of our native species.

Photo Credit: Hugh Shipman

Shoreline Armoring

INDICATOR:

Amount of shoreline armoring

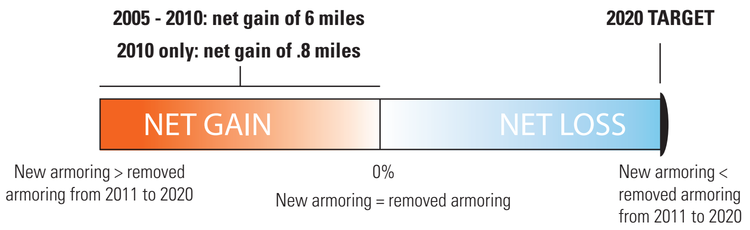
Indicator leads: Randy Carman, Washington Department of Fish and Wildlife and
Hugh Shipman, Washington Department of Ecology

TARGET:

From 2011 to 2020, the total amount of armoring removed should be greater than the total amount of new armoring in Puget Sound (total miles removed is greater than the total miles added).

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**UNKNOWN**



For years where data were available, 2005 through 2010, there was a net gain of six miles of shoreline armoring.

Progress towards 2020 target

The analysis of current progress is pending due to ongoing compilation and analysis of 2011 data. However, we can use data from 2005 through 2010 to report on status and trends of shoreline armoring and make some predictions about progress toward reaching the target by 2020.

The amount of new shoreline armoring in Puget Sound was substantially greater than the amount removed for every year from 2005 through 2010 (Figure 1). Cumulatively, a net amount (new armoring minus removed armoring) of six miles of new armoring was constructed during this time frame, or on average, one mile of additional armoring per year. This pattern of net gain in armoring is the opposite of what is needed to meet the 2020 target.

However, the net amount of armoring per year declined by roughly 50% over these six years. This result is driven by the fact that more and more armoring has been removed annually since 2005, while additions have remained fairly constant. A notable exception occurred during 2006 and 2007, when new construction was highest, perhaps due to significant storms and shoreline damage that occurred early in the period. Despite this, the general trend of new versus removed armor has shown some movement towards the target. Even so, the fact remains that new armoring in Puget Sound was four to 400 times greater than removals from 2005 through 2010, overwhelming the small advance in removing armoring.

Although more armoring was removed each year between 2005 and 2010, it will take significant progress on both: a) decreasing the amount of new armoring and b) increasing the amount of removed armoring to meet the target by 2020. If the recent pace of adding and removing armoring continues, an additional 10 miles of new armoring will be added to Puget Sound shorelines between 2010 and 2020, making it unlikely that the 2020 target will be met.

What is this indicator?

Although shoreline armoring is one of the indicators that measure the pressures on Puget Sound, rather than a measure of the state of the ecosystem such as the biomass of Pacific herring, it is an important indicator of ecological conditions in Puget Sound.

Shoreline armoring is the most common type of shoreline modification on Puget Sound. Armoring directly alters geologic processes that build and maintain beaches and spits. Bulkheads also impact erosion patterns on nearby beaches, alter beach substrate and hydrology, and reduce the availability of large wood.

These physical changes to beaches can diminish the availability and condition of key shoreline habitats. Armoring can also directly impact organisms and ecological processes by burying or displacing upper beach habitat and altering the natural transition between terrestrial and aquatic ecosystems. Impacts of armoring differ from one coastal setting to another, but have been demonstrated both on Puget Sound and elsewhere to impact habitat for fish, birds, and invertebrates.

Because of these adverse impacts on coastal processes and shoreline habitat, the goal is to decrease the amount of new armoring that occurs on Puget Sound, while also seeking opportunities to reduce armoring where feasible.

As new armoring is being constructed, concurrent efforts are deployed to remove armoring primarily for habitat restoration. Thus, it is the difference between new and removed armoring that is of interest to address the target specifically, reported here as the net amount of shoreline armoring. To reach the target, there has to be a net loss of armoring cumulatively over 2011 to 2020.

Alterations to the shoreline are regulated primarily by two state laws, the Shoreline Management Act and the Hydraulic Code. Under the Hydraulic

Puget Sound Shoreline Armoring Summary
2005–2010

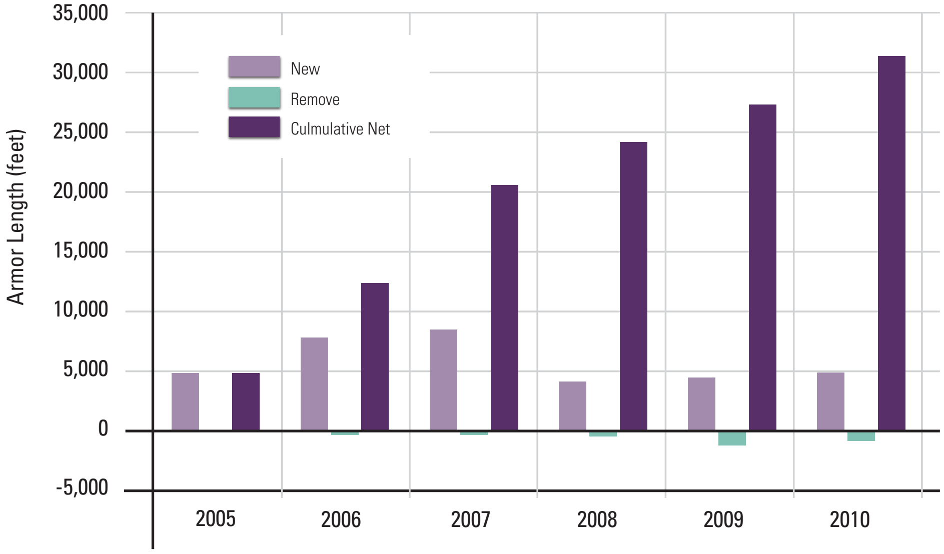


Figure 1. Amount of new armoring and removed armoring reported annually from 2005 to 2010 in Puget Sound, and the net amount of armoring accumulated since 2005. Data were compiled from the Hydraulic Project Approvals permits issued by the Washington Department of Fish and Wildlife.
Source: Washington Department of Fish and Wildlife, Habitat Program.

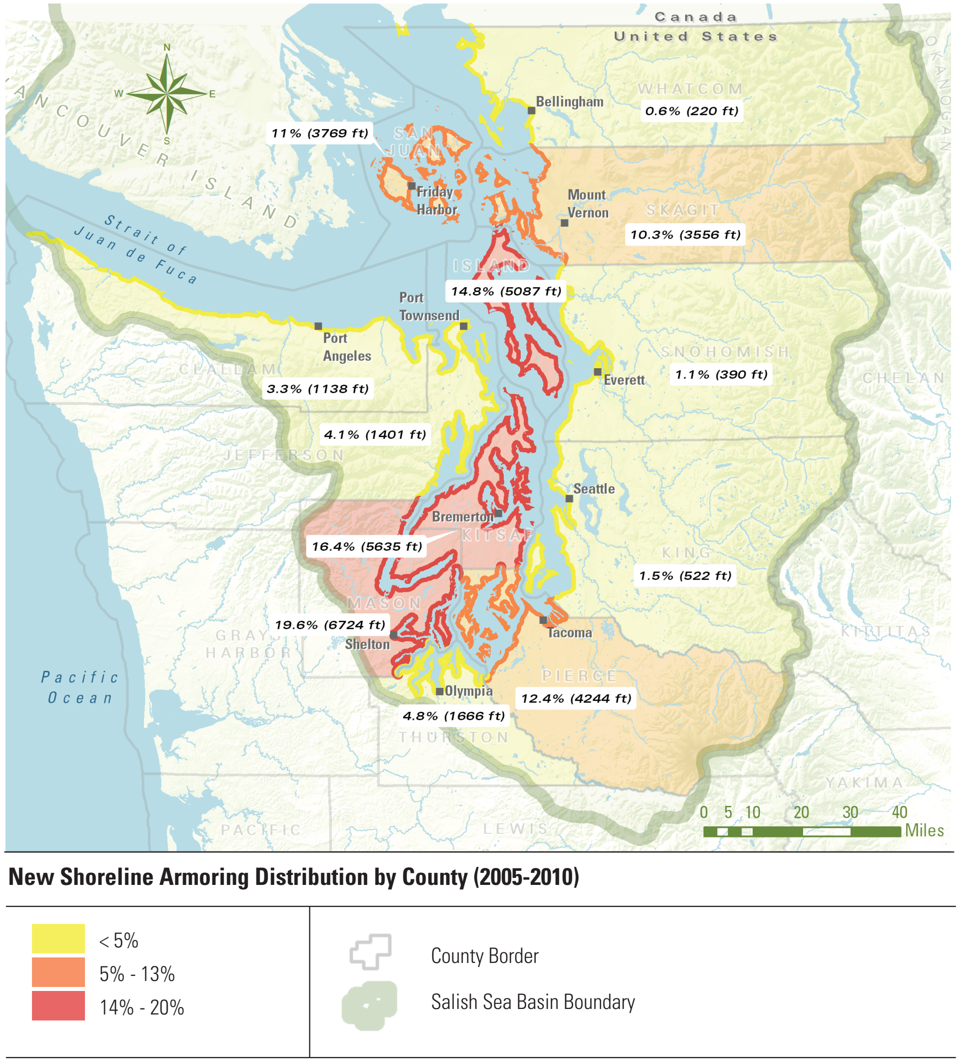
Shoreline Armoring

Code, project proponents seeking a permit for in-water and shoreline construction activities declare the amount of armoring they plan on adding, replacing, or removing in their application. Thus, data reported here were compiled from HPAs (Hydraulic Project Approval) issued from January 2005 through December 2010 by the Washington Department of Fish and Wildlife (WDFW). Projects were identified as: 1) new (previously unarmored shoreline), 2) replacement (complete replacement of existing armoring), and 3) removals (removal of existing armoring without replacement).

The Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) has been instrumental in compiling and reporting on changes to shorelines in Puget Sound over the past several decades. We relied on their data to report the length of shoreline and the overall amount of shoreline armoring in Puget Sound and by county.

Other targets

Part of the 2020 target for shoreline armoring includes a focus on preventing new armoring and reducing existing armoring on feeder bluffs that supply sediments to Puget Sound shorelines. Activities are currently in progress to complete mapping of feeder bluffs in Puget Sound, including the condition of the



New Shoreline Armoring Distribution by County (2005-2010)

Figure 2. Amount of new armoring, county by county, as a percent of all new armoring in Puget Sound, cumulatively between 2005 and 2010. The numbers in the boxes are the percent of all new armoring and the amount of new armoring in feet for each county.
Source: Washington Department of Fish and Wildlife, Habitat Program.

bluffs. Until the feeder bluff mapping project is completed, it will not be possible to report on the amount of new armoring added or removed on feeder bluffs.

Similar language in the 2020 target refers to the use of soft shore techniques for new and replacement armoring where feasible. Reporting on this metric is currently constrained by the lack of adequate agreement on what constitutes a true soft shore project. Progress is being made to address this issue as part of a design guidance document currently being developed by WDFW and a consultant.

A total of 980 HPAs were issued for shoreline armoring projects in Puget Sound from January 2005 through December 2010. In all years, the amount of new armoring exceeded the amount removed (Figure 1). Just in 2010, the last year for which data were available, there were approximately 4,869 feet (0.9 miles) of new armoring, six times more than the amount of armoring removed (Figure 1). Furthermore, the amount of armoring replaced greatly exceeded either new or removed armoring.

Cumulatively, a net total of six miles of armoring was added in Puget Sound from 2005-2010, or, on average, one mile of additional armoring per year.

Interpretation of data

Status and trends of Puget Sound wide armoring

Based on a compilation of a variety of data sources by the PSNERP, 27% of the shoreline of Puget Sound is armored (666 miles). Armoring is particularly extensive in highly developed residential, urban, or industrial centers. While most alterations to nearshore areas are heavily regulated, new and replacement shoreline armoring is still relatively commonplace for single-family residences, which accounted for more than three-quarters of the HPA permit applicants wishing to construct new armoring between 2005 and 2010 (Figure 3).

New shoreline armoring by applicant type

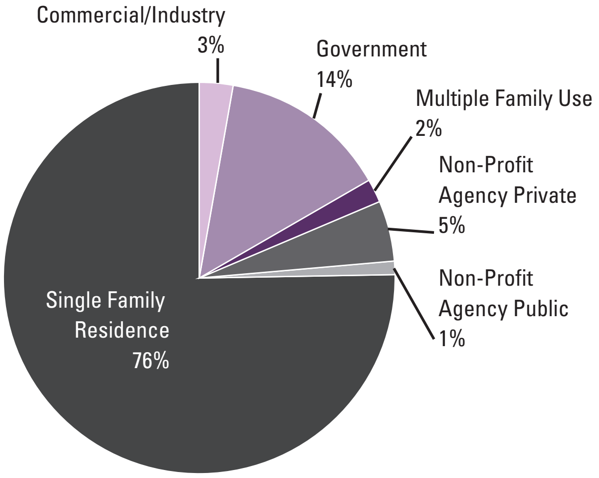


Figure 3. Percent of new armoring, by applicant type for years 2005-2010.

Armoring removal by applicant group

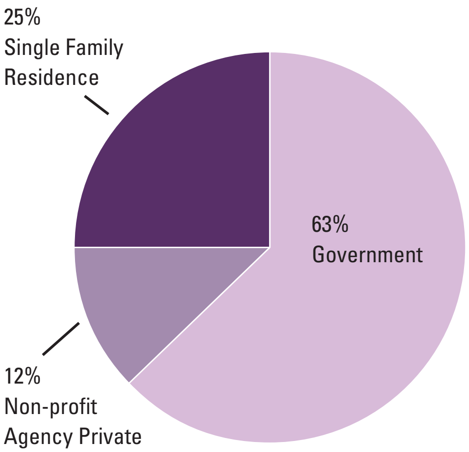


Figure 4. Percent of removed armoring, by applicant group for years 2005-2010.

Shoreline Armoring

Overall, all project applications resulted in 6.5 miles of new shoreline armor, 0.61 miles of armor removal, and 14.45 miles of replacement armor.

There were no statistically significant linear trends in the amount of new or replacement armoring constructed through the six-year period. However, the amount of removed armoring significantly and steadily increased over the study period, albeit at a very small fraction of new armoring.

Increases in removals coupled with a reduced amount of new armoring for the second half of this period meant that the net amount of armoring declined between 2005 and 2010. During the first three years, the total net increase in armoring was 20,397 feet, compared to a total of 10,736 feet during the last three years. This is a 47% decrease in net new armoring constructed between the first and second half of the six-year period.

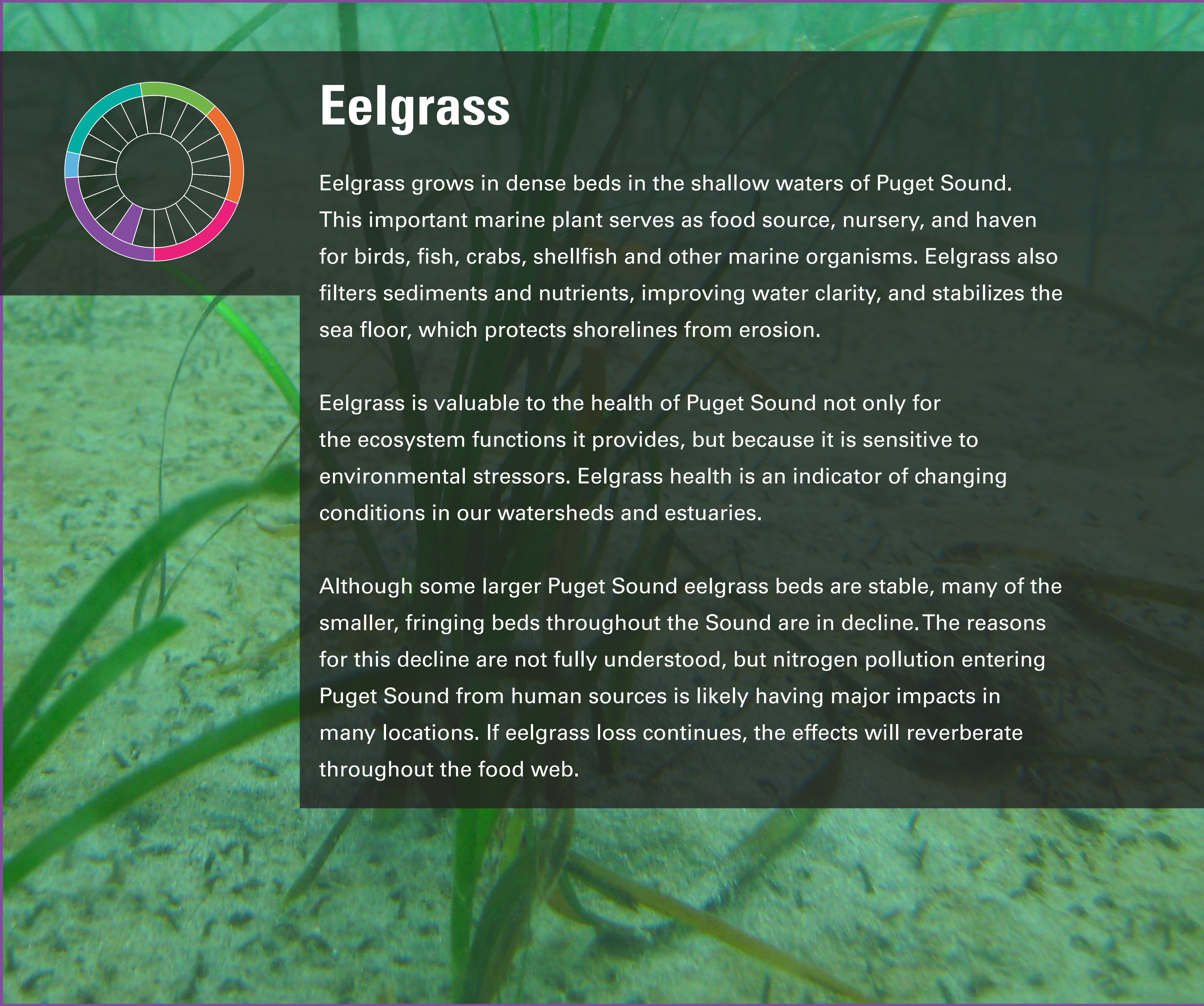
Armoring by counties

The total amount of shoreline armoring varies considerably across the twelve counties that border Puget Sound. Three counties account for nearly 50% of all the armoring in Puget Sound: King (13%), Pierce (18%), and Kitsap (16%) counties. These counties all have a high percentage of their shorelines armored: King 73%, Pierce 51%, and Kitsap 43%.

However, the HPA data revealed that most of the new armoring that was constructed between 2005-2010 has been concentrated in somewhat different areas (Figure 2). Mason, Kitsap, and Island counties had the highest percentage of the new armoring, comprising a total of 51%. Pierce, San Juan and Skagit counties also accounted for a substantial amount of the new armoring with a combined total of 34%. Therefore, six of the twelve counties in Puget Sound accounted for 85% of the new armoring from 2005 through 2010.

The same dataset indicates that armoring was removed in seven counties from 2005-2010. More armoring was removed in Kitsap County, totaling 1,873 feet (0.4 miles), than in any other county. A combined total of 1,353 feet (0.3 miles) was removed among the other six counties that included King, Pierce, Mason, San Juan, Island, and Jefferson. The remaining six counties in Puget Sound did not conduct any armor removal projects during the same time period.

The type of applicant that conducts new or armor removal projects was also compiled from the HPA data for years 2005-2010. Not surprisingly, most new armoring in Puget Sound (76%) was constructed on single family residence properties (Figure 3). In contrast, armor removal projects were primarily conducted on government properties (63%), whereas only 25% of the removals were on single family residential properties (Figure 4).



Eelgrass

Eelgrass grows in dense beds in the shallow waters of Puget Sound. This important marine plant serves as food source, nursery, and haven for birds, fish, crabs, shellfish and other marine organisms. Eelgrass also filters sediments and nutrients, improving water clarity, and stabilizes the sea floor, which protects shorelines from erosion.

Eelgrass is valuable to the health of Puget Sound not only for the ecosystem functions it provides, but because it is sensitive to environmental stressors. Eelgrass health is an indicator of changing conditions in our watersheds and estuaries.

Although some larger Puget Sound eelgrass beds are stable, many of the smaller, fringing beds throughout the Sound are in decline. The reasons for this decline are not fully understood, but nitrogen pollution entering Puget Sound from human sources is likely having major impacts in many locations. If eelgrass loss continues, the effects will reverberate throughout the food web.

Photo Credit: DNR Nearshore Habitat Program

Eelgrass

INDICATOR:

Eelgrass Area

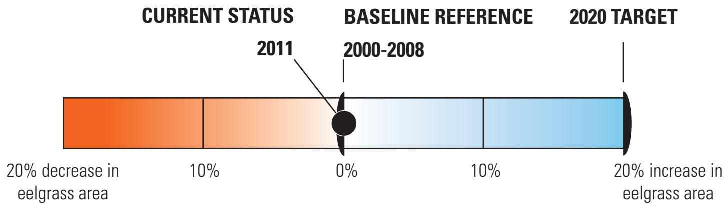
Indicator lead: Fred Short, Washington Department of Natural Resources

TARGET:

A 20% increase in the area of eelgrass in Puget Sound relative to the 2000–2008 baseline reference by the year 2020.

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**NO**



There was a 0% increase in eelgrass area in 2011 relative to the 2000-2008 baseline.

Progress towards the target

The sound-wide area of eelgrass measured in 2011 has not changed relative to the 2000-2008 baseline reference, and thus there has been no progress towards the eelgrass 2020 target. The overall finding is that the majority of sampling sites across the Sound show no gains in eelgrass area. Furthermore, sites with decreasing trends in eelgrass area greatly outnumber those with increases, a concern for the health of eelgrass beds around the Sound.

Monitoring information indicates that the goal to achieve 20% increase in eelgrass area by 2020 cannot be met with current management practices: the stresses on eelgrass in Puget Sound must be significantly reduced to see gains in eelgrass area and health.

What is this indicator?

Eelgrass is an important submerged marine plant growing throughout Puget Sound. Changes in the abundance or distribution of this resource reflect changes in environmental conditions.

Eelgrass and other seagrass species are used as indicators of ecosystem health throughout the world because they respond sensitively to many natural and human-caused environmental factors that affect water quality and shoreline conditions. These factors are also likely to affect many other species that depend on eelgrass habitat.

For example, excess nutrients, sewage, and algae can reduce water clarity, while storms, runoff and dredging can stir up sediment, preventing light from penetrating the water and reaching the eelgrass. Boat wakes, propellers, and docks can also disturb eelgrass beds.

Also, since eelgrass is protected by many regulations, its condition reflects, in part, the success of management actions. The Washington Department of Natural Resources assesses status and trends in eelgrass by evaluating eelgrass area and depth range at over 100 sites throughout Puget Sound annually, using a statistical sampling framework.

Two measures are used to demonstrate eelgrass status and trends in Puget Sound:

1. Sound-wide eelgrass area. The total area of eelgrass beds in Puget Sound.
2. Number of increasing, decreasing or stable eelgrass beds. Count of eelgrass gains and losses on a site basis.

Interpretation of Data

Measure 1: Sound-wide eelgrass area

Puget Sound supports roughly 22,600 hectares of eelgrass beds (Figure 1). Eelgrass distribution patterns vary by sub-basin, with two main types of eelgrass beds: narrow fringing beds and broad beds on shallow flats. Approximately 25% of the total eelgrass area occurs in only two embayments: Padilla and Samish Bays.

There was no significant increasing or decreasing trend in eelgrass area in 2011 relative to the 2000-2008 baseline, calculated as the weighed mean of eelgrass area in that time period (Figure 1).

Acres of Eelgrass in Puget Sound
in thousands, 2000-2008 baseline and 2009-2011 annual data

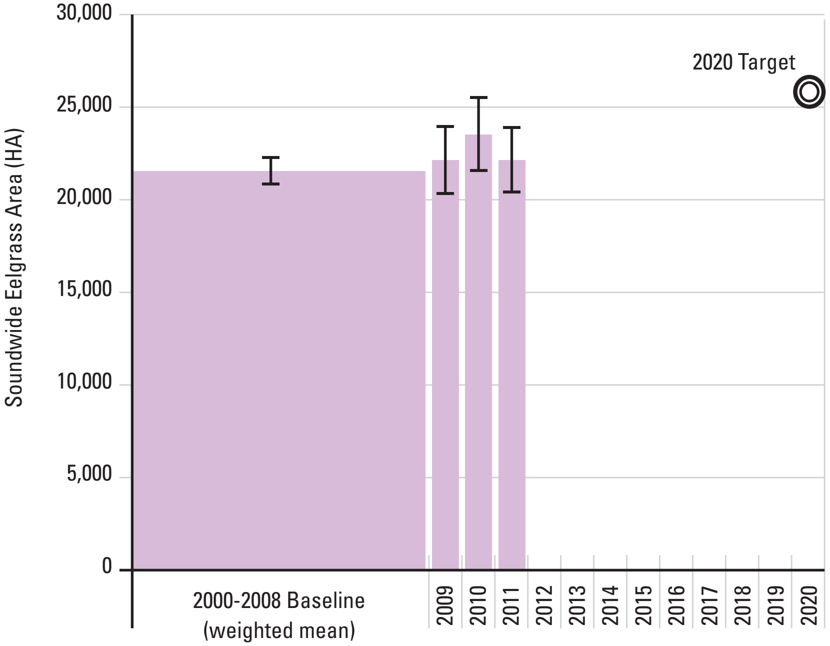


Figure 1. The annual estimates of Sound-wide eelgrass area for 2009-2011 compared to the baseline eelgrass area established by the Puget Sound Partnership and the Partnership's 2020 target for eelgrass area recovery. Mean ± standard error are shown.

Source: Washington Department of Natural Resources, Submerged Vegetation Monitoring Program

Measure 2: Count of eelgrass gains and losses on a site-by-site basis

A total of 211 sites are classified for eelgrass area trends. The majority of these sites are eelgrass beds where no change or trend in the size of the bed has been detected (170 sites; Figure 2).

However, there are more than twice as many sites where the size of the eelgrass bed decreased than sites that increased. Of all sites analyzed, there were five cases of total eelgrass loss. In no region do improving eelgrass sites outnumber declining eelgrass sites.

Eelgrass

Concerns about Hood Canal

Among the five eelgrass monitoring regions of Puget Sound, Hood Canal has the greatest number of sites where the amount of eelgrass decreased (Figure 3), including two sites where eelgrass beds completely disappeared. The Hood Canal region is a major concern particularly because many more eelgrass sites decreased (83%) than increased. Another region of concern is the Saratoga-Whidbey Basin where 71% of changing sites are in decline.

Several factors contribute to the eelgrass losses seen in Hood Canal. The deep fjord-like basin is stratified and has poor water circulation. Hood Canal is showing signs of eutrophication: excess nitrogen loading from human sources contributes to the formation of seaweed blooms, which are abundant along the shoreline and accumulate in eelgrass beds, stressing eelgrass and contributing to anoxic conditions. Such localized eutrophic conditions are evident throughout Puget Sound and pose a major threat to eelgrass and the health of the Sound.

Status of eelgrass sites in Puget Sound

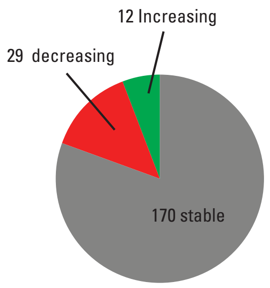


Figure 2. Number of sites in Puget Sound where the size of eelgrass beds increased, decreased, or remained stable since 2000.
Source: Washington Department of Natural Resources, Submerged Vegetation Monitoring Program

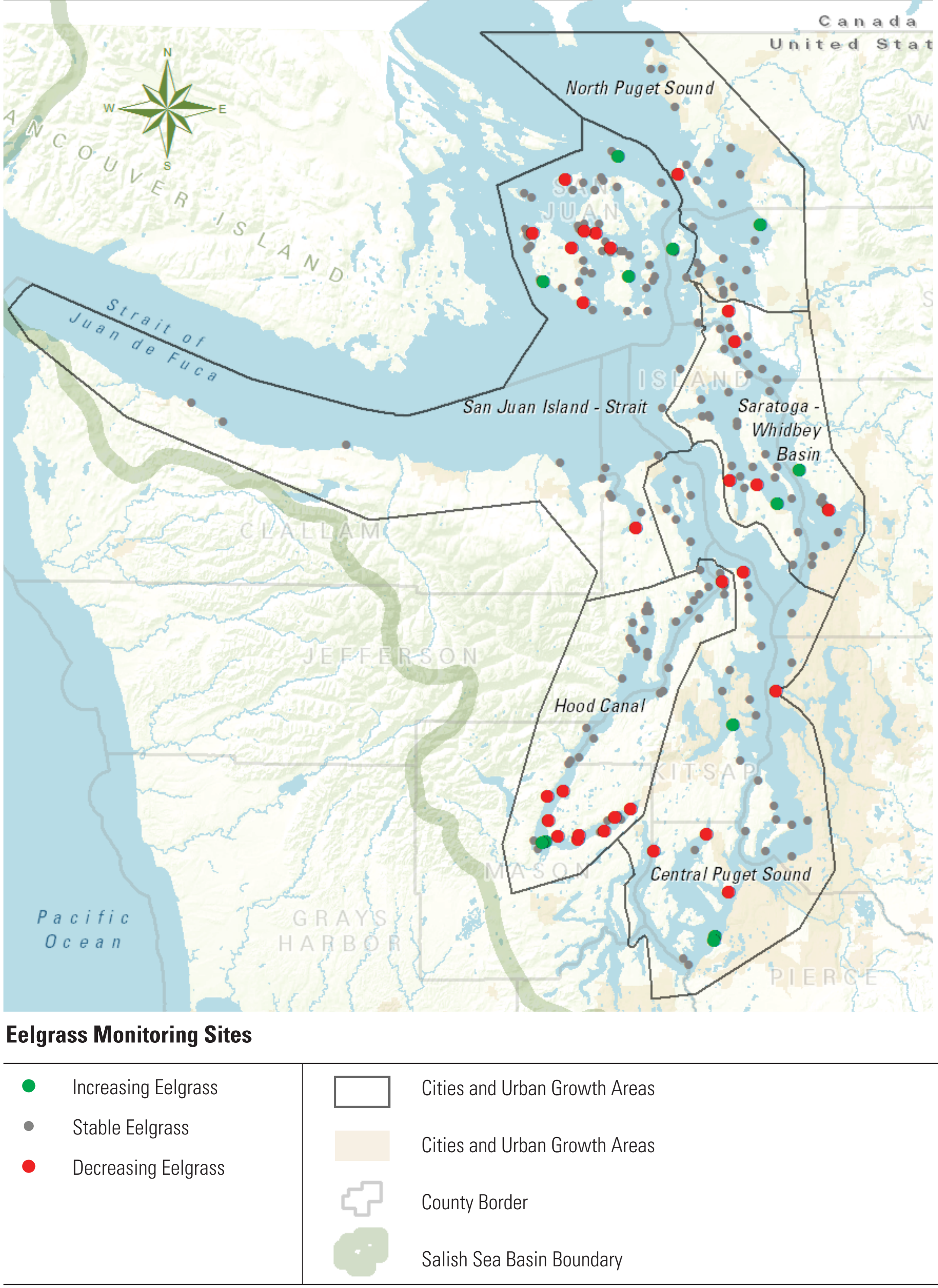


Figure 3. Distribution of eelgrass monitoring sites and their status.
Source: Washington Department of Natural Resources, Submerged Vegetation Monitoring Program

LOCAL STORY

Beachwatchers keeping an eye on the eelgrass

Washington State University Extension Island County Beach Watchers – Eelgrass Monitoring Project

Lush, subtidal beds of eelgrass provide habitat where snails and fish lay eggs, larvae thrive, crabs and forage fish reside, and young salmon seek shelter. Eelgrass dampens the impact of waves and resists the pressures of erosion. Knowledge about eelgrass in Island County is fueled by the Washington State University (WSU) Extension Island County Beach Watchers' Eelgrass Monitoring Project, which was born from a combination of university vision, knowledgeable and resourceful volunteers, a compelling question, and collaboration.

In the late 1990s, WSU Extension launched Beach Watchers to provide education, outreach, research and stewardship for the marine environment in Puget Sound and the Salish Sea. Since it inception, the program in Island County has trained more than 400 volunteers, and each year it records approximately 20,000 volunteer hours and monitors 30 beaches. In 2002, Beach Watchers turned attention to eelgrass in a membership survey. Information and educational materials about eelgrass continued. The combination of increased eelgrass awareness, knowledge of the marine environment and skillful observation fostered an important observation in 2007 when a Beach Watcher noted some eelgrass beds at Holmes Harbor had disappeared. The idea for the Eelgrass Monitoring Project soon followed. With funding from the Island County Marine Resource Committee, advice and assistance from the University of Washington Friday Harbor Labs and Washington State Department of Natural Resources (DNR), and a pilot study in 2008, the Eelgrass Monitoring Project was up and running at full-scale in 2009.

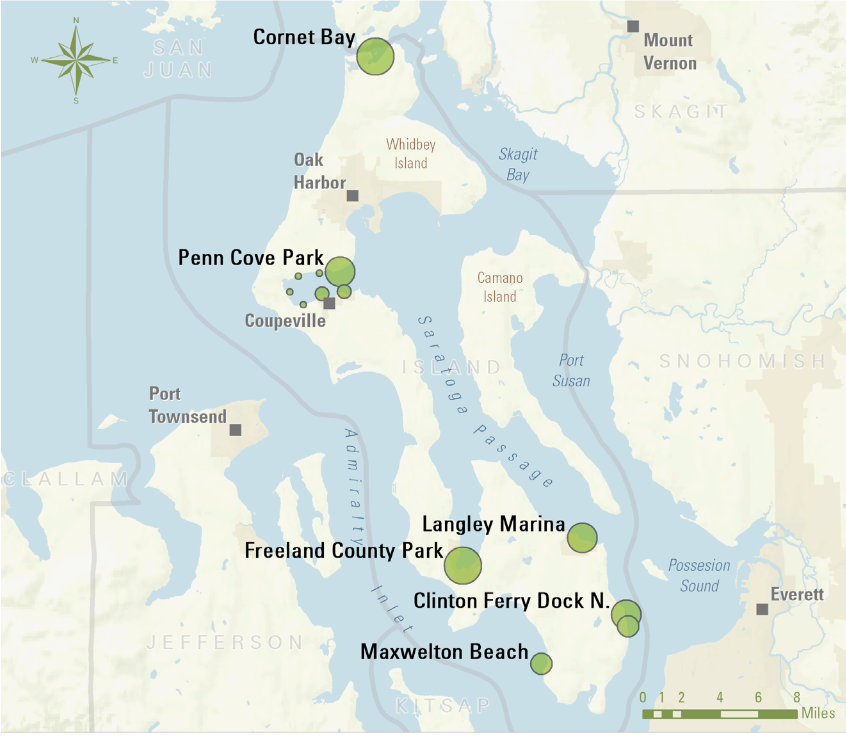
The Eelgrass Monitoring Project is conducted annually and includes three components– a boat survey using underwater videography to document presence and absence of eelgrass along DNR-specified transects perpendicular to the shoreline at ten sites, aerial photography during summer low tides to provide a broader look at eelgrass extent over a larger area, and a boots-in-the-muck survey to count eelgrass leaves, measure plant density and water temperature, and gather vegetation samples in Holmes Harbor. Since program inception, more than 50 volunteers have contributed more than 1000 hours to collecting eelgrass data.

Surveys in 2009 and 2010 confirmed extensive eelgrass beds

...more than 50 volunteers have contributed more than 1000 hours to collecting eelgrass data.

Photo from Island County Beachwatchers - need citation ▶

in Cornet Bay and Holmes Harbor. Damage to eelgrass beds was documented in Cornet Bay with the patterns suggesting possible damage from boating activities. Penn Cove surveys showed relatively few eelgrass beds with an unusual number of green sea urchins. Three years of study in Holmes Harbor point to eelgrass return and relatively stable beds since 2007 and suggest an unusual 2006-2007 winter storm from the north that coincided with an extreme low tide may have influenced the 2007 losses. Data from the eelgrass monitoring project are provided to DNR and are available on the Island County Marine Resource Committee's Sound IQ data system (www.iqmap.org/icSoundIQ/). These data on eelgrass, combined with other data on birds and mammals, intertidal habitats, fish distribution and more are contributing to the overall understanding of the nearshore ecosystem around Whidbey Island.

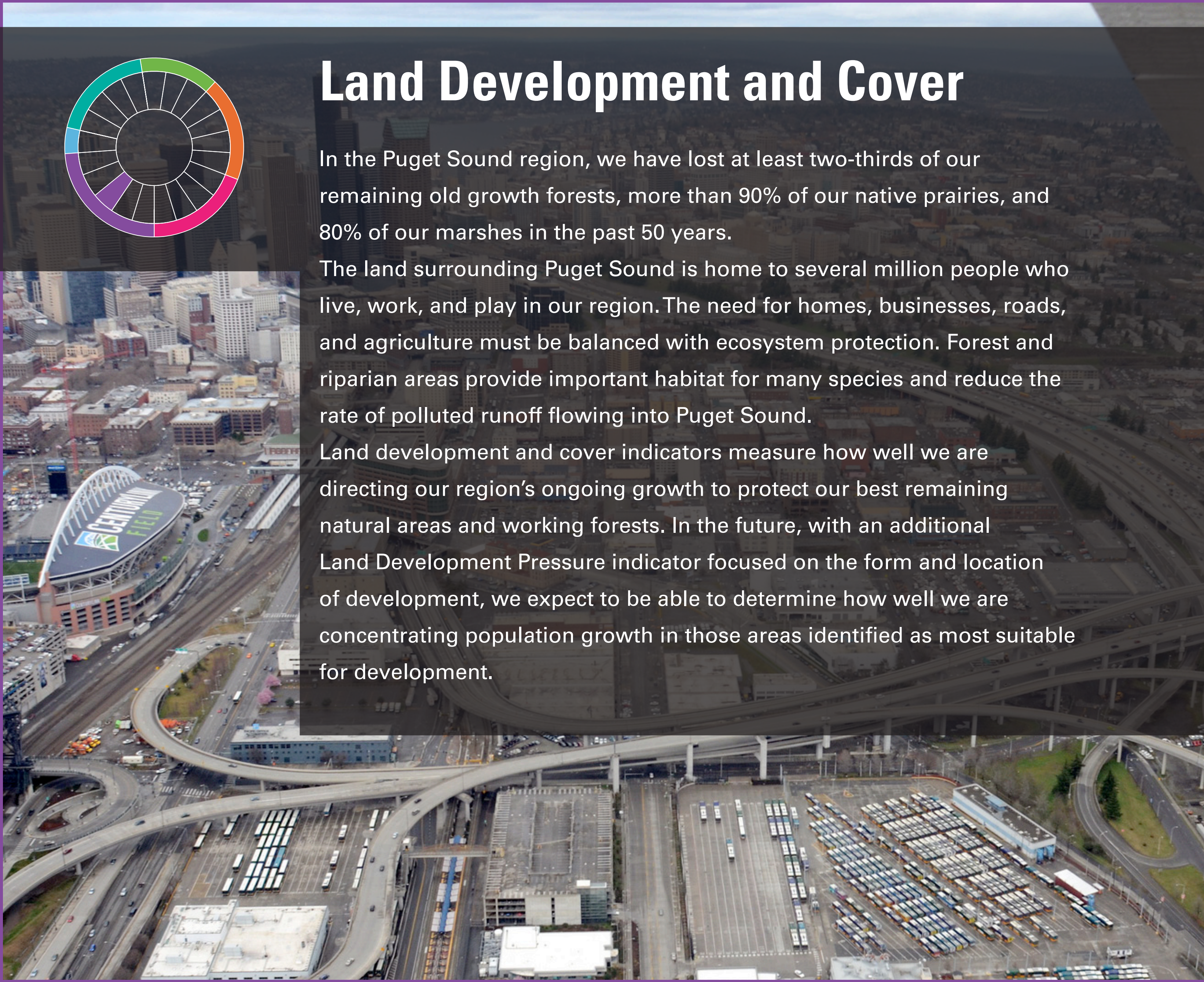


WSU Extension Island County Beach Watchers

2010 - 2011 Eelgrass Surveys

Estimated Bed Area (Acres)

- ● < 0.10
- ● 2.0 - 2.5
- ● 6.5 - 9.0
- ● 14.5 - 22.5
- ● 37.0 - 54.0
- ☐ County Border
- ▭ Salish Sea Basin Boundary
- ▨ Cities and Urban Growth Areas



Land Development and Cover

In the Puget Sound region, we have lost at least two-thirds of our remaining old growth forests, more than 90% of our native prairies, and 80% of our marshes in the past 50 years.

The land surrounding Puget Sound is home to several million people who live, work, and play in our region. The need for homes, businesses, roads, and agriculture must be balanced with ecosystem protection. Forest and riparian areas provide important habitat for many species and reduce the rate of polluted runoff flowing into Puget Sound.

Land development and cover indicators measure how well we are directing our region's ongoing growth to protect our best remaining natural areas and working forests. In the future, with an additional Land Development Pressure indicator focused on the form and location of development, we expect to be able to determine how well we are concentrating population growth in those areas identified as most suitable for development.

Photo Credit: Jon Bridgman, Puget Sound Partnership

Land Development and Cover

INDICATOR:

Land Cover Change: Forest to Developed

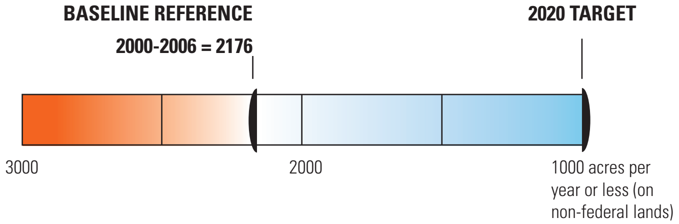
Indicator lead: Kenneth B. Pierce Jr. PhD, Washington Department of Fish and Wildlife

TARGET:

The average annual loss of forested land cover to developed land cover in non-federal lands does not exceed 1,000 acres per year, as measured with Landsat-based change detection.

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**UNKNOWN**



Baseline conversion rates: 2001-2006 conversion of forested cover to developed cover was 2,176 acres per year; 1992-2001 conversion of forested cover to developed cover was 5,048 acres per year. Information on the rate of conversion from 2006 to 2011 is expected to be available in 2013.

Progress towards 2020 target

The 2020 target has not yet been reached, and progress towards the target is unknown due to lack of data.

Non-federal Puget Sound basin forest was converted to developed cover at a rate of 2,176 acres per year for the period 2001-2006. Data needed to calculate an updated conversion rate for the period 2006-2011 were not yet available, but are expected in 2013.

Achievement of the 2020 target rate of 1,000 acres converted per year would represent a roughly 50% reduction from the 2001-2006 annual conversion rate, or an 80% reduction from the 1991-2001 conversion rate of 5,048 acres per year.

What is this indicator?

Forest conversion measures the loss of forested land cover to developed land cover. The indicator provides a check on our regional success in maintaining forest cover throughout the Puget Sound Basin.

Forested landscapes, as measured by forest cover, provide the following: 1) habitat functions that support terrestrial species, 2) watershed functions that support freshwater systems, and 3) provisioning and cultural services for humans.

Interpretation of data

Change in forested lands is monitored using NOAA analysis of satellite imagery to track change from forested land cover, including coniferous, deciduous, and mixed forest classes, to developed land cover using four classes of development intensity, on a five-year basis. Forest cover conversion in the Puget Sound basin has been consistently measured every four to five years since 1992 with the next results expected in late 2012 for change during the period 2006-2011.

The current trends and targets were set using land-cover change information for lands not in federal ownership as determined by the Landsat satellite imaging system. Due to image element limitations, this approach does not capture relatively small land use change, such as clearing for single homes or lot expansion, and therefore only larger events (more than two acres) are reliably captured in these values.

Land Development and Cover

INDICATOR:

Land Cover Change: Riparian Restoration

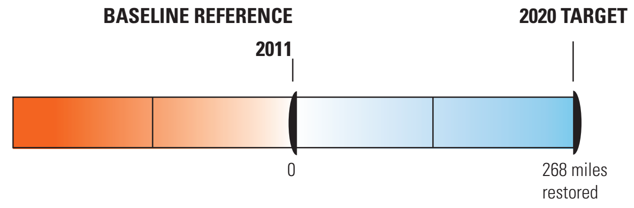
Indicator lead: Alex Mitchell, Puget Sound Partnership

TARGET:

Restore 268 miles of riparian vegetation or have an equivalent extent of restoration projects underway.

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**YES**



Nineteen projects conducted from October 2009 to September 2012 restored 76 miles riparian miles in the Puget Sound basin. This is 28 percent of the 2020 target of 268 miles.

Progress towards 2020 target

The 2020 target has not yet been reached. Habitat data collected by the Puget Sound Partnership on behalf the Environmental Protection Agency indicates that 19 riparian restoration projects were conducted in the Puget Sound basin from October 2009 through September 2012.

What is this indicator?

Riparian vegetation restoration measures the amount of new vegetated cover delivered by restoration projects along riparian corridors. It is intended to evaluate the effect of direct efforts to improve the health of a critical component of the Puget Sound ecosystem—riparian corridors. Intact, vegetated riparian corridors are critical for the following reasons: 1) keeping fresh and marine waters clean and cool, 2) for moderating variability in water volume and timing of flow (i.e. flood storage), and 3) as key habitat for myriad terrestrial, freshwater and interface (e.g. salmon) species.

The amount of riparian area restored to vegetated cover will be measured through collection of acreage or linear riparian shoreline restoration reported for Puget Sound restoration projects. Riparian restoration effort is being measured instead of riparian condition due to the difficulty in assessing riparian condition Sound-wide and the length of time necessary to call a specific location successfully restored. Although tracking total riparian condition is a much more difficult task than tracking regional forest cover, the initiation and completion of restoration activities are tractable measures. Successful restoration may take many years and measuring its success requires ongoing monitoring.

Interpretation of data

Recent restoration efforts in the Puget Sound basin have included 19 projects completed from October 2009 to September 2012 to restore riparian vegetation. These projects involved planting and other actions beyond treatment to remove invasive species. A project length was reported for 13 of the projects. The sum of these lengths is about 76 miles, which is 28 percent of the 2020 target. If the median project length were applied to the six projects with no length estimate provided, we would estimate that the total mileage restored in this three-year period at 86 miles, which is 32 percent of the 2020 target.

Data Source

Puget Sound Partnership staff analysis of data for federal fiscal years 2010, 2011, and 2012 primarily from the Recreation and Conservation Office's PRISM database and reports of Natural Resource Conservation Service (NRCS) habitat programs.

Land Development and Cover

INDICATOR:

Land Development Pressure: conversion of ecologically important lands

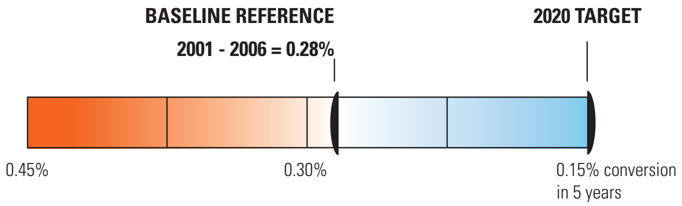
Indicator lead: Kenneth B. Pierce Jr., Washington Department of Fish and Wildlife
Kari Stiles, PhD, Puget Sound Institute, University of Washington

TARGET:

Basin-wide loss of vegetation cover on ecologically important lands under high pressure from development does not exceed 0.15% of the total 2011 baseline land area over a five-year period

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**UNKNOWN**



Baseline rate of change of 0.28% is equivalent to the proportion of total indicator land area converted from vegetated to developed cover for the five-year period of 2001-2006. Information on the rate of conversion from 2006 to 2011 is expected to be available in 2013.

Progress towards 2020 target

The 2020 target has not been met yet, and progress towards the target is unknown due to the lack of data, which will not be available until 2013. However, achieving the 2020 target will require reducing the conversion of ecologically important lands to development to just over one-half the rate of conversion observed in 2001 – 2006.

The five-year baseline rate of land cover change on the indicator base lands across all 12 counties in Puget Sound for the period 2001-2006 was 0.28% of the total indicator base land area. Similar analyses will be completed every five years to track change over the periods 2006-2011, 2011-2016, and 2016-2021.

What is this indicator?

The indicator tracks the conversion from vegetated cover to developed cover on undeveloped lands identified as ecologically important and under to high pressure from development for residential, commercial, and industrial uses. The indicator land base was identified in 2011as areas that have not reached maximum developed capacity, are not protected from development, and are identified as ecologically significant.

Because of the coarse-scale approach to defining ecologically important lands in the indicator land base, this indicator is appropriately used to identify broad regional trends. This indicator's results are not intended for use in local decision-making, permitting or planning.

This indicator provides a regional measure of the effectiveness of local jurisdictions' efforts to direct growth away from undeveloped ecologically functional areas. Specifically, the indicator provides a measure of the success of local governments in identifying and protecting ecologically significant and intact lands within and outside of Urban Growth Areas, a priority strategy in the Puget Sound Action Agenda.

It is also an indicator, though perhaps a weaker one, of how effectively local jurisdictions are using or incorporating landscape characterization methods, or other ecologically based information, into their land use decision-making.

Interpretation of data

A 12-county analysis of Puget Sound basin land cover change indicates a loss of vegetative cover on 0.28 % of the indicator land base (2,996 of 1,084,785 acres) over the period 2001-2006 (Table 1). In contrast, only 0.02% of important ecological lands under low pressure from development (1,140 of 5,737,559 acres) were converted for the same five-year period. Lands of low ecological importance were converted at a rate of roughly 1% per five years, or 0.92% and 1.09% for high and low development pressure lands, respectively.

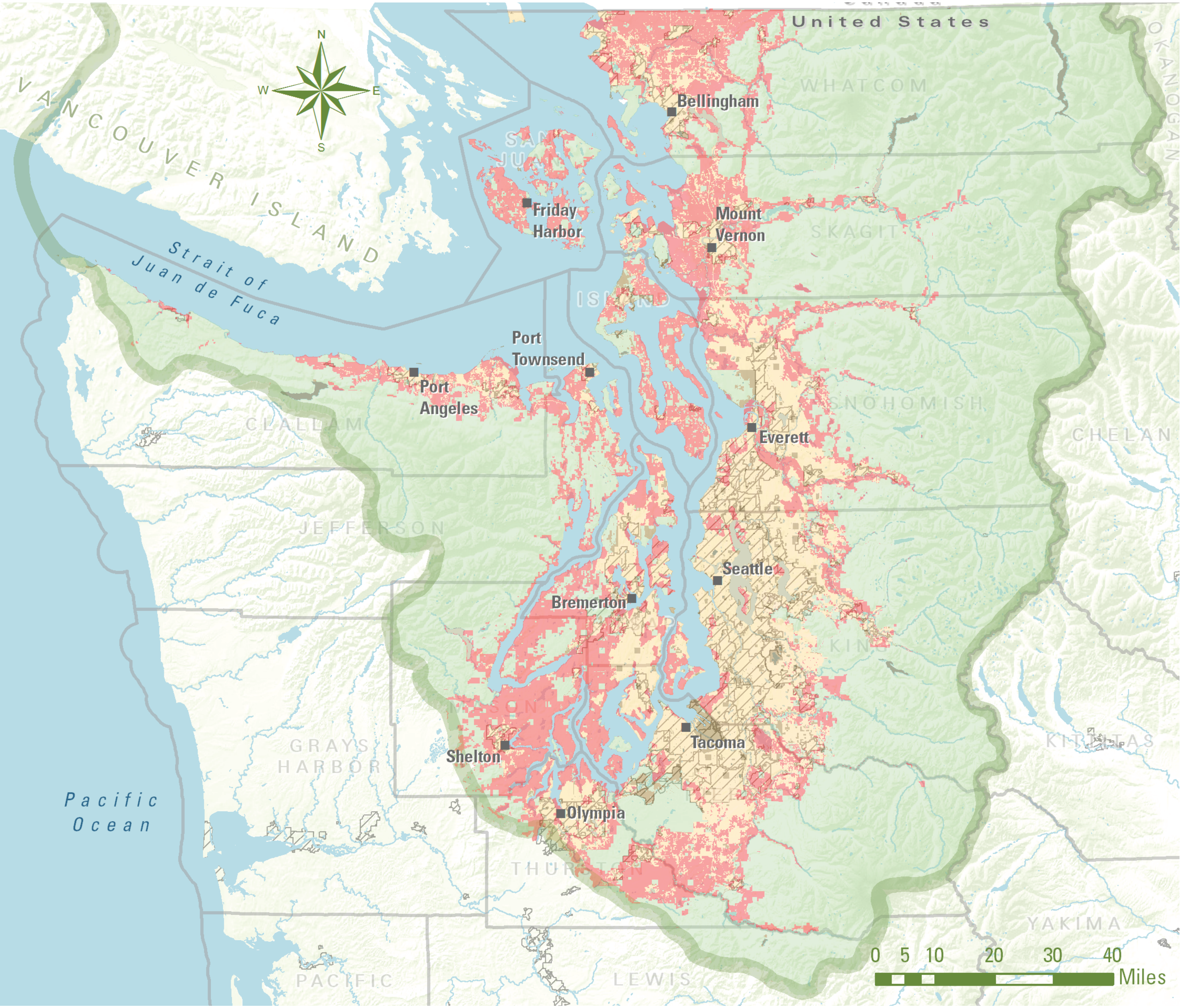
Overall, the indicator land base represents 13% of total Puget Sound land area. The remaining land area includes 68% of high ecological importance but under low pressure from development, 13% of lands under high pressure from development but of low ecological importance, and 7% of low ecological importance and under low pressure from development.

Conversion of indicator lands represents 15% of total land conversion in Puget Sound for period 2001-2006. An additional 6% of land conversion occurred on lands that are of high ecological importance but classified as low pressure from development. About 80% of land conversion for this five-year period occurred on lands classified as low ecological importance, with 50% and 30% conversion happening on high and low development pressure lands, respectively.

Land cover change from a vegetated class to a developed class over the period 2001-2006 in twelve Puget Sound counties

Land Base Type	Land area (proportion of total Puget Sound land area)	Area converted 2001-2006 (acres)	Proportion of area converted 2001-2006	Proportion of total Puget Sound 2001-2006 conversion
Indicator Land Base **high ecological importance,** **high development pressure**	1,084,785 (12.8%)	2,996	0.28%	14.7%
high ecological importance, **low development pressure**	5,737,559 (67.6%)	1,140	0.02%	5.6%
low ecological importance, **high development pressure**	1,101,134 (13.0%)	10,136	0.92%	49.8%
low ecological importance, **low development pressure**	558,315 (6.6%)	6,077	1.09%	29.9%
TOTAL	**8,481,793**	**20,349**	**0.24%**	

Table 1. Land cover change from a vegetated class to a developed class over the period 2001-2006 in twelve Puget Sound counties.
Source: Washington Department of Fish and Wildlife


United States
N
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Friday Harbor
Mount Vernon
SKAGIT
VANCOUVER ISLAND
Strait of Juan de Fuca
ISLAND
Port Townsend
Port Angeles
CLALLAM
SNOHOMISH
Everett
CHELAN
OKANOGAN
JEFFERSON
Seattle
Bremerton
KING
KITTITAS
Tacoma
Shelton
GRAYS HARBOR
Pacific Ocean
Olympia
THURSTON
YAKIMA
LEWIS
PACIFIC
0 5 10 20 30 40
Miles

◂ Ecologically important base lands under high pressure from development in Puget Sound

🟥	High Development Pressure: Higher Ecological Importance	▨	Cities and Urban Growth Areas
🟨	High Development Pressure: Lower Ecological Importance	☐	County Border
🟩	Low Development Pressure: Higher Ecological Importance	🟩	Salish Sea Basin Boundary
🟫	Low Development Pressure: Lower Ecological Importance		

Figure X. Caption forthcoming.
Source: Forthcoming

Land Development and Cover

INDICATOR:

Land Development Pressure: proportion of basin-wide population growth distribution within Urban Growth Areas (UGAs)

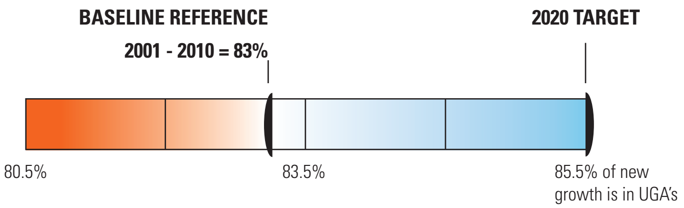
Indicator lead: Kenneth B. Pierce Jr., Washington Department of Fish and Wildlife
Kari Stiles, PhD, Puget Sound Institute, University of Washington

TARGET:

Basin-wide loss of vegetation cover on ecologically important lands under high pressure from development does not exceed 0.15% of the total 2011 baseline land area over a five-year period.

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	UNKNOWN



Based on basin-wide census data from 2000-2010, 83% of new growth occurred in UGAs.

Progress Towards 2020 Target

The 2020 target has not been met yet, and progress towards the target is unknown because the status for this indicator has not been updated since 2011 when analysis was completed to establish an indicator baseline and 2020 recovery targets.

The 2020 recovery target established a basin-wide goal of 86.5% of population growth occurring within UGAs, equivalent to a 3.5% increase in the proportion of new population growth occurring within all Puget Sound UGAs, and a minimum goal of increasing the proportion of growth occurring within UGAs in all counties. This target represents an ambitious basin-wide goal to direct more growth to those areas deemed best suited for development, while also respecting that Puget Sound includes very urban as well as very rural counties with very different growth management needs and objectives.

What is this indicator?

The indicator tracks the conversion from vegetated cover to developed cover on undeveloped lands identified as ecologically important due to high pressure from development for residential, commercial, and industrial uses. The indicator land base was identified in 2011-2012 as areas that have not reached maximum developed capacity, are not protected from development, and are identified as ecologically significant.

Because of the coarse-scale approach to defining ecologically important lands in the indicator land base, this indicator is appropriately used to identify broad regional trends. This indicator's results are not intended for use in local decision-making, permitting or planning.

This indicator provides a regional measure of the effectiveness of local jurisdictions' efforts to direct growth away from undeveloped

Percent of population growth occurring within UGA's

County	% pop growth occurring within UGAs (2000-2010)
Clallam	47%
Island	40%
Jefferson	28%
King	101%*
Kitsap	**65%**
Mason	**28%**
Pierce	**85%**
San Juan	**37%**
Skagit	**83%**
Snohomish	**92%**
Thurston	**50%**
Whatcom	**78%**

Table 1. Baseline counties, 2000-2010
Source: TBD

* This number reflects new growth occurring within UGAs and migration of some existing population into UGAs.

Interpretation of data

Washington population data, based on 2010 U.S. Census data, was used for the baseline analysis of population growth distribution for UGAs and rural areas between 2000 and 2010 (Table 1). Basin-wide, 83% of new population growth from 2000 to 2010 occurred within UGAs. For individual counties, the proportion of growth occurring within UGAs ranged from a low of 28% for Mason and Jefferson counties to highs of 92% and 101%* for Snohomish and King counties, respectively.

This indicator will not be updated until U.S. Census data are next available in 2020. However, in between the ten-year census, the American Community Survey conducted by the U.S. Census, although less accurate than the census, can be used as surrogate population data to generate intermediate measures of population growth distribution.

A related measure provides information about more recent trends in development patterns in the region and suggests that new development is increasingly occurring within UGAs. The proportion of permits for new development within UGAs for five central Puget Sound counties increased at an average rate of 0.85% per year from 2001 to2010, as compared to a 0.35% average annual increase that would be needed to meet the 202 recovery target. While permit activity does not correlate exactly to population increase, these reports provide an indication of progress (in a six county area) toward the 2020 recovery goal of an increasing proportion of population growth with UGAs.

Number of people within and outside UGAs from 2000-2010

	2010 population	2000-2010 Total New Population	% new population within UGA 2010	% New Growth (2000-2010) occurring within UGA
Clallam	64,262	7,546	50.0%	47%
Island	78,506	7,878	30.9%	40%
Jefferson	28,605	3,532	41.4%	28%
King	1,931,249	195,569	93.6%	101%
Kitsap	251,133	20,418	62.1%	65%
Mason	60,699	13,931	27.1%	28%
Pierce	795,225	95,538	82.5%	85%
San Juan	15,769	1,986	21.6%	37%
Skagit	116,901	14,608	67.6%	83%
Snohomish	713,335	107,775	83.0%	92%
Thurston	252,264	76,584	67.6%	50%
Whatcom	201,140	35,034	67.4%	78%
Basin-wide	4,509,088	580,399	81.7%	83%

Table 2. Number of people within and outside UGAs from 2000 – 2010, both at the county level and basin-wide*
Source: Washington Department of Fish and Wildlife

Floodplains

Floodplains work like giant sponges. As rains increase with fall storms and snowpack melts in the mountains in spring and early summer, waters in the rivers around Puget Sound rise and flood onto the low-lying land along the rivers and streams. In addition to absorbing this overflow, floodplains provide functions and services like refuge, food and fresh water for a variety of species, good agricultural land through soil and habitat formation, and flat land that supports a variety of human uses.

Unfortunately, the functions and services in large areas of floodplains in Puget Sound have been lost through a combination of shoreline armoring and levees, as well as residential, commercial, industrial, and agricultural development. Improving riverside and floodplain habitat is a key part of virtually all recovery plans for endangered salmon. Restoration and better management of floodplains are essential for both recovering salmon and Puget Sound.

Photo Credit: AVGeekJoe@flickr

Floodplains

The Leadership Council set two 2020 targets for floodplains:

1. Restore, or have projects underway to restore, 15% of Puget Sound floodplain area.

2. Have no net loss of floodplain function in any watershed.

What is this indicator?

Currently there is no agreed-upon definition of a floodplain. A working group comprised of floodplain experts is late developing definitions and data for this target, which will be available in 2012.

Although floodplains data are under development, based on other studies the National Oceanic and Atmospheric Administration (NOAA) estimates that almost three-quarters of wetlands have been lost in Puget Sound, the vast majority of which occurred in floodplains. Floodplains functions and services have been lost through a combination of shoreline armoring, levees, and residential, commercial, industrial, and agricultural development.

Estuary Restoration

River delta estuaries form where river floodplains meet the sea, creating a unique and important environment where freshwater mixes with salt water and sediments collect. A diverse array of specially-adapted plants and animals thrive and take advantage of the fertility there, moving in and out with the tides. Estuaries provide important feeding and resting habitat for young salmon, migratory birds, and many other species that cannot find these unique benefits in any other place in our landscape. For example, young salmon that can rear longer in delta estuaries grow faster and are more likely to survive their ocean migration.

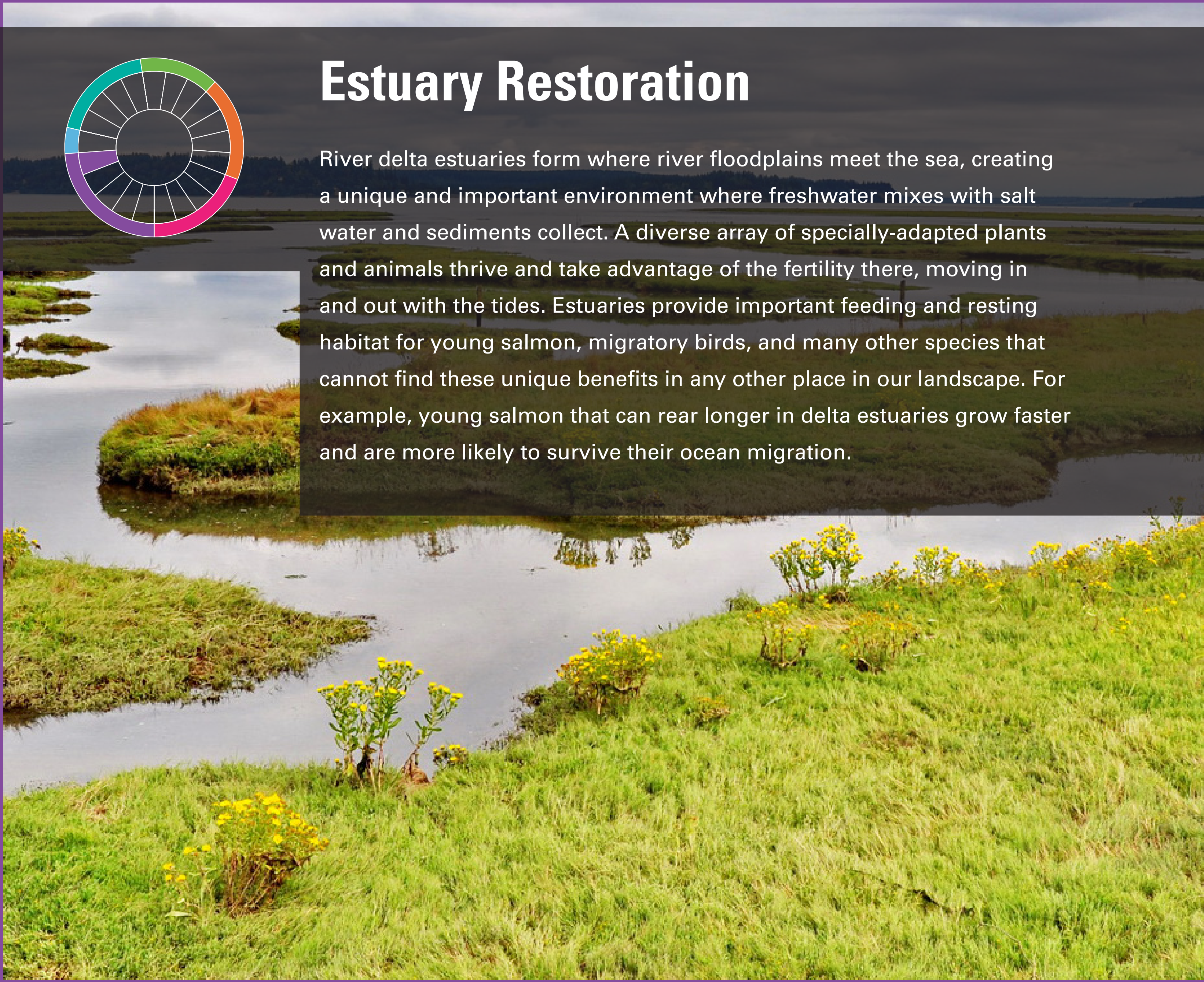


Photo Credit: Jim Culp

Estuary Restoration

INDICATOR:

Estuary Restoration

Indicator lead: Paul Cereghino (NOAA Restoration Center)

TARGET #1:

By 2020, all Chinook natal river deltas meet 10-year salmon recovery goals (or 10% of restoration need as proxy for river deltas lacking quantitative acreage goals in salmon recovery plans)

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	N/A

Salmon recovery plans are in the process of being updated, and measurable restoration goals are being defined.

INDICATOR:

Estuary Restoration

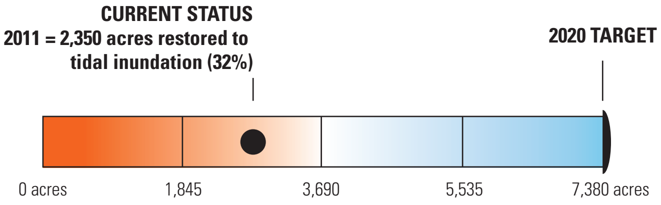
Indicator lead: Paul Cereghino (NOAA Restoration Center)

TARGET #2:

7,380 quality acres are restored basin-wide, which is 20% of restoration need.

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	YES


CURRENT STATUS
2011 = 2,350 acres restored to tidal inundation (32%)

2020 TARGET

As of 2011, approximately 2,350 acres of estuary lands have been restored to tidal inundation since 2006.

Progress towards the 2020 target

Neither of the two 2020 targets for estuaries have been met yet, but there has been progress on target 2 (number of quality acres restored). Although this may indicate progress towards salmon recovery goals, progress towards target 1 cannot be measured because recovery plans are in the process of being updated, and measurable restoration goals are being defined.

Approximately 2,350 acres of estuary lands have been restored to tidal inundation in the 16 major Puget Sound river mouth estuaries (Figure 1). Data summarized here are provisional because each watershed characterizes estuary restoration differently. The Partnership is working with other agencies and watershed groups to standardize how estuary restoration is measured and reported.

Significant restoration work has been implemented in the Nisqually, Skokomish, and Quilcene river delta systems, restoring a large proportion of area historically subject to tidal flooding. Substantial projects have also been completed in the Nooksack, Skagit, Snohomish, and Stilliquamish estuaries, but these remain modest when compared to the original historic extent of these larger river delta systems. Smaller projects have been completed in two deltas that are among the least degraded in Puget Sound: the Duckabush and the Dosewallips.

The Duwamish and the Puyallup river deltas, two of the most industrialized in Puget Sound, have seen substantial activity associated with Natural Resource Damage Assessment efforts. But acreage gains there are modest in terms of restoring tidal inundation, and there are fewer options in those highly developed systems compared to some levee and dike setback opportunities in less developed systems.

Estuary acres restored to tidal inundation by year

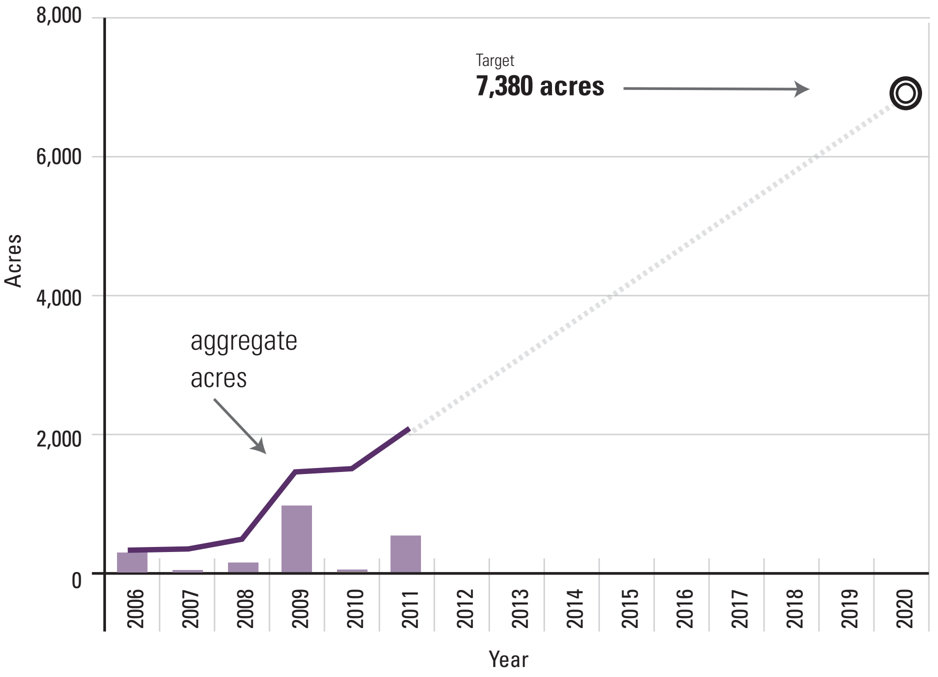


Figure 1. Approximate acres of estuarine lands where tidal flow has been restored for projects completed between 2006-2011 in the 16 major Puget Sound river mouth estuaries (data for 2009 includes the Nisqually estuary refuge restoration project of 762 acres). Columns show annual amounts, and the line shows the cumulative acres.

Source: National Estuary Program Online Reporting Tool (NEPORT), Environmental Protection Agency

Estuary Restoration

What is this indicator?

The estuary restoration indicator tracks the amount of land returned to a natural pattern of tidal inundation. Until more robust measures become available, we generally assume that restoring tidal flooding to historic estuarine lands will improve the natural habitat functions and productivity of those lands.

Many estuarine restoration projects have been undertaken in Puget Sound. However, they have been planned, funded, and implemented over a decade or more by many different organizations, including local governments, state and federal agencies, watershed groups, tribes, and private organizations and landowners. Unfortunately, project reporting is scattered and inconsistent, mapping and survey methods are not standardized, and the accuracy of completed ("as-built") project reporting is highly variable.

Consequently, the data reported here represent only a rough estimate of the actual area treated. Project reporting has been subject to considerable variability over the years, and our results were obtained from several different and inconsistent databases designed to collect project data (including PRISM, Habitat Work Schedule, and NEPORT). Efforts are currently underway to standardize how estuarine restoration efforts are reported and characterized. The intent is to eliminate inconsistencies and gaps in data and improve our ability to track actual net gains and losses of estuarine habitat.

Interpretation of data

Historic trends

In Puget Sound there are 16 large river-mouth estuaries: nine larger deltas drain the Cascade Mountains, and seven smaller deltas drain the Olympics. These estuaries and wetlands were a cornerstone of the Puget Sound ecosystem and served as a critical nursery for historically large populations of now-threatened Pacific salmon.

Over the last 150 years, the region has suffered dramatic losses of intertidal wetlands. Of the approximately 62,000 acres of mapped historical swamp and marsh, only an estimated 14,640 acres remain. The swamps of the Skagit and Snohomish once contained over 37,000 acres alone (compared to around 1,620 acres for all the Olympic deltas combined). In the most highly developed river mouth estuaries, such as the Duwamish and Puyallup Rivers, estuarine habitat has been reduced to only a minute fragment of its original extent, and may never be recovered.

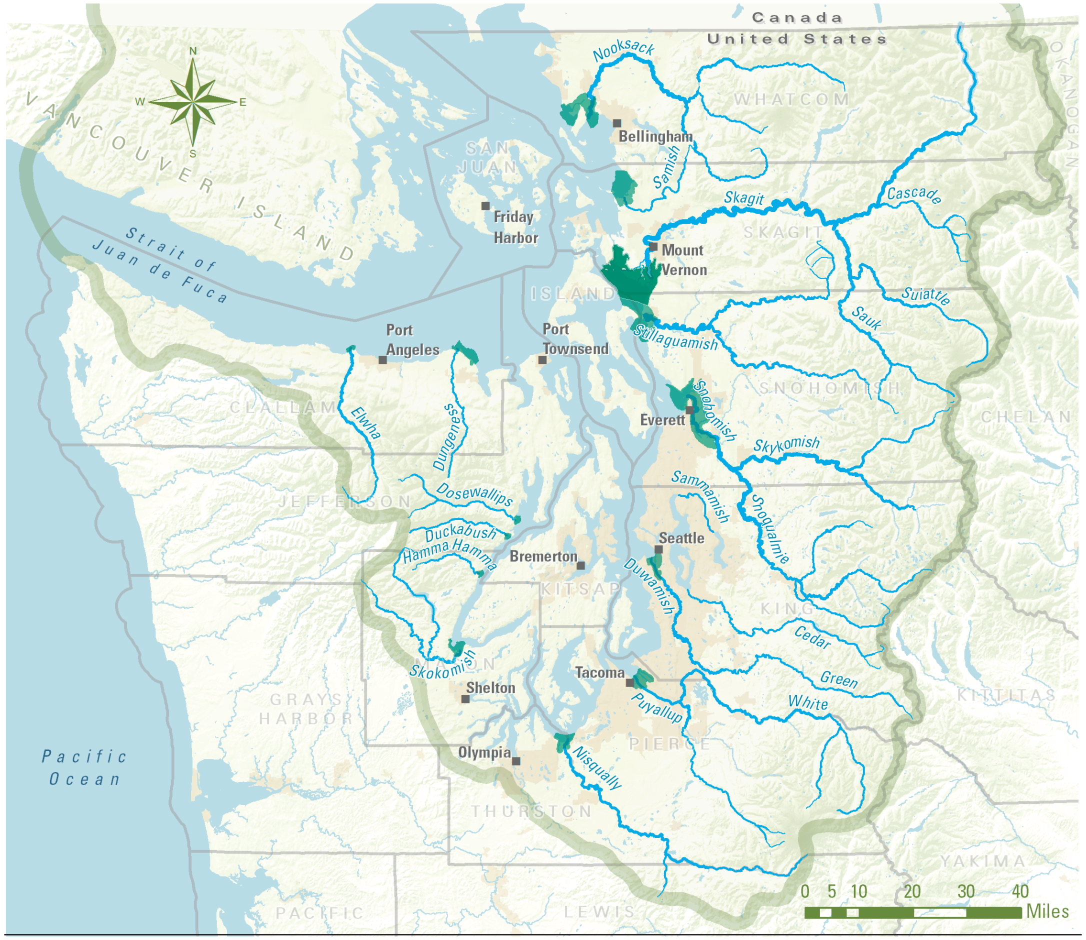
Much of the loss can be attributed to the development of natural waterways for economic and commercial purposes. Across the region, estuaries and tidal wetlands have been diked, drained, or filled. They have been converted to farms and agriculture, or developed into modern ports and industrial sites. Loss of intertidal wetlands has contributed to the decline of many species, including especially Chinook and chum salmon that depend on river delta estuaries for essential juvenile rearing habitat.

Recent trends

Recent trends remain challenging to quantify. A number of efforts are now under way to restore estuarine habitat because it is believed to be a bottleneck to the recovery and success of wild salmon and other species. Salmon recovery and watershed restoration groups are working with the support of state and federal partners to set local watershed-specific restoration targets, identify willing landowners, work through intense local politics, and restore habitat as part of their salmon recovery planning process. These efforts are technically complex, and often require public-private partnerships in a complex social, economic, and natural environment.

In contrast to project restoration efforts, habitat losses still occur. Habitat is still being impacted by on-going development, changes in river hydrology and sediment loads, and even the long-term effects of geologic subsidence of delta areas and sea level rise.

Recent advances in remote sensing technologies, improved geographic analysis tools, new ways of tracking fish movements, and better understanding of habitat functions all promise to improve our understanding of the net effect of habitat losses and gains over the coming years.



Chinook salmon river deltas

🟩 Chinook salmon river deltas

▨ Cities and Urban Growth Areas

County Border

Salish Sea Basin Boundary

Figure 2. Caption forthcoming.
Source: Forthcoming.

Carpenter creek Local Story

Freshwater Quantity

Although Puget Sound is known for plentiful rain most of the year, the roaring torrents of spring can slow to a trickle during our dry and sunny summer months. Although this seasonal variation is normal, development that draws water away from streams can exacerbate the problem.

Low summer flows affect salmon runs, wildlife, and our water supply. New wells that tap ground water and new buildings, roads, and parking lots that prevent water from percolating into the ground reduce the amount of water that would otherwise recharge summer streams.

Freshwater Quantity

INDICATOR:

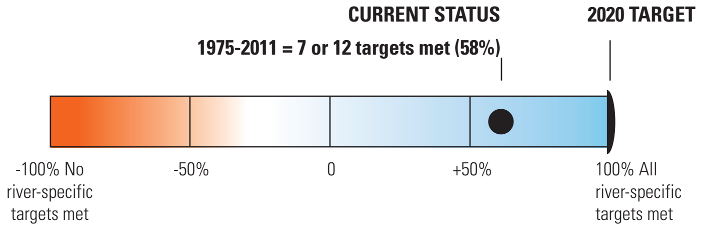
Summer Low Flows

Indicator lead:Paul Pickett, Washington Department of Ecology

TARGET:
Increase, maintain, monitor, and/or restore summer flows in 12 key rivers, including those regulated by dams (Nisqually, Cedar, Skokomish, Skagit, and Green Rivers,) and those that are not (Elwha, Puyallup, Dungeness, Nooksack, Snohomish, Deschutes, North Fork Stillaguamish, and Issaquah Rivers).

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**Mixed**



Targets for summer low flows were met in 2011 for seven out of 12 rivers.

Progress towards the 2020 target

The trend in summer low flows for seven of the 12 rivers met their targets in 2011. With just 58% of target rivers trending positively, progress is mixed.

The target for low summer flows (maintain, increase, monitor, or restore) varies per river:

- Maintain stable or increasing flows in highly regulated rivers: Nisqually, Cedar, Skokomish, Skagit, and Green.
- Monitor low flow in the Elwha River after dam removal. (The Elwha River gage was removed from the indicator because of the dynamic changes occurring from river restoration activities). See page XX for more information on the Elwha Dam removal.
- Maintain stable flows in unregulated rivers that currently are stable: Puyallup, Dungeness, and Nooksack.
- Restore low flows to bring the Snohomish River from a weakly decreasing trend to no trend.
- Restore low flows to bring the Deschutes River, North Fork Stillaguamish River, and Issaquah Creek from a strongly decreasing trend to a weakly decreasing trend.

All five rivers that are highly regulated by dams were expected to maintain stable or increase their flows. The Green and Skagit Rivers were stable and the Nisqually, Cedar and Skokomish Rivers had strongly increasing flows.

Three rivers not regulated by dams were expected to maintain their stable flows. The Puyallup and Dungeness Rivers had weak increasing flows and Nooksack had a weak decreasing flow; thus, two out of three met their target.

The Snohomish River remained weakly decreasing and did not meet its target. The Deschutes River, North Fork Stillaguamish River, and Issaquah Creek did not improve from strongly decreasing trends; thus, all three failed to meet their target.

What is this indicator?

Low flow occurs during summer months when there is less rain and warmer temperatures. Summer low flow is measured as the 30-day minimum water flow at river and stream gaging stations.

The summer low flow indicator measures trend over a long time period. The indicator tracks how flow conditions are changing over the years, rather than comparing flow levels to a fixed value. The indicator is not sensitive to changes over a shorter time period, which makes it difficult to measure improving trends by 2020, even if significant flow restoration occurs. To measure a change, either large changes in flow must occur, such as a dam setting minimum downstream flows, or a very consistent change over a long period of time is needed.

The indicator tests whether the long-term trends of annual summer low flow levels are declining or increasing. The trend test uses data collected since 1975, representing more than 30 years of measurements. The advantage of a long-term data set is that the influence of climactic changes associated with regional cooling and warming cycles (e.g., the phases of the Pacific Decadal Oscillation) are minimized over time.

One possible way to address this limitation would be to develop a method to evaluate trend over a shorter time period. One approach to accomplish this would be to standardize flows by removing the influence of climate and rainfall over a shorter time period (five-10 years).

30-day average summer low flow (1975–2011)

▲ Strong increasing
▲ Weak increasing
● No trend
▼ Weak decreasing
▼ Strong decreasing

〰 Summer flow creeks
〰 Rivers having chinook salmon populations
▨ Cities and Urban Growth Areas
▢ County Border
▨ Salish Sea Basin Boundary

Fresh Water Quantity

Stream flow trends in 29 Puget Sound rivers

30-day average summer low flow, 1975-2011

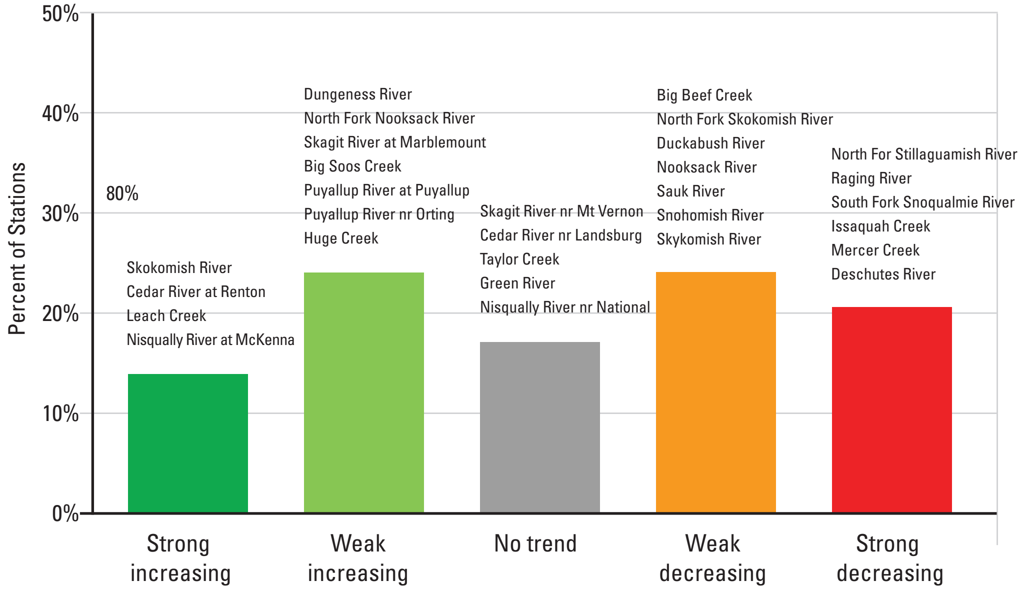


Figure1. Summer low flow trends by category.

Source: River and Stream Flow Monitoring Network, Department of Ecology

Interpretation of data

Status and trend

River-specific targets were created for 12 locations for the Action Agenda. To provide a more complete regional picture, 17 additional gages were also evaluated. Of the 29 gages used to measure summer low flow (Table 1):

- 15 gages are located near the mouth of major rivers or small streams that drain directly to Puget Sound
- 6 gages are from upstream sites on the mainstem of major rivers
- 8 gages are from tributaries to major rivers.

Of the stations assessed, 55% had stable or increasing summer low flows (16 out of 29; Figure 1). Rivers regulated by dams with mandatory minimum downstream flows generally showed increasing or no trends (Skagit, Cedar, Green, Puyallup, Nisqually, and Skokomish Rivers). Some of the glacier-fed upper tributaries had increasing trends (North Fork Nooksack River, Puyallup River at Orting). This could be the result of climatic warming trends and glacial recession.

The Cedar River near Landsburg immediately below the reservoir but above the City of Seattle water diversion showed no trend, while the Cedar River at Renton (near the mouth) showed a strong increasing trend. Low flows upstream were almost twice the low flows downstream. Taken together this shows the effect of the implementation of the City of Seattle Habitat Conservation Plan.

Unregulated rivers and streams that showed decreasing summer low flows included the Issaquah and Mercer Creeks, which are in urban areas, and the North Fork Stillaguamish, South Fork Snoqualmie, and Raging Rivers, which are in areas of rapid population growth. The effect of increased impervious surfaces and ground and surface water withdrawals may be affecting summer low flow levels. The Deschutes River showed a strong decreasing trend even though the watershed above the gaging station is mostly forested land. Decreasing summer low flows may be due to forest practices or climate change.

How much is water worth?

The Nisqually and Snohomish Pilot Watersheds Services Transaction Projects

Two Washington state watersheds – the Nisqually and Snohomish - have been credited with protecting and restoring the largest amount of habitat in Puget Sound to date. Now these watersheds have been selected as the most likely candidates for an innovative strategy to keep working forests in the State of Washington from being converted to non-forest uses. How? By getting potential buyers, such as utilities, flood districts or tribal nations, to pay forest landowners to undertake specific land management activities that achieve measurable improvements in watershed services and enhance water quality, increase water supplies, and improve salmon habitat protection.

The Watershed Services Transaction Project was launched in June 2011 by the State Department of Natural Resources in collaboration with the University of Washington Northwest Environmental Forum. After extensive deliberation during the Forums held in 2010 and 2011, the Snohomish and Nisqually watersheds were identified as the most likely pilot locations for watershed services transactions, primarily because critical organizations presented themselves to lead the projects.

Forested watersheds provide almost two-thirds of the drinking water in the United States. Many other critical services, such as timber, flood control, habitat for animals and birds, carbon sequestration and recreation, are provided by forests, but we too often assume that forest landowners will continue to manage their lands to realize all of these values and that they do not need to be compensated.

A few locations around the country are developing comprehensive valuations of the benefits provided by forests, and creating incentives for private landowners to manage their forests for these diverse public values. “Payments for watershed services” is an approach that has been implemented successfully in a few communities, and is now being considered in Washington.

The Snohomish River Basin pilot project addresses the second largest drainage in Puget Sound. Seventy four percent of the drainage is forest land. The basin is also one of the fastest growing areas in the region, and it is critical to balance the area’s growth needs with maintaining a healthy ecosystem. A recent study valued the potential benefits provided in the watershed to range from a low of $383.1 million to a high of $5.2 billion. Snohomish County Department of Public Works is leading this demonstration transaction, joined by several key watershed partners, including the Tulalip Tribes, Forterra, King County and Washington DNR.

The Nisqually pilot project focuses on the Nisqually watershed, which encompasses 78 miles of habitat, from the Nisqually Glacier on Mount Rainier to the delta in the

A recent study valued the potential benefits provided in the watershed to range from a low of $383.1 million to a high of $5.2 billion.

Nisqually National Wildlife Refuge. The watershed has a range of land uses, including rural communities; parks, such as Mt Rainier; hydropower projects; military bases and the Nisqually Indian Reservation. The communities, tribes and organizations in the watershed have worked together to conserve, restore and protect habitat in the basin. The Nisqually River Council, Nisqually Land Trust and Northwest Natural Resource Group are spearheading the watershed services pilot project. As in the Snohomish project, their focus will be to provide a demonstration transaction and deliver new sources of income to forest landowners that help them offset the costs of new practices that improve water quality and quantity.

The pilot projects are intended to benefit the individual watersheds, and also provide an effective and transferable model for a state or perhaps national watershed services program. A successful Watershed Services Transaction Project in these two locations can lead the way to address future water supply and water flow needs and create a new financing mechanism for restoration and recovery of the Puget Sound and to sustain Washington's valuable private forest lands.

Marine Water Quality

Every time we visit the beach, fish, or dig clams in Puget Sound, we rely on good water quality. Marine water quality in much of Puget Sound is poorer than we would like, especially in areas where the circulation of water is restricted.

The marine waters of Puget Sound are affected by many different factors including weather and climate, inflow from rivers and streams, discharges from wastewater treatment plants and industries, off-shore ocean conditions, storm-water runoff, and even ground water.

Excess pollution can force beach closures and shellfish harvesting restrictions, and may cause algae blooms that eventually deplete oxygen levels leading to fish kills.

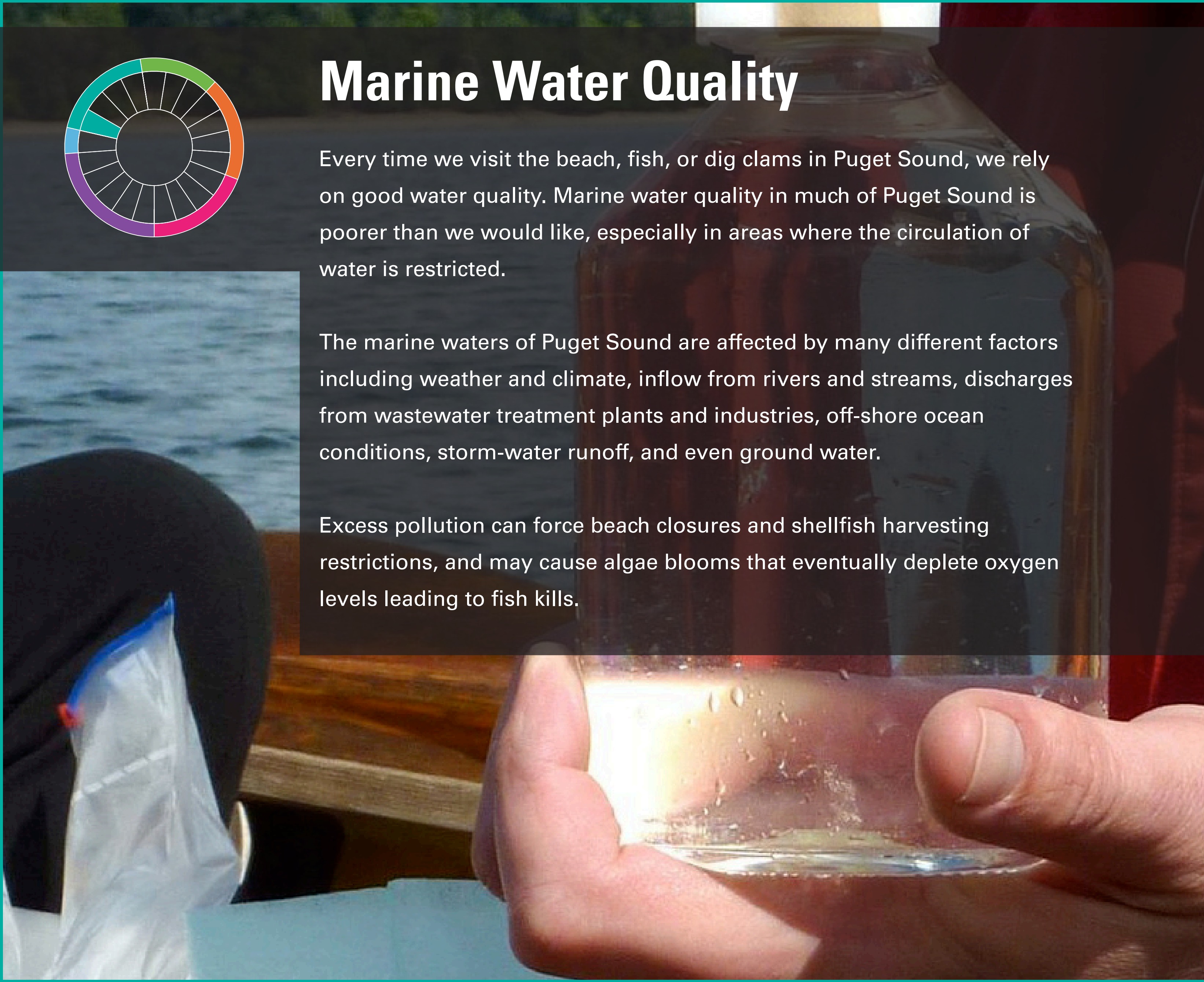


Photo Credit: Duane Fagergren, Puget Sound Partnership

Marine Water Quality

INDICATOR:

Marine Water Condition Index

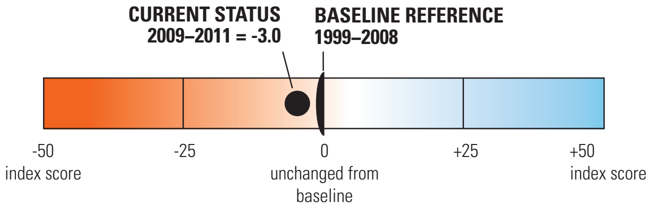
Indicator lead: Christopher Krembs, Washington Department of Ecology

TARGET:

The Leadership Council has not adopted a specific target for the Marine Water Condition Index. They did, however, adopt a target related to one key component of the index: Keep dissolved oxygen levels from declining more than 0.2 milligrams per liter in any part of Puget Sound as a result of human input.

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	NO



Using 1999-2008 as the baseline period with zero indicating conditions unchanged from the baseline, water quality conditions were slightly worse, on average, from 2009-2011.

Progress towards 2020 target

Marine Water Condition Index

Marine water quality was generally lower throughout Puget Sound in 2009 and 2010 relative to the ten year, 1999–2008 baseline. Conditions improved somewhat in 2011, with higher index scores reported in every one of the 12 regions monitored (Fig 1).

Dissolved Oxygen

For the most part, comprehensive studies to evaluate human contributions to low dissolved oxygen have not yet been completed in Puget Sound. A number of previous studies have suggested human inputs may be contributing to low dissolved oxygen problems. However, a recent study of Hood Canal indicated that human releases of nitrogen are unlikely to be contributing to low dissolved oxygen in the main arm of the Canal. The same study found that human inputs to Lynch Cove (in the southern part of Hood Canal) may be cause for concern, although the available data remains unclear.

Additional studies will be required to refine current models and improve our understanding of the degree to which human inputs contribute to low dissolved oxygen problems in Puget Sound, and what management actions may be necessary to address them.

What are these indicators?

Marine Water Condition Index

The Washington State Department of Ecology developed the Marine Water Condition Index (MWCI) to better adddress the large amount of variability inherent in marine water quality measures, in order to detect subtle changes over time.

The MWCI integrates 12 variables that describe an important aspect of water quality conditions (e.g. temperature, salinity, nutrients, algae biomass, dissolved oxygen, etc.). The goal of the MWCI is to provide a framework that links changes in local water quality and physical conditions to a larger context of oceanic water quality and natural variability. The MWCI can detect subtle changes in water conditions relevant to eutrophication and physical conditions against site and seasonal-specific baseline conditions measured from 1999 to 2008.

The index is reported on a scale of -50 to 50 indicating a complete change from baseline conditions, with zero indicating unchanged conditions relative to the baseline. The index is reported for 12 regions (Figure 1).

Dissolved Oxygen

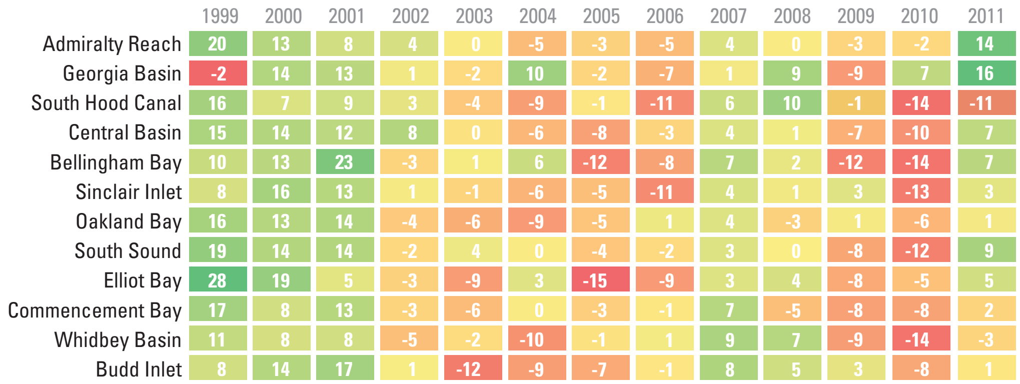
Low dissolved oxygen has been observed in a number of locations in Puget Sound and can create significant problems, such as extensive fish kills, human inputs, especially nutrients, are often suspected of creating, or exacerbating, the conditions which lead to low oxygen in Puget Sound. To reduce the frequency and severity of oxygen problems in Puget Sound, the Leadership Council adopted a target intended to minimize any human contributions to low dissolved oxygen in Puget Sound.

The problem is, dissolved oxygen naturally exhibits a high degree of variability in marine waters, changing almost continuously with time of day, location, season, tidal cycle, depth, the mixing and movement of different water sources, and many other factors. Also, there are several main sources of nitrogen to Puget Sound, including the ocean (generally the largest overall source), terrestrial sources (some of which are natural, and some of which are human), groundwater, and the atmosphere.

Consequently, determining the precise degree to which human inputs are responsible for a relatively small decline in dissolved oxygen, relative to the normal range of variability, is a complex issue. Addressing the issue requires a combination of good monitoring data, studies on the sources of nitrogen, and sophisticated mathematical models.

Marine Water Condition Index Scores

1999-2011



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Admiralty Reach	20	13	8	4	0	-5	-3	-5	4	0	-3	-2	14
Georgia Basin	-2	14	13	1	-2	10	-2	-7	1	9	-9	7	16
South Hood Canal	16	7	9	3	-4	-9	-1	-11	6	10	-1	-14	-11
Central Basin	15	14	12	8	0	-6	-8	-3	4	1	-7	-10	7
Bellingham Bay	10	13	23	-3	1	6	-12	-8	7	2	-12	-14	7
Sinclair Inlet	8	16	13	1	-1	-6	-5	-11	4	1	3	-13	3
Oakland Bay	16	13	14	-4	-6	-9	-5	1	4	-3	1	-6	1
South Sound	19	14	14	-2	4	0	-4	-2	3	0	-8	-12	9
Elliot Bay	28	19	5	-3	-9	3	-15	-9	3	4	-8	-5	5
Commencement Bay	17	8	13	-3	-6	0	-3	-1	7	-5	-8	-8	2
Whidbey Basin	11	8	8	-5	-2	-10	-1	1	9	7	-9	-14	-3
Budd Inlet	8	14	17	1	-12	-9	-7	-1	8	5	3	-8	1

Figure1. Marine Water Condition Index scores for twelve regions of Puget Sound, between 2001 and 2010. Changes in water quality relative to the 1999 to 2008 baseline are reported, with numbers greater than zero indicating improving water quality (in green), and numbers smaller than zero indicating decreasing water quality (in red).

Source: Washington Department of Ecology, Environmental Assessment Program, Marine

Marine Water Quality

Interpretation of data

Status and trend

Marine Water Condition Index scores have generally declined over the past ten years, illustrated by a shift from green to red colors and an increase in negative scores (Figure 1). These results indicate that conditions overall are shifting in the direction of lower water quality, although recent, more stable conditions have slowed the apparent decline. The largest changes, more than 20% decline, were in South Sound, Bellingham Bay, and Central Sound.

The largest driver of declining marine water quality has been nitrate concentrations. Over the past ten years, nitrate levels have increased significantly. Because nitrate is an important plant nutrient, increasing nitrate loads can fuel algae blooms which, as the algae subsequently die and decay,can drive low dissolved oxygen events.

There are two main sources of nitrate in Puget Sound waters: input from ocean waters flowing into Puget Sound, and human pollution. Recent evidence suggests that increasing nitrate loads to Puget Sound are predominately non-oceanic. However, as discussed earlier, the overall contribution of human inputs to low dissolved oxygen in Puget Sound remains a topic of active study.

Freshwater Quality

The rivers and streams that flow into Puget Sound are the lifeblood of our region's ecosystems and our health, economy, and quality of life. Yet only 64% of the major rivers in Puget Sound meet water quality goals.

Clean water is vital to people and to healthy fish and wildlife populations. When our rivers and streams pick up pollutants, toxic contaminants, or excessive sediments and nutrients, it adversely affects the health of our watersheds, marine waters, swimming beaches, and shellfish beds.

Three key indicators help us monitor the health of Puget Sound: the number of impaired waters, the Water Quality Index (WQI), and the Benthic Index of Biotic Integrity (B-IBI). Under the federal Clean Water Act of 1972, waters that fail to meet water quality standards are considered impaired. The WQI integrates complex water quality data into a readily understood scale. The B-IBI measures the abundance and diversity of macroinvertebrates in a streambed. Also known as stream bugs, these creatures are a critical part of the aquatic food web and are sensitive to changes in the environment.

Photo Credit: Flickr @ pfly

Freshwater Quality

INDICATOR:

Freshwater Quality Index

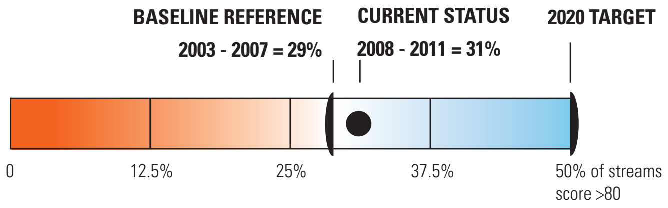
Indicator lead: David Hallock, Washington Department of Ecology

TARGET:

At least half of all monitored streams should score 80 or above on the fresh water quality index.

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**YES**



During the 2003-2007 baseline period, 16 of 55 stations (29%) met the target value based on averaging index scores for each site during this period (Fresh Water Quality Index >80). During 2008-2011, 17 of 55 stations (31%) met the target value (a slight increase).

Progress towards 2020 target

Monitored sites showed a very slight increase in the number of sites with Fresh Water Quality Index (WQI) scores of 80 or above. However, results from the trend analysis of 14 of the major rivers at their most downstream sites suggest that we are not likely to reach the target by 2020.

The earliest projection to meet the target for these 14 rivers would be 2025. When adjusted for differences in seasonal flows, the trend is much slower: average flow-adjusted scores of 80 are projected for 2060. (Flow-adjusting accounts for the effect of flow on the parameters underlying the index.)

However, this kind of estimate is a best guess due to fluctuations in drivers like the rate of population growth, global warming, and effectiveness of management activities, as well as possible long-term cycles not visible in the current 15-year dataset. For example, management tends to address the easier and more egregious problems first. As those problems get fixed, remaining problems become more difficult to correct with less effect on the water body for a given level of effort. Consequently, the rate of improvement in the index could be less, perhaps much less, than predicted by simply extending current trends.

What is this indicator?

The Fresh WQI for rivers and streams combines eight measures of water quality. Expectations for four of the component measures (dissolved oxygen, pH, temperature, and fecal coliform bacteria) are tied to the State's Water Quality Standards for protecting aquatic life and contact recreation. The other four measures (nitrogen, phosphorus, suspended sediment, and turbidity) do not have numeric standards. Toxics are not included in the index.

Water Quality Index
Annual, 2000-2012

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Duckabush River nr Brinnon	94	92	96	78	92	89	93	95	94	90	74	94	89	85	88	96	86	89
Skokomish River nr Potlach	88	93	87	86	75	87	95	95	94	85	70	67	92	89	89	94	86	70
Snohomish River at Snohomish	83	77	82	76	89	83	92	91	89	81	74	75	89	75	81	85	79	77
Elwha River nr Port Angeles	83	83	79	80	87	74	86	88	83	76	73	74	89	67	66	81	81	76
Cedar River at Logan st/Renton	81	76	68	75	65	83	87	76	60	78	72	84	81	79	79	81	77	75
Skagit River at Marblemount	90	78	75	64	87	71	87	86	59	85	64	81	84	75	75	81	56	77
Skagit River nr Mount Vernon	75	73	72	65	84	77	89	91	71	76	61	73	77	77	75	76	74	73
Nisqually River at Nisqually	65	74	58	59	76	60	40	60	79	79	69	71	74	75	91	74	83	86
Deschutes River at East St Bridge		67	74	47	61	62	62	72	70	73	61	83	88	88	82	76	74	60
Stillaguamish River nr Silvana	83	70	66	58	71	70	81	60	44	72	55	67	71	69	75	75	71	59
Green River at Tukwila	62	52	35	50	63	70	82	73	66	67	75	49	72	68	60	69	63	68
Samish River nr Burlington		66	59	50	58	66	86	75	32	49	34	71	67	74	59	80	63	52
Nooksack River at Brennan	73	56	49	41	62	42	65	68	58	57	52	54	61	51	60	69	56	55
Puyallup River at Meridian St	49	52	47	48	41	62	60	58	57	55	51	58	59	58	61	49	62	56

Table 1. Annual Water Quality Index scores for monitoring stations near the mouth of 14 major rivers. Scores are calculated for each water year from October 1st to September 30th. Higher numbers indicate better water quality. Scores above 80 are shown in green, 70 to 80 in orange, 40 to 70 in pink, and scores <40 are in red.

Index values are based on monthly monitoring at individual stations. The index values range from 1 to 100; a higher number is indicative of better water quality. However, a particular station may receive a good WQI score, and yet have water quality impaired by parameters not included in the index. Similarly, some locations may have poor WQI scores based on measures that do not have Water Quality Standards.

Interpretation of data

Status and trend

From 2008-2011, 17 of the 55 long-term monitoring stations reported average Water Quality Index scores of 80 or more, indicating that they support water quality goals for conventional pollutants (toxics are not included); 11 stations had values that were “borderline” (70 – 79); 25 had “poor” scores (40 – 69); and two stations had a very poor index score (< 40) (Figure 1). For major rivers, three out of 14 stations reported average Water Quality Index scores of 80 or higher during this time period (Table 1).

Freshwater Quality

Freshwater Quality Index scores for major rivers in Puget Sound are in the mid 70s. These scores have slowly improved at a rate of about 0.4 units per year since 1995 (seasonal Kendall analysis, $p < 0.10$). Flow-adjusted scores have improved at a slower rate, 0.16 units per year ($p < 0.20$).

Scores have improved most strongly in the Nisqually and Deschutes systems (1.4 and 1.6 units per year, respectively, $p < 0.05$). No Puget Sound basins have had significantly declining scores ($p > 0.20$).

In addition to improvements in the overall scores for major rivers in Puget Sound, fecal coliform bacteria and total nitrogen index scores have improved. Other parameters are unchanged in freshwater systems as a whole, though there may be system-specific trends.

Stations meeting water quality goals are all in the relatively undeveloped Olympic Peninsula, except for the Snohomish River. Stations not meeting water quality goals tend to be in watersheds with more people and more agricultural development.

Freshwater Quality Index scores (averaged) for 55 sites in Puget Sound
2008-2011

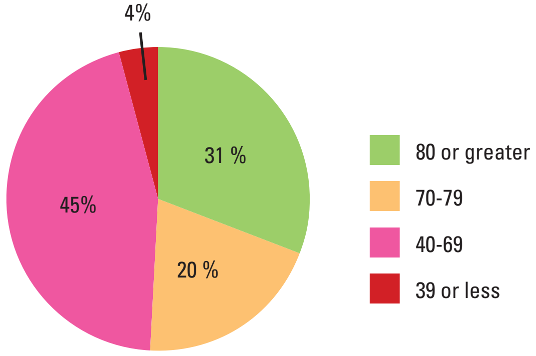


Figure 1. Freshwater Quality Index scores (averaged) from 2008-2011. Shown are percentages of 55 sites by category for WQI. Higher numbers indicate better water quality.

Sources: *Statewide Water Quality Monitoring Network, Washington Department of Ecology; Stream and River Water Quality Monitoring, King*

INDICATOR:

Number of Impaired Waters

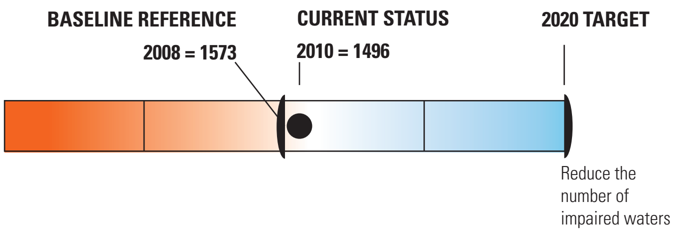
Indicator lead: Ken Koch, Washington Department of Ecology

TARGET:

Reduce the number of "impaired" waters

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**YES**



From 2008–2010, the number of impairments decreased by 77. However, the next assessment (due in 2013) is expected to show a significant increase in impairments (a trend away from the 2020 target) due to an increase in data and the number of sites assessed.

Progress towards the 2020 target

Although the number of impairments for rivers and streams decreased by 77 segments in 2010 (Figure 1), it does not mean that these segments now meet water quality standards. Instead, the change in number of impairments was largely due to the number of segments receiving approval for their water quality improvement project plans or pollution control programs.

Having a plan in place removes a segment from the impairment list, but does not necessarily mean that the area has been restored or that water quality standards are being met. For example, only four segments from the 2010 list were removed from the impaired list because they met water quality standards.

New data for freshwater were not reviewed in 2010; the next water quality assessment for 2012 will use new data and be published in 2013. The number of freshwater impairments is likely to rise significantly in 2012 due to an increase in data and the number of sites assessed. Comparing the number of impairments for 2008 to 2012 will be difficult because the method used to map and count segments will change.

What is this indicator?

Impaired waters are segments of streams, rivers, or lakes that do not meet Washington State's Water Quality Standards for bacteria, dissolved oxygen, temperature, toxics, or other pollutants. Cool, clean water is a key ingredient for a healthy Puget Sound. When lakes and streams have a reduced ability to support native species and human uses, then they are listed as Impaired.

Washington Department of Ecology reviews data from a variety of sources every four years to identify impairments. The data used to list segments as impaired must meet rigorous data quality standards as outlined in

Freshwater Quality

Washington's Water Quality Policy 1-11.

Under the Federal Clean Water Act of 1972, waters are considered impaired when they fail to meet water quality standards or minimum requirements for certain uses. Every two years, states are required to prepare a list of water bodies that do not meet water quality standards. This list is called the 303(d) list, because the process is described in Section 303(d) of the Clean Water Act. To achieve this goal, Washington State established water quality standards designed to protect and restore water quality for drinking, recreation, and habitat for fish and other aquatic life.

More than one segment of a river may be listed as impaired, and a single segment may be listed for more than one pollutant. Once a segment is listed as impaired, a plan must be created and implemented to control pollution or improve water quality. The effects of these restoration programs can take many years to have a positive impact.

Interpretation of data

Status and trend

In the Puget Sound basin, the 2010 Water Quality Assessment showed a total of 6,957 segment and parameters combinations were assessed. A total of 1,496 river and stream segments, in 525 rivers and streams, did not meet Water Quality Standards and thus were listed as impaired.

Impairments occurred in all 19 Water Resource Inventory Areas (WRIAs) in the Puget Sound basin (Figures 2 to 4). More than 60% of the total number of listings for Puget Sound rivers and streams were in five watersheds: Nooksack (296 listings), Kitsap

Number of stream and river segments listed in each assessment category
2008 and 2010

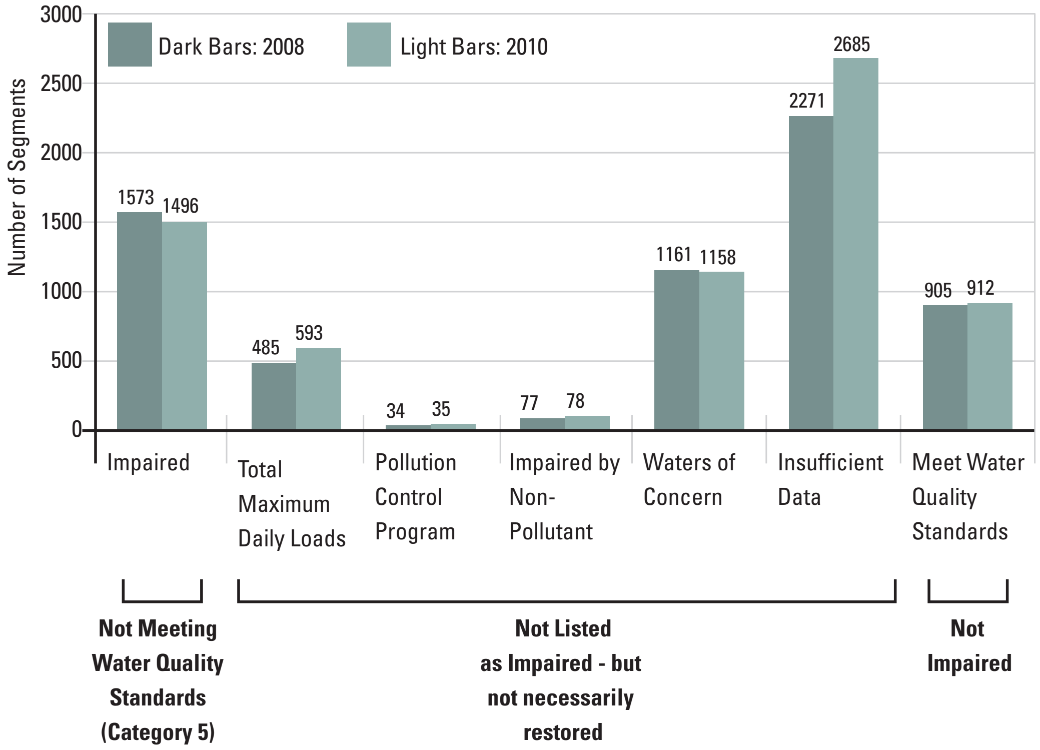


Figure1. Number of stream and river segments listed in each assessment category for 2008 and 2010. Category assignments are from Washington Department of Ecology's Water Quality Assessment process for Puget Sound watersheds. The 2010 Assessment was focused on marine waters and, therefore, showed minimal changes to freshwater listings.
Source: *Forthcoming*

(194), Cedar/Sammamish (181), Duwamish-Green (132), and Lower Skagit-Samish (109). For Puget Sound lakes, 52 were listed as impaired; 48% were listed for bacteria and total phosphorus, and approximately one half were listed for toxic chemical contamination.

The most frequently cited data for listing segments as impaired were bacteria (524 listings), dissolved oxygen (460), temperature (353), and pH (97). However, the largest number of segments (39%) could not be categorized because of insufficient data. Water Quality Standards include strict rules about the number of samples required to determine whether a segment is impaired or meeting standards.

Segments listed as waters of concern have data that indicate a problem, but not enough data to make a determination of impairment.

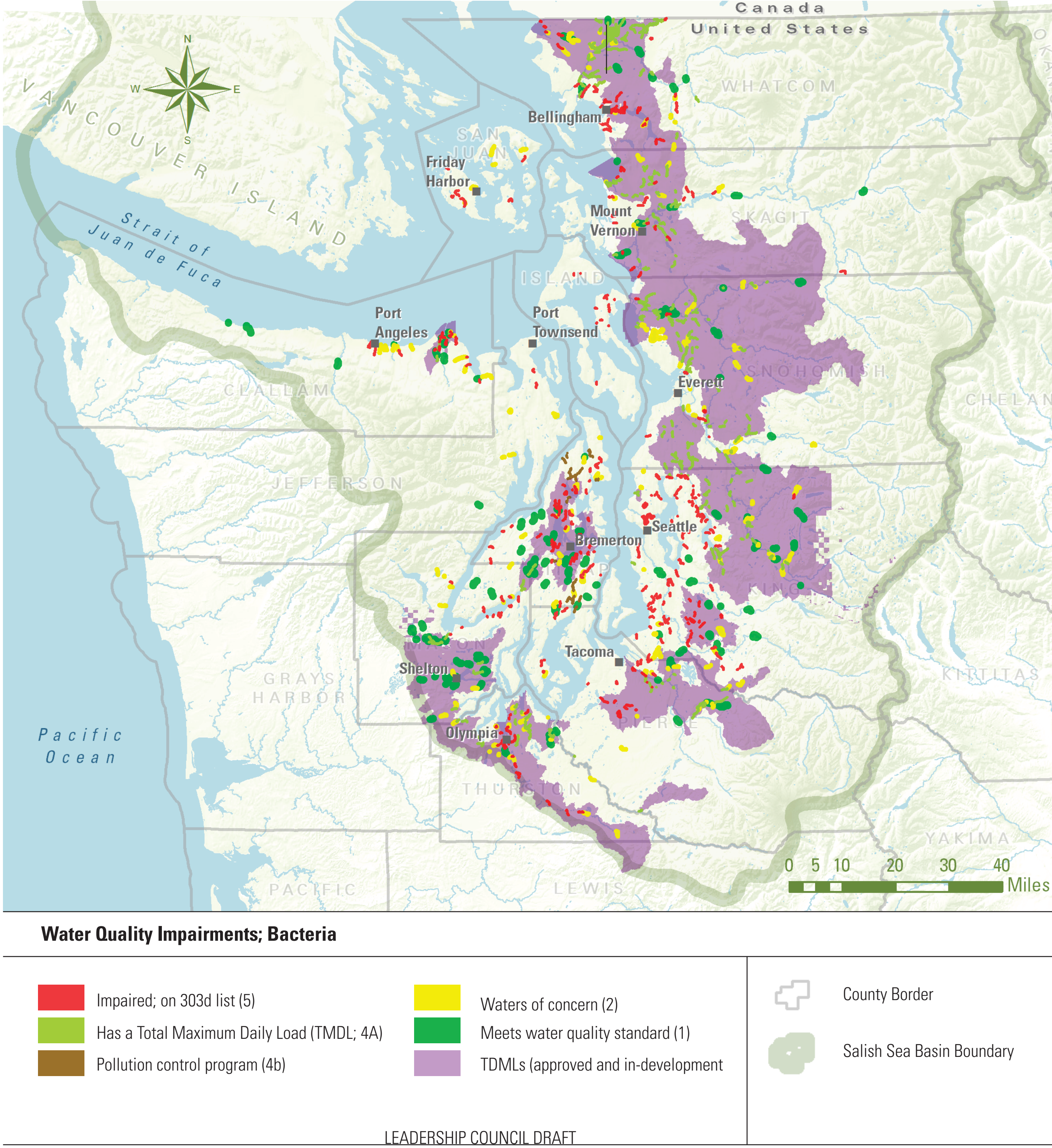
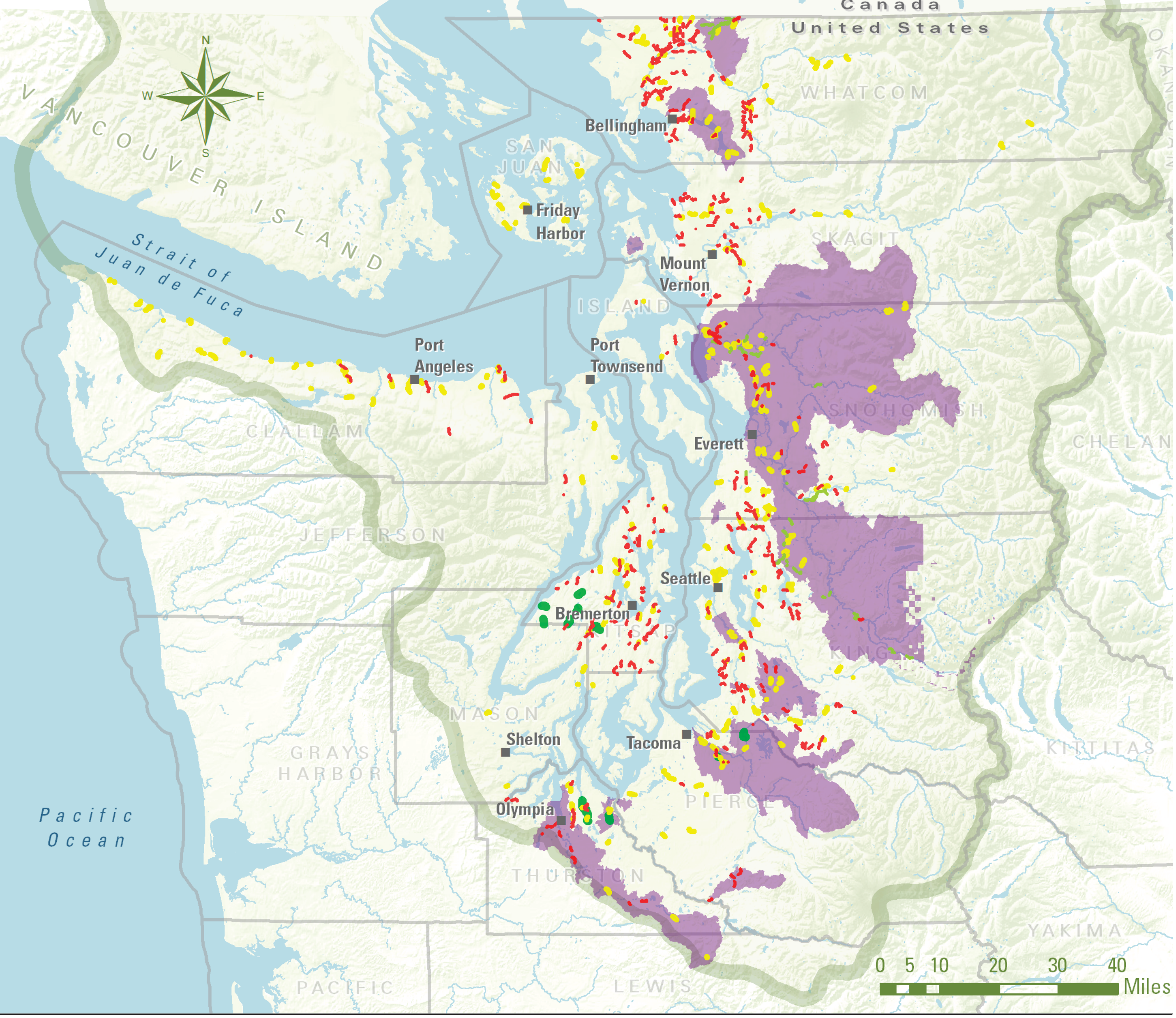


Figure 2. Rivers and stream segments listed as impaired for bacteria.



Water Quality Impairments: Dissolved Oxygen

🟥 Impaired; on 303d list (5)

🟩 Has a Total Maximum Daily Load (TMDL; 4A)

🟫 Pollution control program (4b)

🟨 Waters of concern (2)

🟩 Meets water quality standard (1)

🟪 TDMLs (approved and in-development

County Border

Salish Sea Basin Boundary

Figure 3. Rivers and stream segments listed as impaired for dissolved oxygen.

Sampling of streams, rivers, and lakes tends to focus in areas with known problems; therefore, not all segments have been assessed, and some impairments may be missed. Consequently, impairment data are not a complete reflection of the overall health of all streams, rivers, and lakes in Puget Sound watersheds.

In addition, selection of monitoring sites is frequently constrained by funding. Monitoring efforts are split between monitoring established sites and looking for new problems. This limits the numbers of new waters that are addressed during a cycle.

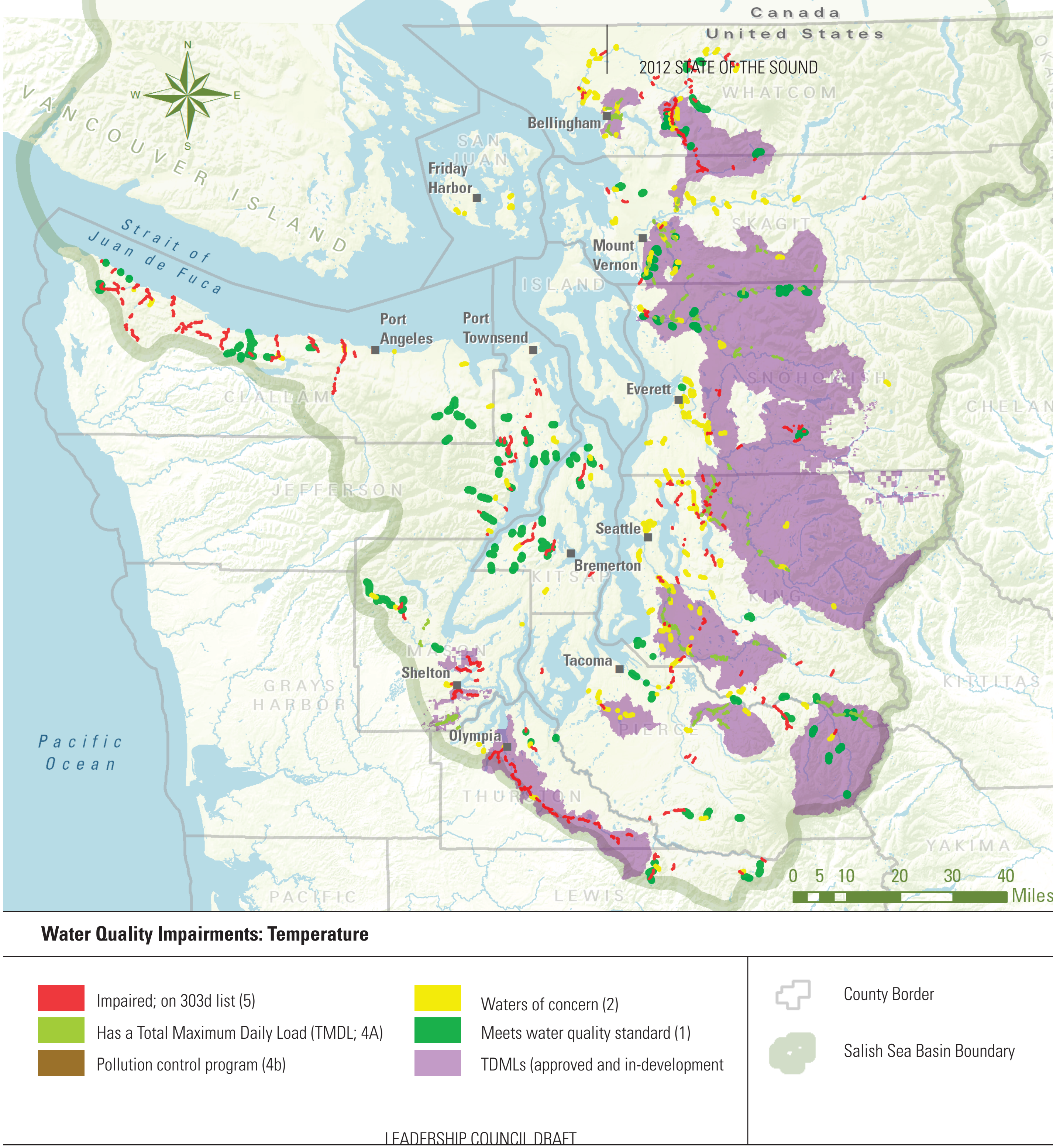


Figure 4. Rivers and stream segments listed as impaired for temperature. Source: Washington Department of Ecology, Water Quality Program

Freshwater Quality

INDICATOR:

Benthic Index of Biotic Integrity (B-IBI)

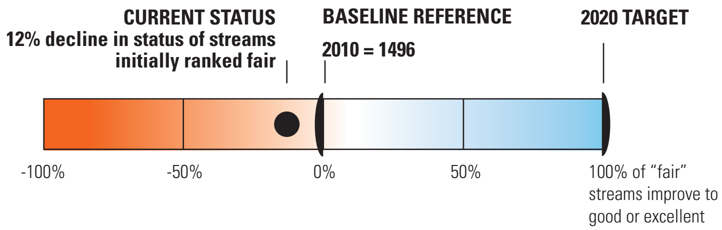
Indicator lead: Jo Wilhelm, King County

TARGET:

Protect small streams that are currently ranked "excellent" by B-IBI for biological condition; and improve and restore streams ranked "fair" so their average scores become "good."

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**NO**



For 128 sites with repeat visits during the last five years (2007 – 2011) more (26 sites) declined in condition to "poor" or "very poor" than improved to "good" or "excellent" (11 sites).

Progress towards 2020 target

No progress has been made. Overall, there was a net decline in condition of 12% of the 128 streams initially ranked "fair."

From 2007-2011, a total of 245 stream sites were sampled more than once. Of these, a total of 91 sites had B-IBI scores indicating "fair" condition. Of these, 11 sites improved and changed categories to "good" or "excellent." In contrast, a total of 26 stream sites declined and changed from "fair" to "poor" or "very poor."

For the streams with "excellent" biological condition as rated by B-IBI, some streams are already protected. A detailed analysis has not been done to identify which streams and watersheds should be protected for this target. The watersheds will likely be small, five to 20 square miles.

What is this indicator?

The indicator is the Benthic Index of Biotic Integrity (B-IBI). This index describes the biological condition of stream sites and their surrounding habitat based on the diversity and relative abundance of the benthic (bottom dwelling) macroinvertebrates living there, such as mayfly larvae, stonefly larvae, caddisfly larvae, worms, beetles, snails, dragonfly larvae, and many others.

Ten measures of biological condition are scored and summarized as the B-IBI, which ranges from a score of 10, indicating a very poor stream condition, to 50, indicating excellent condition.

B-IBI data are routinely collected and reported by more than 20 local jurisdictions, tribes, and other state and federal organizations in Puget Sound for a variety of reasons. In contrast, the Washington State Department of Ecology sampled 50 randomly-selected stream sites in 2009 and will sample again in 2013 to assess status and trend at the regional scale. Snohomish and King Counties also randomly select stream sites and report unbiased estimates of regional stream condition using B-IBI. For 84 sites with long-term data in King County, B-IBI scores for 68 sites did not change (81%), ten improved (12%), and six declined (7%).

Interpretation of data

Status and trend

Biological condition ranged from very poor to excellent for streams assessed between 2007 and 2011. The majority of streams (88%) rated very poor, poor or fair, while fewer than 12% of streams were rated as good or excellent (Figure 1).

Not surprisingly, B-IBI scores were lower in areas with greater urban development (Figure 2). B-IBI is highly correlated with development and component metrics respond to specific aspects of disturbance. For example, long-lived species tend to decline as stream flows become higher in wet periods and lower in dry periods. Stoneflies also decline when natural vegetation near the stream is removed. Stream invertebrates are also sensitive to sediment, toxics, increased temperatures, and loss of habitat.

For sites with repeat visits during the last five years, more sites have declined in biological condition from "fair" to "poor" or "very poor" (29%) than have improved to "good" or "excellent" condition (9%; Figure 3). These B-IBI scores were not derived from a random sample design and, therefore, do not necessarily represent the entire Puget Sound area.

B-IBI scores by category of biological condition for Puget Sound streams
Annual, 2000-2012

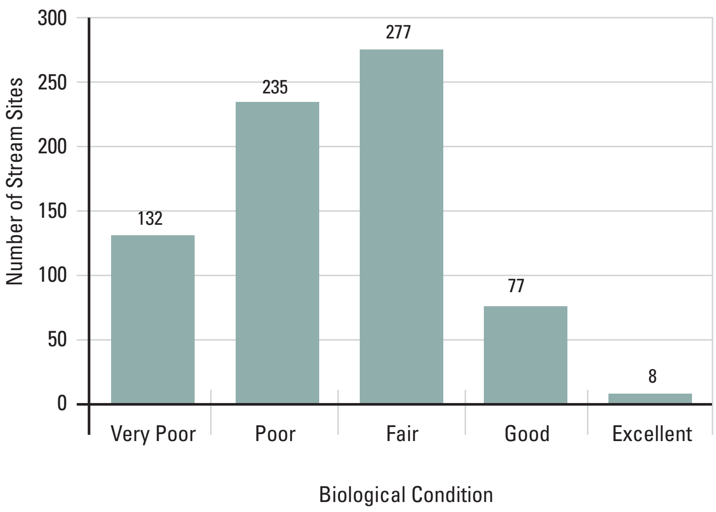


Figure 1. B-IBI scores by category of biological condition for Puget Sound streams. Shown are most recent data for each site.

Source: *Benthic Conditions needs source*

Freshwater Quality

B-IBI scores for 128 streams in Puget Sound
Annual, 2000-2012

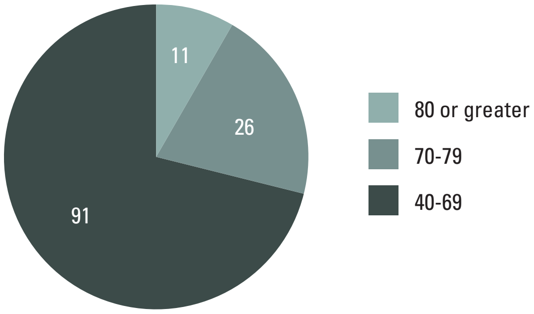
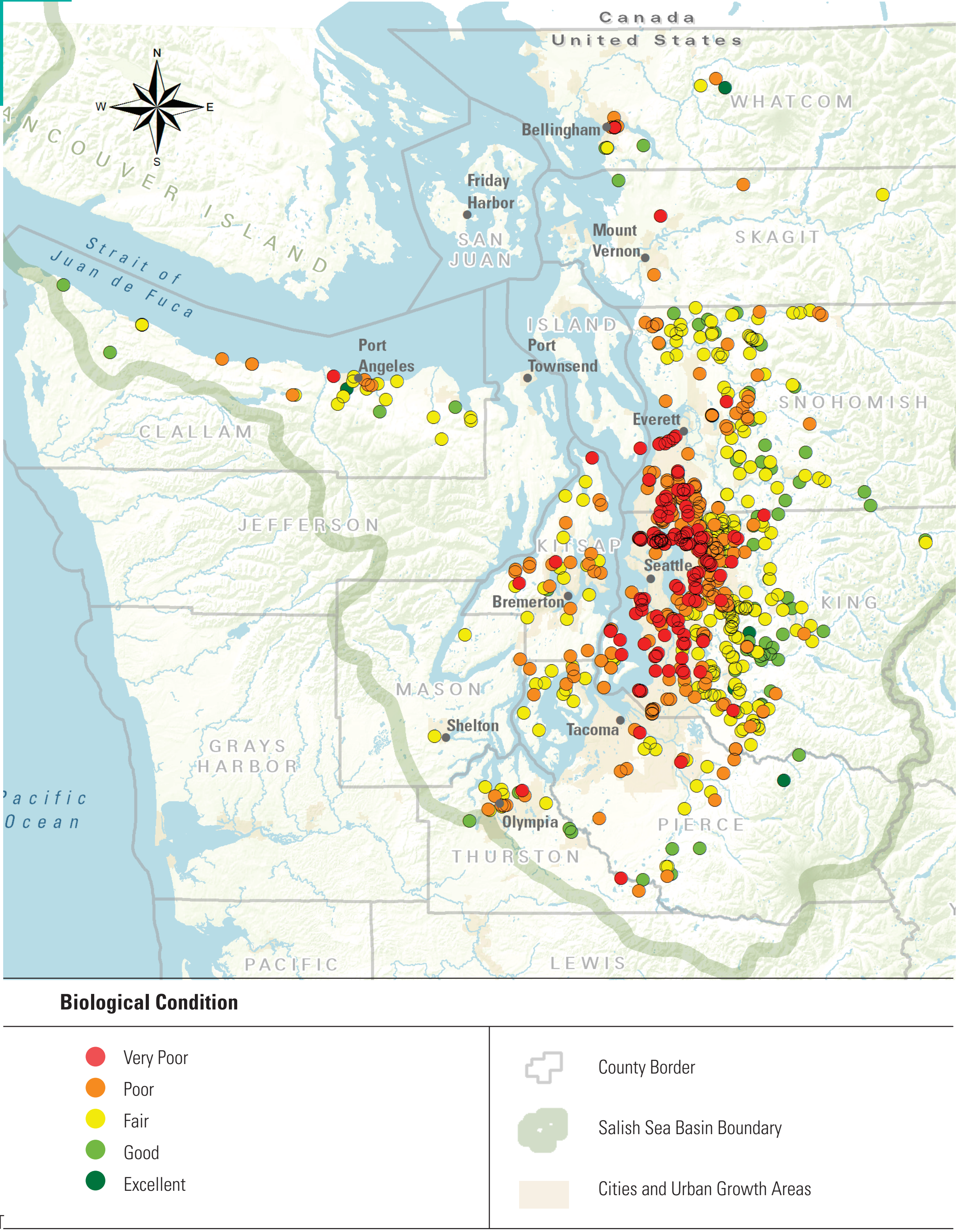


Figure 3. From 2007–2011, B-IBI was measured more than once at 245 sites. Of these, 128 stream sites were rated as "fair" by B-IBI for the first visit. Of these, 11 of these 128 improved in condition to "good" or "excellent" condition; 26 declined in condition to "poor" or "very poor;" and 91 were still rated as "fair.".

Sources: *Benthic Pie needs sources?*



Marine Sediment Quality

Much of the “floor” of Puget Sound is covered with sediment—the mud, sand, silt, and clay that has accumulated over years, decades, centuries, and even millennia. The accumulation of sediment is a natural estuarine process that occurs as beaches and bluffs erode, as streams and rivers carve their way through watersheds and carry sediments from the land into the water, as glaciers grind down the rocks of mountains, and even as the teeming algae and microscopic animals die and settle slowly to the bottom.

These sediments form a unique habitat that is home to clams, marine worms, burrowing shrimp, bottom-dwelling fish, and thousands of other unique species that live in, or on, the bottom sediments. In turn, these animals form a critical part of the marine food web, help filter the overlying water, and even process and help breakdown the sediments themselves—much as earthworms and other soil organisms process and enrich the soils of our farms, gardens, and forests.

In a well-functioning estuary, marine sediments support a healthy biological community. But in Puget Sound sediments have become contaminated and adversely affext aquatic life that rely upon them.

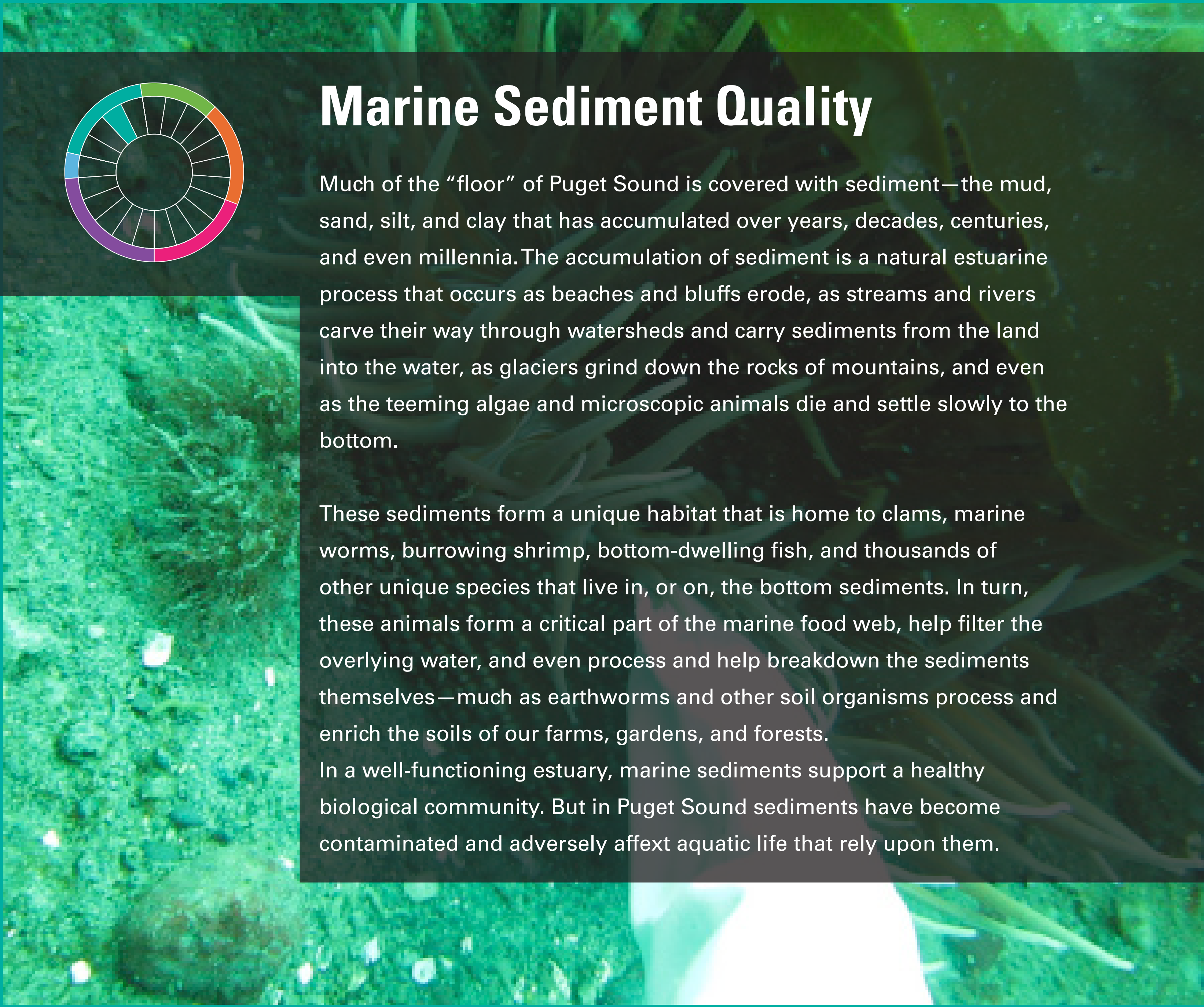


Photo Credit: Sean Sheldrake, EPA Region 10 diver

Marine Sediment Quality

INDICATOR:

Sediment Quality Triad Index

Indicator lead: Maggie Dutch, Department of Ecology

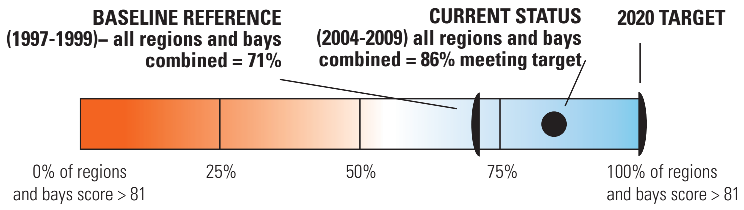
TARGET:

All Puget Sound regions and bays, as characterized by ambient monitoring, achieve the following: Sediment Quality Triad Index (SQTI) scores reflect "unimpacted" conditions (i.e., SQTI values >81)

The threshold criteria for "unimpacted" sediments has been revised from 83 (when the Leadership council adopted the target in 2011) to 81, based on quality control checks indicating the original calculation was incorrect.

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**Yes***



Four Puget Sound regions and three urban bays were first sampled in 1997-1999 and then re-sampled from 2004-2009. The most recent results showed an increase in the number of regions and bays meeting the target.

*Caution must be used in this interpretation as the weighted mean SQTI

Progress towards 2020 target

Sediment Quality Triad Index results suggest that much of Puget Sound has relatively healthy sediments. In the initial round of baseline sampling conducted between 1997 and 2003, four of eight regional areas and all three urban bays (64% of all areas combined) exceeded or were statistically no different from the target value of 81, indicating "unimpacted" sediments (Table 1, Figure 1). The remaining four regions (36% of all areas combined) had somewhat lower scores, but still fell within the range normally characterized as "likely unimpacted" (SQTI >57-81).

While the SQTI scores for the regions and bays fell in the two highest quality categories, values measured in resampled regions and bays still raise a concern. Among four regions and three bays that were re-sampled from 2004-2009, SQTI scores improved in only one area—Whidbey Basin—and declined in the other six areas (Figure 1). The improved score for Whidbey Basin increased the number of regions and bays meeting, or not statistically different from, the 2020 target (now six of seven areas = 86%), despite declining scores at all six other sampled locations . While the results indicate progress towards the target, there is also a somewhat concerning pattern of declining condition evident in sediments across the majority of regions and bays.

What is this indicator?

Sediment quality is a key indicator of a healthy ecosystem, and high quality sediments support a diverse and important biological community. We monitor sediment quality in Puget Sound by measuring the levels of chemical contamination, assessing the toxicity of the sediments to marine life, and examining the diversity and health of the biological community.

Classification of sediment quality based on SQTI scores

Category	SQTI score	Interpretation
Unimpacted	>81-100	Confident that contamination and/or other stressors are not causing significantly adverse impacts to aquatic life in the sediment.
Likely Unimpacted	>57-81	Contamination and/or other stressors are not expected to cause adverse impacts to aquatic life in the sediment, but some disagreement among lines of evidence reduces certainty that the site is unimpacted.
Possibly Impacted	>36-57	Contamination and/or other stressors may be causing adverse impacts to aquatic life in the sediment, but the level of impact is either small or is uncertain because of disagreement among lines of evidence.
Likely Impacted	>5-36	Evidence of contaminant and/or other stressor-related impacts to aquatic life in the sediment is persuasive, in spite of some disagreement among lines of evidence.
Clearly Impacted	0-5	Sediment contamination and/or other stressors are causing clear and severe adverse impacts to aquatic life in the sediment.
Inconclusive	No SQTI score	Disagreement among or within lines of evidence suggests that either the data are suspect or additional information is needed for classification.

Table 1. Classification of sediment quality based on SQTI scores
Source: Washington Department of Ecology, Marine Sediment Monitoring Unit

Citations Dutch, M.E., E.R. Long, S. Weakland, V. Partridge, and K. Welch. 2012. Sediment Quality Indicators for Puget Sound.

Long, E.R., S. Aasen, M. Dutch, K. Welch, and V. Partridge and D. Shull. 2007. Relationships between the Composition of the Benthos and Sediment and Water Quality Parameters in Hood Canal, WA: Task IV – Hood Canal Dissolved Oxygen Program.

Marine Sediment Quality

In Puget Sound and many estuaries around the world, sediments have become contaminated with toxic chemicals from industrial discharges, contaminated run-off from urban streets and roads, discharges from wastewater treatment plants, agricultural and forest chemicals carried down rivers and streams, oil spills, and even chemicals carried long distances through the atmosphere that eventually fall out of the sky with our rain. As the forests around Puget Sound have been logged, our streams and rivers channelized, and towns and cities built up, the amount, rate, and quality of sediment deposited into Puget Sound has changed dramatically.

The Sediment Quality Triad Index (SQTI) provides a weight-of-evidence approach that combines three different types of data into a single index measured from 1 – 100, with higher index values indicating higher quality sediments (Table 1).

The SQTI combines the Sediment Chemistry Index (SCI), sediment toxicity data, and benthic invertebrate community (small animals in sediment) data into a single, broad measure of sediment quality[1]. The SCI measures the concentrations of chemical contaminants. Laboratory toxicity tests measure the combined (synergistic) effects of those chemicals and other sediment characteristics on laboratory test animals. And the benthic invertebrate data reflects the actual biological condition of the sediments as a response to all possible human-caused and natural stressors, whether measured or not.

Together, the SCI and SQTI Indicators describe the overall "health" of the sediments, including their ability to sustain the sediment-dwelling invertebrates that form an important component of the Puget Sound food web.

Sampling Design

The Washington Department of Ecology monitors sediments in eight regional areas across Puget Sound and, separately, in six urban bays (see map). Multiple replicate samples are collected during each sampling effort, and weighted according to the size of the area each sample represents. Because sediment condition is not generally expected to change quickly over time, regions and urban bays are sampled on a rotating basis over a ten- and six-year period, respectively, thus it takes ten years to complete one full round of regional sampling, and six years to complete one full round of urban bay sampling in Puget Sound.

In order to evaluate progress toward the targets, results are discussed here primarily for areas that have been sampled twice: generally first sampled in the late 1990s, and then re-sampled in the mid to late 2000s. Results are evaluated separately for regions (Figure 1, top panel) and urban bays (Figure 1, bottom panel). This allows comparison of sediment quality in areas more closely associated with urban and industrial discharges and runoff to areas with less intensively developed landscapes, keeping in mind that some pesticides and certain other contaminants and natural impacts may in fact be more closely associated with agriculture and rural land uses.

Finally, it is important to note that results presented here are representative of only those regions and urban bays that have been sampled, and not necessarily all of Puget Sound since we do not have data for areas not sampled.

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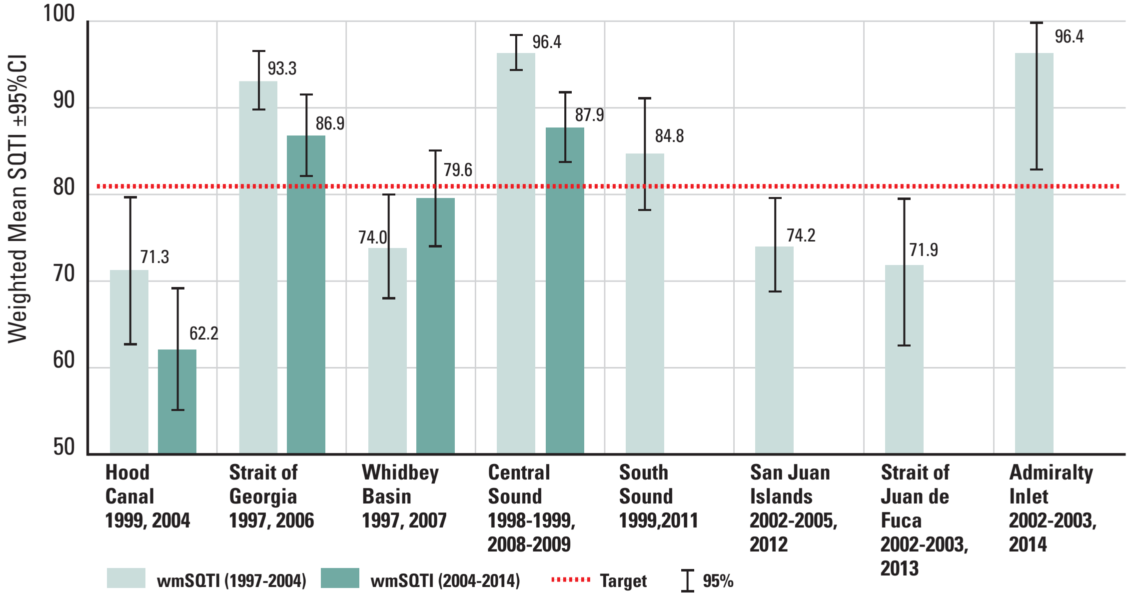
[1] Dutch, et al., 2012

Weighted Mean Sediment Quality Triad Index Scores in eight Puget Sound Regions



Weighted Mean Sediment Quality Triad Index Scores in six Puget Sound Urban Bays

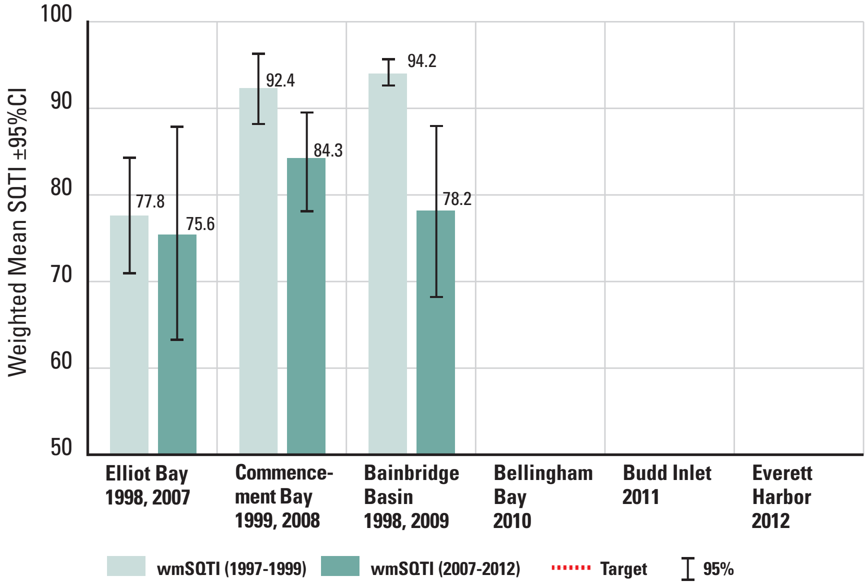


Figure1. Sediment Quality Triad Index, reported for eight regions (top panel) and six urban bays in Puget Sound (bottom panel). The light bars show the overall SQTI scores for samples collected in 1997-2003. The dark bars show the overall SQTI scores for samples collected in 2007-2009. The higher the index value, the higher the sediment quality. *Source: Washington Department of Ecology, Marine Sediment Monitoring Unit*

Marine Sediment Quality

Interpretation of data

Sediment quality monitoring in Puget Sound shows that about two-thirds of the areas monitored have sediments classified as "unimpacted", as indicated by low chemical concentrations, absence of toxicity, and the presence of abundant and diverse benthic invertebrate communities. The remaining one-third of the monitoring areas generally have sediments of "likely unimpacted" quality (Figure 1, Table 1).

Only a small percentage (~3.2%) of the sediment monitoring area in Puget Sound has sediments classified as "possibly, likely, or clearly impacted" (Table 1) with impairment in one, two, or all three components of the SQTI. These impacted sediments are located in and around both the urban and industrial bays with measurable levels of chemical contaminants in the sediments, and in more rural bays which are likely experiencing pressure from other stressors, such as low dissolved oxygen in bottom waters. Although small in total area, the proximity of these impaired sediments to important river mouths and nearshore habitats may disproportionately affect fish, shellfish, and other aquatic life.

Trends

Despite the small improvement shown in this indicator relative to the target, the most striking feature of the data is the apparent widespread decline in overall SQTI scores. This decline was statistically significant in two areas: Central Sound and Bainbridge Basin.

The lower SQTI values were driven primarily by reductions in the benthic invertebrate community measures. There appear to be large increases in the incidence and spatial extent of adversely affected benthos between the first (baseline) samples collected in the late 1990s and more recent samples. Invertebrate abundance and species richness has decreased significantly in some areas. The reasons for the decline in benthic health are not known. Decline in benthic invertebrate communities is evident in both urban and nonurban areas, with only limited correlation with changes in sediment chemistry or toxicity.

Since changes in the benthos aren't closely correlated to the chemical and toxicity-related environmental parameters currently being measured, other factors must be important. Benthic invertebrate communities are affected by a complex interplay of natural and human-caused variables, and there are many environmental factors that can impact benthic invertebrate populations that aren't measured by the SQTI. These include low dissolved oxygen, pH, sediment flux and loading, natural population cycles, and a variety of species interactions. All of these factors can have important local effects. For example, benthic communities sampled in Hood Canal in 2004 appeared to be adversely affected by very low, near-bottom dissolved oxygen concentrations.

Other possible factors include the introduction of new chemicals of concern not currently monitored, and sub-lethal toxic effects such as reproductive impairment, that are not easily identified by current toxicity testing methods.

Over time, changes in sediment quality reflect the cumulative effects of many factors impacting the chemistry, physical processes, and biological responses of the Puget Sound ecosystem. The Sediment Quality Triad is a useful integrating measure of sediment condition, which can both explain observed effects, and help focus new inquiries on emerging problems.

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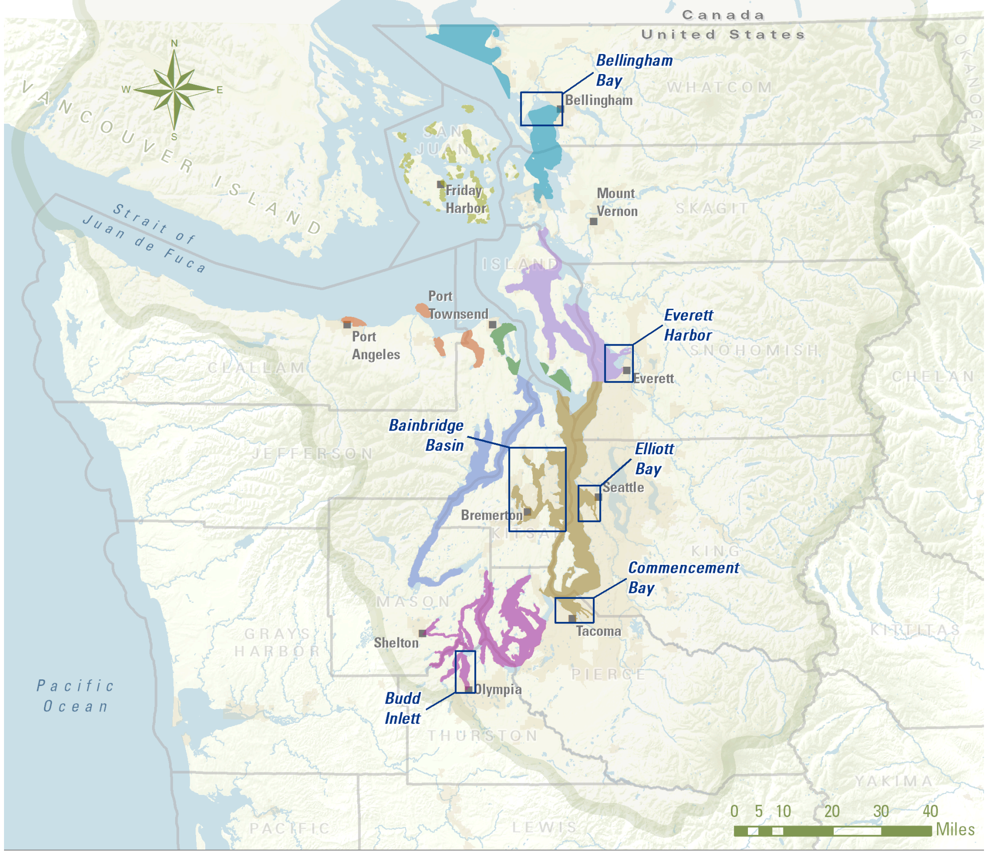
[2] unpublished data, Washington State Dept of Ecology; data not displayed.

[3] Long et al., 2007



Marine sediment monitoring regions and urban bays

Sediment monitoring regions

- 🟩 Admiralty Inlet
- 🟫 Central Sound
- 🟧 Eastern Strait of Juan de Fuca
- 🟦 Hood Canal
- 🟨 San Juan Archipelago
- 🟦 Strait of Georgia
- 🟪 South Sound
- 🟪 Whidbey Basin

- ▢ Cities and Urban Growth Areas
- ☐ County Borders
- ▭ Salish Sea Basin Boundary

Clean sewers, Clean Thea Foss Waterway

Located in the heart of downtown Tacoma, the Thea Foss Waterway was once characterized by dilapidated buildings, oil sheens, coal tar deposits, and contaminated bottom sediments which led the Environmental Protection Agency to declare the waterway a Superfund site in 1983. For more than 100 years, the Thea Foss Waterway had been a sink for waste from industrial dischargers and runoff from the upland drainages.

Today, it's a very different picture. The Thea Foss Waterway is the centerpiece of bustling marinas, internationally renowned museums, restaurants, grass esplanades, luxury apartments, and a variety of business and industry.

Even before the City of Tacoma and its partners finished the $105 million remediation of the Thea Foss Waterway in 2006, they knew it was imperative to find ways to protect the quality of the sediment and receiving water in the waterway.

While significant efforts were made by the City to reduce or eliminate ongoing sources of contamination to the storm drainage system, it was found that elevated levels of PAHs, PCBs , and mercury remained in sediment and debris collected from Tacoma's 100-year-old storm sewer lines. This legacy pollution was being washed into the Thea Foss by stormwater, threatening to degrade the quality of the newly remediated marine sediment.

Photo Credit: mash187@flickr

In response, Tacoma launched two new enhanced maintenance programs to prevent new and legacy contaminants from reaching the waterway.

- Storm Line Cleaning - completed in four entire drainages and part of a fifth between 2006 and 2011. This program was intended to remove legacy contaminants from storm pipe.
- Street sweeping - expanded to a more aggressive city-wide street sweeping program in 2007. This program was intended to remove more street contaminants preventing them from entering the storm system.

These two maintenance efforts, storm cleaning and street sweeping, were above and beyond Tacoma's NPDES permit requirements. This enhanced maintenance resulted in dramatic reductions in contaminant levels:

- PAH1 [1] concentrations showed 59-92% reductions in four drainages tested.
- DEHP [2] concentrations showed 26-68% reductions in three of the four drainages tested.
- TSS [3] concentrations showed 17- 44% reductions in three of the four drainages tested.
- Lead and zinc concentrations showed 11- 36% reductions in three drainages.

These programs were so successful that they are now part of Tacoma's city-wide operating procedures. The work is not over. The City of Tacoma's team of innovative stormwater professionals will continue to use every tool at its disposal– science, investigation, education, enforcement and even intuition – to do its part to protect the investment in the Thea Foss Waterway. Their mission is to create an asset for future generations by making sure stormwater discharges do not harm the health of the water and sediments in the Foss.

[1] PAH = Polycyclic aromatic hydrocarbons, PCB = polychlorinated biphenyl

[2] DEHP = Di-(2-Ethylhexyl) phthalate

[3] TSS = Total suspended solids

Marine Sediment Quality

INDICATOR:

Sediment Chemistry Index

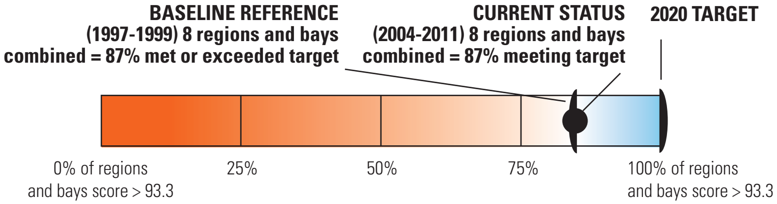
Indicator lead: Maggie Dutch, Department of Ecology

TARGET:

By 2020, all Puget Sound regions and bays achieve chemistry measures reflecting “minimum exposure” with Sediment Chemistry Index (SCI) scores >93.3.

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	NO



BASELINE REFERENCE
(1997-1999) 8 regions and bays combined = 87% met or exceeded target

CURRENT STATUS
(2004-2011) 8 regions and bays combined = 87% meeting target

2020 TARGET

Five Puget Sound regions and three urban bays were sampled from 1997-1999, and re-sampled from 2004-2011. Results show no significant change between sampling periods, with seven of eight areas (87%) meeting (or not statistically different from) the target during both periods.

INDICATOR:

Sediment Quality Standards

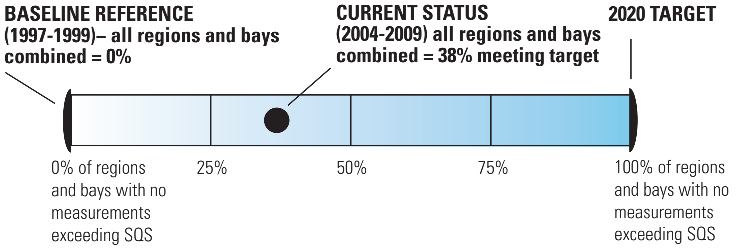
Indicator lead: Maggie Dutch, Department of Ecology

TARGET:

Have no sediment chemistry measurements exceeding the Sediment Quality Standards (SQS) set for Washington State

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	Yes



BASELINE REFERENCE
(1997-1999)– all regions and bays combined = 0%

CURRENT STATUS
(2004-2009) all regions and bays combined = 38% meeting target

2020 TARGET

For five regions and three urban bays evaluated from 1997-1999, no area met the target that 0% of sediment chemistry measurements exceed Washington State Sediment Quality Standards. However, three of the eight areas re-sampled from 2004-2011 did meet this target.

Progress towards 2020 target

Sediment chemistry index values have met or exceeded the 2020 target in all areas sampled so far except Elliott Bay (Figure 1). In all areas that have been sampled twice, none showed any statistically significant change from their original results, including Elliott Bay. Even though the SCI score in Elliott Bay has improved, the change was not statistically different, hence our conclusion that we are not yet seeing progress in this target. Therefore, we remain slightly short of the 2020 goal that all regions and bays show an SCI score >93.3.

The number of individual chemicals exceeding state sediment quality standards (SQS) over the past decade is typically small (mostly less than 1%) except for Central Sound, Elliott Bay, and Commencement Bay, where the number still never exceeded 5%. Even fewer chemicals exceeded state SQS in the most recent round of sampling, with three areas dropping to zero and now meeting the target in those areas. Although the target is not fully met across all of Puget Sound, recent improvements suggest progress toward the target.

What are these indicators?

The Sediment Chemistry Index (SCI) is one component of the Sediment Quality Triad Index. It combines data on the concentrations of a variety of chemicals into an overall index of chemical exposure (Table 1). Contaminants measured as part of the SCI include metals, polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), polybrominated diphenyl ethers (PBDEs – flame retardants), chlorinated pesticides, phthalates, some solvents, and various other pollutants. Note that analyses for newer chemicals of concern, such as dioxins, furans, endocrine disrupting chemicals, pharmaceuticals, personal care products, and perfluorinated chemicals, are not conducted as part of the PSEMP sediment component, and therefore not included in these Sediment Quality Dashboard Indicators.

Higher index values indicate less exposure to chemicals and thus healthier sediments (Table 1). Tracking the SCI gives an indication of how concentrations of those chemicals in marine sediments change over time, primarily in response to anthropogenic input, such as stormwater runoff and direct discharge, as well as cleanup activities and passive burial as cleaner sediments settle over older, and sometimes more contaminated, sediments.

Sediment Chemistry Category	Sediment Chemistry Index
Minimum Exposure	>93.0-100.0
Low Exposure	>80.0 - 93.0
Moderate Exposure	>66.0 - 80.0
Maximum Exposure	>0- 66.0

Table 1. Categories of exposure to chemicals and associated index values

The second (related) indicator reports the percent of individual chemical measurements that exceed the Washington Sediment Quality Standards (SQS). SQS values have been determined for a total of 47 chemicals in Puget Sound. Of those, 39 are included in the SCI and evaluated for this indicator.

Interpretation of data

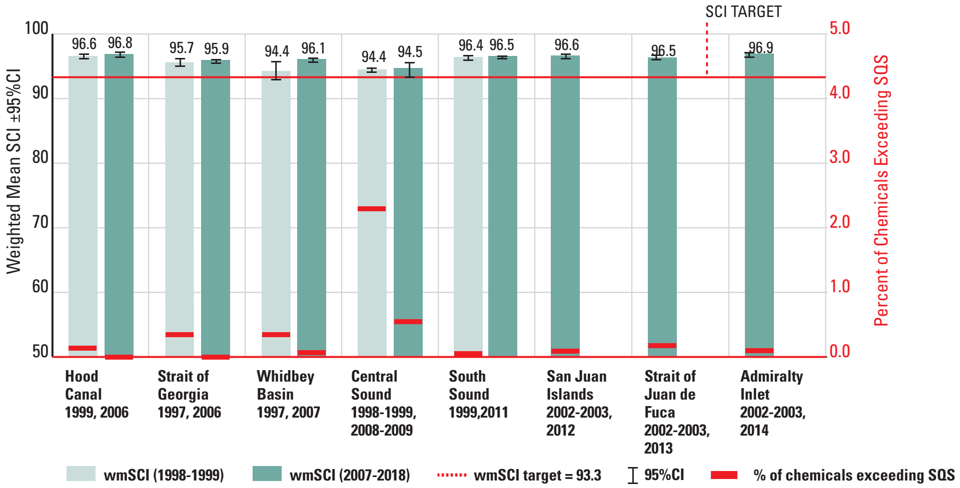
Overall, sediments in Puget Sound appear to be in generally good condition with regard to the measured suite of chemicals. Since 1997, all of the eight sampled regions and four of five urban bays met the SCI target, and values in most areas have changed little since the late 1990s.

In general, levels of toxic chemicals have been, and continue to be, highest in urban bays, but only Elliott Bay was clearly not meeting the SCI target in the low exposure category. The target has not been met in Elliott Bay since SCI scores were first calculated for data collected there in 1998, and only barely met in Commencement Bay, although scores in both bays appear to have improved over the years.

Given that sediment contamination generally changes very slowly, we expect most areas currently meeting the target to continue to do so through 2020 unless contaminant inputs to the areas increase. It is possible that the target may eventually be reached in Elliott Bay if conditions there continue to improve.

The second target, chemicals exceeding state sediment quality standards, was not met over the past decade in most regions and bays, again with urban bays—particularly Commencement and Elliott bays—showing the highest numbers. But the percent of chemicals exceeding the SQS value has declined in most areas that have been re-sampled, with three regions—Hood Canal, Strait of Georgia, and South Puget Sound—now showing no sediment chemical values exceeding SQS, and both Commencement and Elliott bays dropping to below 3%. The value for Bainbridge Basin remained the same, below 1% for 1998 and 2009. Given the direction of the data, it is possible that values will continue to improve and may reach, or come very close to, the target by 2020.

Weighted Mean Sediment Chemistry Index (SCI) Scores for 8 Puget Sound Regions and Percent of Chemicals Exceeding Sediment Quality Standards (SQS)



Weighted Mean Sediment Chemistry Index (SCI) Scores for 6 Puget Sound Urban Bays and Percent of Chemicals Exceeding Sediment Quality Standards (SQS)

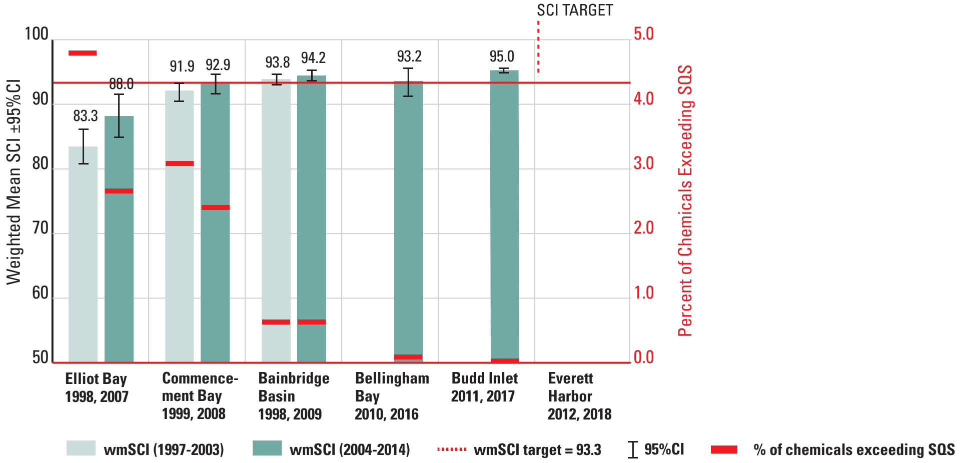


Figure1. The Sediment Chemistry Index (SCI) is shown for eight regions (top panel) and six urban bays (bottom panel). Light bars show results for first-round sampling efforts. Dark bars show results for second-round re-sampling. Higher values indicate healthier sediments. Also shown (red squares) are the percent of chemicals exceeding Sediment Quality Standards (SQS) for each sampling event.

Source: *Washington Department of Ecology, Marine Sediment Monitoring Unit*

Toxics in Fish

Toxic pollutants in our bays, rivers, and streams can show up in the fish that live there, causing them to become diseased and posing a health threat to us when we eat the fish. Pollutants in the Puget Sound ecosystem include several important classes of chemicals including, PCBs, PBDEs, PAHs, and Endocrine Disrupting Compounds.

Concern over these chemicals in Puget Sound is high because they are toxic, they last for a long time in the ecosystem, and their levels increase in predators as the chemicals move up the food chain, a process called biomagnification. Measuring these pollutants in fish tissues tells us whether present-day levels are harmful to the fish or the predators that consume them and whether they are safe for us to eat.

Scientists have been tracking contaminant levels in Puget Sound fish since 1989 and have established threshold limits for these chemicals in fish tissues. These thresholds give us a guideline for the level of toxic chemicals that fish can tolerate, before they become diseased or show other harmful effects.

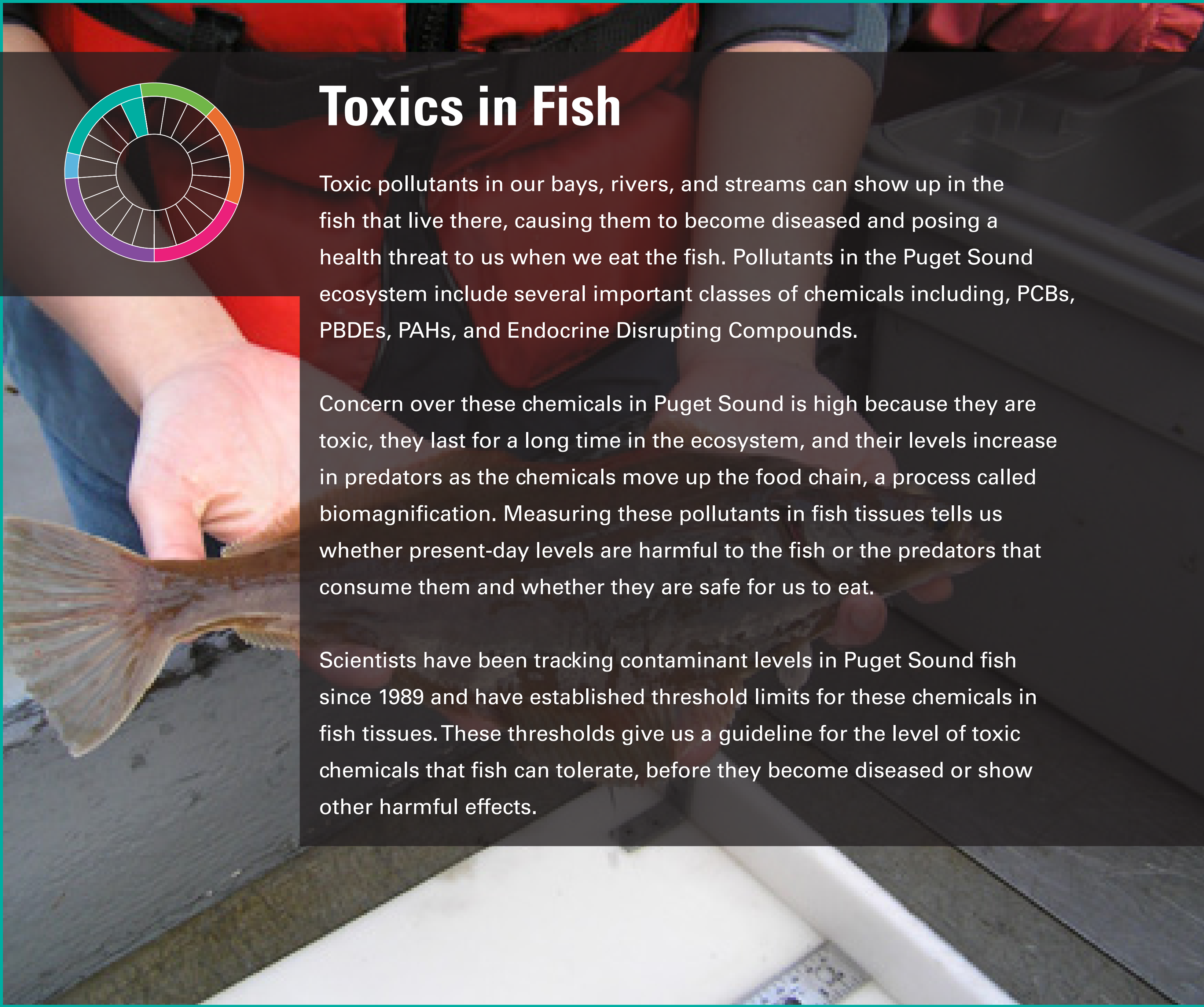


Photo Credit: Walter Rung

Toxics in Fish

INDICATOR:

1)Levels of four types of toxic contaminants in several species of fish
2)Contaminant-related disease in fish

Indicator lead: Jim West, Washington Department of Fish and Wildlife

TARGET:

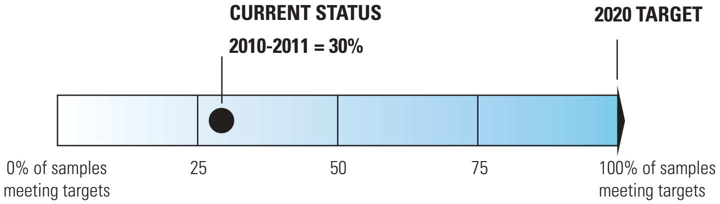
Target 1) By 2020, contaminant levels in fish will be below health effects thresholds (i.e. levels considered harmful to fish health, or harmful to the health of people who consume them)
Target 2) By 2020, contaminant-related disease or impairments in fish are reduced to background levels

Contaminant Type 1

Polychlorinated Biphenyls (PCBs)

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**NO**



PCBs exceeded health effects thresholds or have been identified as a risk to seafood consumers in recent years for (1) urban English sole, (2) adult Chinook salmon returning to Puget Sound rivers, (3) juvenile Chinook salmon in Puget Sound or its river mouths, and (4) Pacific herring in Southern and Central Puget Sound. There has been no significant decline in PCBs in these species for the period monitored. However, adult coho salmon returning to Puget Sound rivers were below thresholds.

Progress towards 2020 targets

The full 2020 target language for toxics in fish that was adopted by the Leadership Council is complex, relating four different classes of chemical contaminants to three different types of fish (herring, English sole, and salmon/steelhead), with four different concentration thresholds that range from no adverse effects to no toxics-related reproductive impairment.

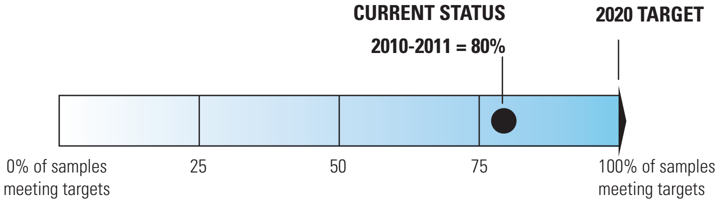
Making progress towards 2020 targets requires identifying which chemicals are most problematic, and then controlling their sources or cleaning up pollutants that have accumulated in the environment.

Contaminant Type 2

Flame Retardants (polybrominated diphenyls, or PBDEs)

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**YES**



Evaluation of PBDEs is challenging because health effects thresholds are not yet available for some species. However, it appears that levels in most species are at levels below obvious, immediate concern for most areas. In addition, PBDE levels appear to be declining in Pacific herring from Central and Southern Puget Sound.

The danger of some chemicals (such as PCBs) was identified, and source controls imposed, over thirty years ago. PCB levels in Puget Sound fish today are probably ten times lower than they were in the 1970s, but they have not changed appreciably in the past 20 years. Current PCB levels are high enough to trigger Department of Health consumption advisories for Chinook salmon and other species, and are probably still high enough to harm fish health. Further reduction of PCBs in the ecosystem will likely require a combination of activities, including cleaning up contaminated sediments, identifying and halting new sources of PCBs into the system, and waiting for existing PCBs in the system to degrade or become unavailable.

Some progress towards 2020 targets for PBDEs has been made. The danger of flame retardants (polybrominated diphenyl ethers, or PBDEs) was recognized relatively recently, and source controls have been imposed. These include a legislated ban on the use of certain PBDE compounds and voluntary reduction in production of other compounds by industry. Although it is unclear whether these actions were responsible, PBDEs have been declining in one monitored species, Pacific herring, from Central and Southern Puget Sound, to levels that are likely below cause for concern.

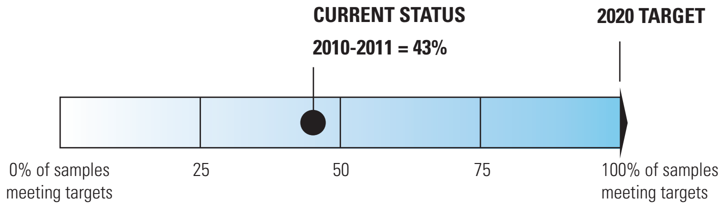
Progress related to hydrocarbons (polycyclic aromatic hydrocarbons, or PAHs) has been mixed. This is probably related to the huge range of sources for these compounds (they come from petroleum, and from burning fossil fuels), and the difficulty in controlling such pervasive sources. Some effects of PAHs in the ecosystem may be significant but are currently not monitored. Of the effects represented by this indicator, we have seen a dramatic decline in PAH-related liver disease from prevalence rates of over 30% to less than 10% in English sole from Elliott Bay, one of Puget Sound's most highly contaminated bays. The reason for this recovery is unclear, but could be related to sediment cleanup, removal of creosote-treated pilings, or

Contaminant Type 3

Hydrocarbons (products of petroleum or combustion; polycyclic aromatic hydrocarbons, or PAHs)

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**NO**



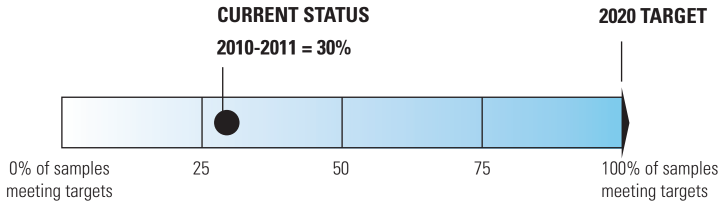
PAHs are tracked in fish by measuring byproducts (metabolites) of the compounds in their body fluids (in Pacific herring), or by measuring liver disease caused by PAH exposure (in English sole). PAHs levels in herring, a water-column species, from Central and Southern Puget Sound are similar to those of some urban English sole, a bottom-dwelling species. PAH levels in both species from these areas are cause for some concern. However PAH-related liver disease has declined to near background levels in one urban area (Elliott Bay).

Contaminant Type 4

Endocrine Disrupting Compounds (typically from pharmaceuticals, personal care products, but also from a wide range of other chemicals)

PROGRESS:

IS THE TARGET MET?	**NO**	**IS THERE PROGRESS?**	**UNKNOWN**



Endocrine disrupting compounds (EDCs) are chemicals that alter the normal hormonal system of fish, often resulting in problems related to growth or reproduction. EDCs have been evaluated in two species, English sole (adults) and Chinook salmon (juveniles). EDC-related feminization of male English sole was observed at five of six sampled locations, and in juvenile Chinook salmon from three of four sampled locations

Toxics in Fish

control of new inputs to the bay.

Not enough monitoring has been conducted yet to fully evaluate progress towards the target of reducing Endocrine Disrupting Compounds (EDCs). These chemicals originate from a huge range of sources including pharmaceuticals, personal care products, plastics, other industrial, agricultural or household products, and some of the chemicals described above. EDC effects were observed in fish, primarily as a trend towards feminization of males, in most places where English sole and juvenile salmon were sampled. Only one status survey has been conducted for these species so far. Unlike the pollutants above, EDC effects have been observed in fish from waters surrounded by rural areas. Many of these chemicals can be introduced to aquatic systems via wastewater.

What are these indicators?

Indicators

Each of the Toxics in Fish indicator metrics begins with a measure of the degree to which fish are exposed to toxic contaminants. In most cases this means measuring the chemicals in fish tissues, in the form of "tissue residues". In some cases fish systems can break down or metabolize the chemicals, in which case the pollutants don't accumulate in their bodies. In these cases chemists measure "metabolites" of the chemicals, usually in the bile or blood of the fish.

In order to understand the potential harm these chemicals may cause, these metrics also incorporate an understanding of the "health effects threshold" of each chemical for each species. This is the level of contamination an individual can tolerate before it experiences some health effect. The combination of knowing what contaminant levels the fish is exposed to with its tolerance for a chemical provides a guide for selecting recovery targets.

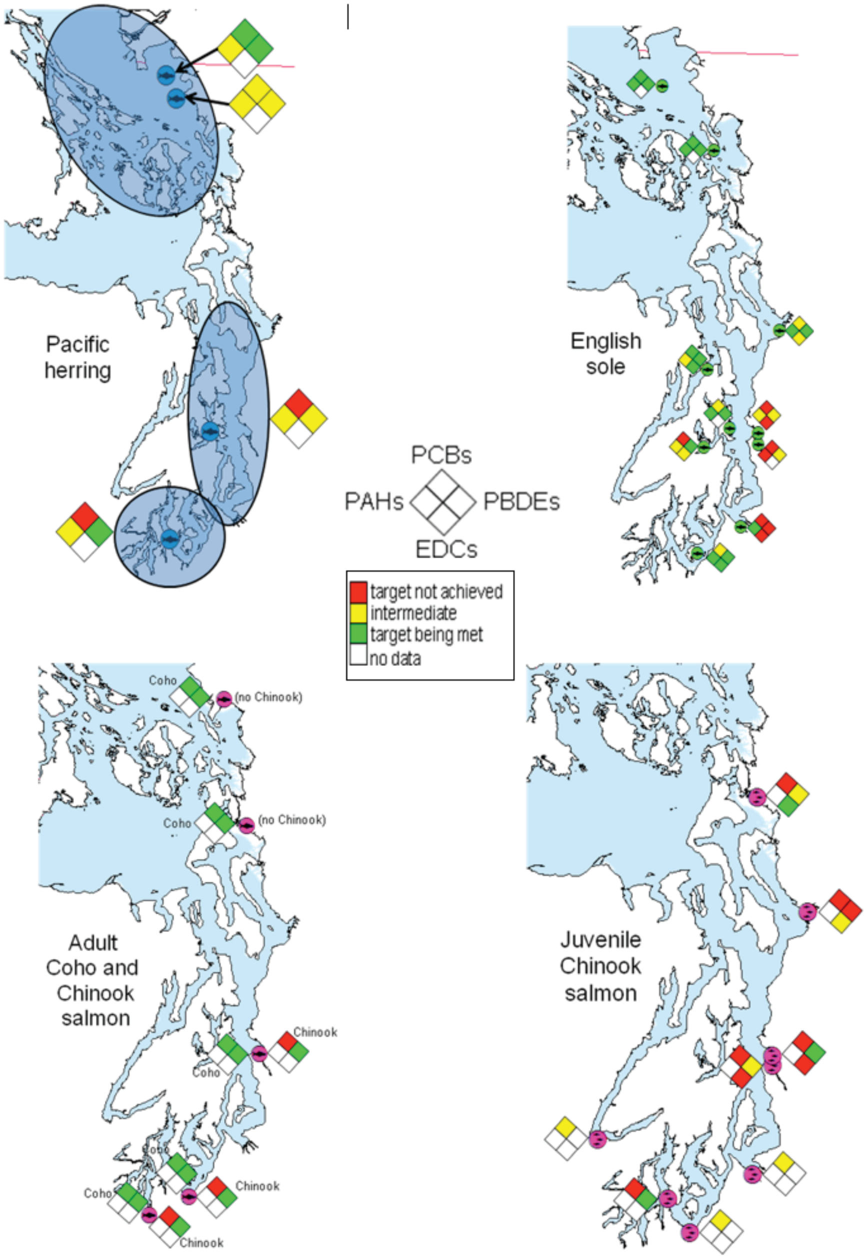
In some cases it is easier to measure contaminant-induced disease or other health impairment directly. Examples of these metrics in the Toxics in Fish Indicator are PAH-related liver disease and EDC-related reproductive impairment in English sole. In these cases it is possible to observe recovery of fish health directly, after exposure to the contaminant is removed from the fish's habitat.

The Contaminant Monitoring Program

The Washington Department of Fish and Wildlife monitors toxic contaminants in fish and other organisms, as a member of the Puget Sound Ecosystem Monitoring Program (PSEMP). This program has tracked the indicator metrics described above for several species in the ecosystem, in addition to a number of chemicals not covered here. In addition, the PSEMP Toxics in Fish Unit has conducted a number of focus and diagnostic studies, along with partners including NOAA Fisheries, to develop new markers and investigate contaminants in the food web.

Interpretation of data

The Indicator metrics provided in this summary simplify a highly complex relationship between exposure of organisms to pollutants, and the effects such exposure might have on their health. Toxic contaminants in Puget Sound are found in fish throughout the ecosystem – not just in urban areas, and not just in bottom-dwelling fish. In addition, many contaminants accumulate in fish as they age. Some of these "bioaccumulative" contaminants also move up the food chain, increasing to high concentrations in apex predators. It is important to interpret data with reference to where the fish live, where they were sampled, their age, and their position in Puget Sound's food web.



Climate Change and Its Impact on the Status of the Ecosystem

Puget Sound is especially vulnerable to climate change, which has already disrupted its environment, economy, and communities. Without action, climate change will negatively affect nearly every part of Washington's economy through changes in temperature, sea level, and water availability.

Climate change pressures in Puget Sound include changes in stream flow timing and volume, air and water temperature, loss of snow-fed water supplies, sea level rise, and ocean acidification. These pressures will have serious consequences for human health, including reduced water supply, losses to agriculture and forest industries, losses of fish and wildlife, impaired functioning of natural systems, and increased frequency, and intensity of extreme weather event such as droughts, floods, heat waves, wildfires, and heavy rain and snow storms. Other impacts to natural resources and Puget Sound communities will vary, but these are not as readily predictable.

Puget Sound climate is also affected by large-scale patterns of natural variability, particularly the El Niño/Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO). While it is not clear at this time how climate change will affect the frequency or intensity of ENSO or PDO, we should expect continued year-to-year and decade-to-decade variability in regional conditions even as the long-term mean around which we vary is affected by climate change.

Adapting to our changing climate means understanding how climate change could affect priority recovery issues and using that knowledge to take steps that will reduce or avoid the negative impacts of climate change. Although we should seize opportunities that exist now, adaptation is part of long-term risk management, not a one-time effort. Decision-makers must consider the impacts of climate change when funding and prioritizing restoration projects.

Climate change affects more than just the weather and the seasons. Climate patterns play a fundamental role in shaping natural ecosystems as well as the human economies and cultures that depend on them. Because so many systems are tied to climate, a change in climate can affect many related aspects of where and how people, plants, and animals live, including food production, availability and use of water, and health risks. For example, a change in the usual timing of rains or temperatures can affect when plants bloom and set fruit, when insects hatch or when streams are their fullest. This can affect historically synchronized pollination of crops, food for migrating birds, spawning of fish, water supplies for drinking and irrigation, forest health, and more.

Climate Change and the 2012 Action Agenda

To ensure that the 2012 Action Agenda is consistent with state strategies and actions for responding to climate change, its approximately 250 strategies, sub-strategies, and actions were reviewed to determine their degree of climate sensitivity. Roughly half reflected observed and predicted changes in climate or aligned to the state's climate response strategy. Based on this review, achieving our long-term goal of Puget Sound ecosystem

What are climate change and global warming?

Global warming refers to the recent and ongoing rise in global average temperature near Earth's surface. It is caused mostly by increasing concentrations of greenhouse gases in the atmosphere. Global warming is causing climate patterns to change. However, global warming itself represents only one aspect of climate change.

Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among other effects, that occur over several decades or longer.

Source: EPA

recovery requires consideration of the relevance of climate change to strategies and actions beyond the 2020 time horizon of the Action Agenda.

The Department of Ecology recently released Preparing for a Changing Climate: Washington State's Integrated Climate Response Strategy (April 2012). Adaptation steps reduce the vulnerability of human and natural systems, increase the capacity to withstand or cope with changes in climate, and transform the system to be compatible with likely future conditions. Many adaptation strategies are considered win-win strategies because they address existing stresses on communities, economy, and environment while also helping reduce climate-related risks.

State climate response strategies and actions were integrated into the 2012 Action Agenda. Each strategy or sub-strategy of the Action Agenda includes a description of climate change impacts and related state strategies. Where possible, a climate change adaptation step was included in Near Term Actions. Climate change next steps are included in the future opportunities and emerging issues for each strategy section.

Fully integrating climate change into the Action Agenda will require looking at the implications of a changing climate beyond 2020. This will entail revisiting and possibly adjusting our definitions of a healthy Puget Sound, how we measure and evaluate progress, our use of value terms such as priority, ecologically important, sensitive, and high value. This also means that we will continually design and adjust policies, plans and tools so they account for a changing and variable climate.

This year and next, the Puget Sound Partnership and the Puget Sound Institute are working with the University of Washington's Climate Impacts Group to synthesize and update a growing body of climate change science. This new information will become part of the Puget Sound Science Review in the Encyclopedia of Puget Sound.

How Climate Change Guidance Is Applied to Near Term Actions

The degree of climate sensitivity for each Near Term Action was evaluated based on the following questions:

- Do proposed restoration projects take into account observed or likely changes in climate? If not, is it possible to do so?
- Given the likelihood of climate change, will a proposed project provide even some recovery benefits?

Example: **2008 Action Agenda Near Term Action A.1.2**

Near Term Action A.1.2: Prepare a set of criteria to guide decisions for acquiring and protecting high-value, high-risk habitat.

Is the Near Term Action sensitive to changes in climate?

Yes. Habitat type, quality, and distribution may be affected by changes in temperature, precipitation, salinity, sea level, and other climate-related factors. Therefore, climate change may affect what is currently defined as "high-value, high-risk habitat."

Can the Near Term Action meet its objectives "as is" given its sensitivity to climate?

While the act of preparing the criteria described in this Near Term Action is not sensitive to climate, the criteria may be inadequate if they do not consider how climate change may affect target habitats.

Suggested adjustments for implementation:

1. climate change should be considered when designating "high risk habitat
2. the criteria should include an assessment of how climate change is anticipated to affect habitat being evaluated.

Climate Changes

☑ **Changes in streamflow timing and volume:** Watersheds with streamflow based mostly or partially on snowmelt are projected to have the greatest hydrological shifts associated with climate change. Impacts to streamflow include earlier peak streamflows, decreasing runoff in late spring and summer, and increasing runoff in fall and winter.

☑ **Temperature changes:** Despite natural climate variability between years and decades, average annual and seasonal temperature is expected to continue to increase over the coming century. Most models project an enhanced seasonal precipitation cycle with wetter winters and drier summers.

☑ **Loss of snowpack and glacial retreat:** The loss of snowpack and glacial retreat are one of the most far-reaching impacts of rising temperature, affecting water availability for both people and wildlife. Under a moderate warming scenario, average spring snowpack in Washington State is projected to decrease 29% by the 2020s.

☑ **Sea Level Rise:** Global sea level is rising due to ocean thermal expansion and melting of land-based ice sheets. A medium estimate of sea level rise in the Puget Sound region is +6 inches (range of 3 to 22 inches) by 2050. Major impacts associated with sea level rise are likely to be inundation of low-lying areas, flooding, erosion, and infrastructure damage, with the largest impacts occurring when storm and river flooding events converge with high tides. Shifts in or loss of coastal habitat types is another major concern associated with sea level rise.

☑ **Ocean Acidification:** As the global ocean absorbs atmospheric carbon dioxide, these increasing concentrations are reducing ocean pH and carbonate ion concentrations, resulting in ocean acidification. Impacts of ocean acidification include altered marine food web, loss of shellfish production, and impacts to the growing environment for sea grasses like eelgrass.

Consequences of Climate Change

☑ Severe impacts and risks to human health from increased injuries and disease due to higher temperatures, heat waves, declining urban air quality, and smoke from more frequent wildfires. More frequent extreme storms are likely to cause river and coastal flooding that could lead to increased injuries and loss of life.

☑ Increased damage costs and disruptions to communities, transportation systems, and other infrastructure. Damage to roads, bridges, ports, rail, power, and communication transmission systems, and communities due to extreme storms, flooding, erosion, landslides, sea level rise, and storm surges could occur. In Puget Sound counties, structures valued at $29 billion are located in flood hazard areas. Ports, rail, highways, wastewater treatment plans, and other infrastructure could require retrofits or relocation to accommodate rising sea levels and stronger coastal storms.

☑ Reduced summer water supply. Increasing temperatures will significantly reduce snowpack in the Cascade and Olympic Mountains. This will lead to reduced summer streamflows, reduced soil moisture, higher summer stream temperatures, and an increased risk of drought for Washington's water users, including agriculture, municipalities, and fish and wildlife. Increased water demand could increase the potential for conflict among users.

☑ Loss of fish, wildlife, and natural systems. Species will be forced to move northward or higher in elevation, and some will perish. Higher summer stream temperatures and reduced flows are projected to increase lethal stream conditions for salmon and other coldwater species. Increased forest fires will destroy habitat, leading to erosion and degraded water quality. Sea level rise is projected to eliminate valuable habitat, and increasing ocean acidity and upland runoff threatens shellfish aquaculture.

☑ Losses to agriculture and forest industries. Increased disease, pests, weeds, and fire, along with reduced summer water supplies, are already affecting Washington's farms and forests. Crops and yields are also likely to be impacted.