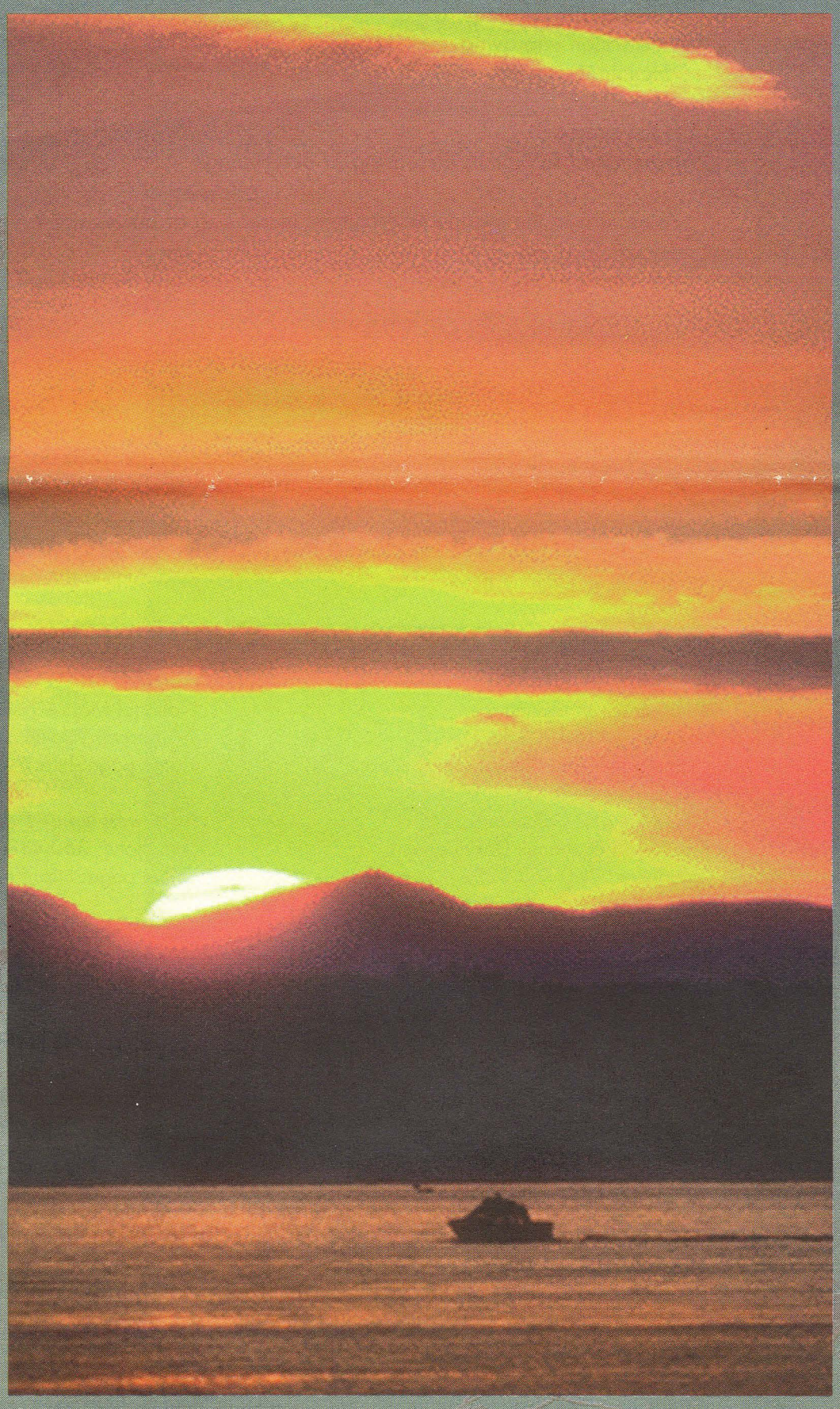
PUGET SOUND'S HEALTH 1998

A Special Report on the Status and Trends of Key Indicators of Puget Sound's Health



PUGET SOUND
WATER QUALITY
ACTION TEAM
Office of the Governor

Puget Sound Water Quality Action Team
Office of the Governor

The Puget Sound Water Quality Action Team works with federal, state, tribal and local governments, businesses and citizens to develop and implement two-year work plans that protect water quality and biological resources. The biennial work plans are based on the Puget Sound Water Quality Management Plan. The management plan outlines a strategy for protecting Puget Sound.

Members of the Action Team include the heads of 10 state agencies, a tribal representative, a city representative and a county representative, and the regional heads of the U.S. Environmental Protection Agency, the National Marine Fisheries Service, and the U.S. Fish and Wildlife Service.

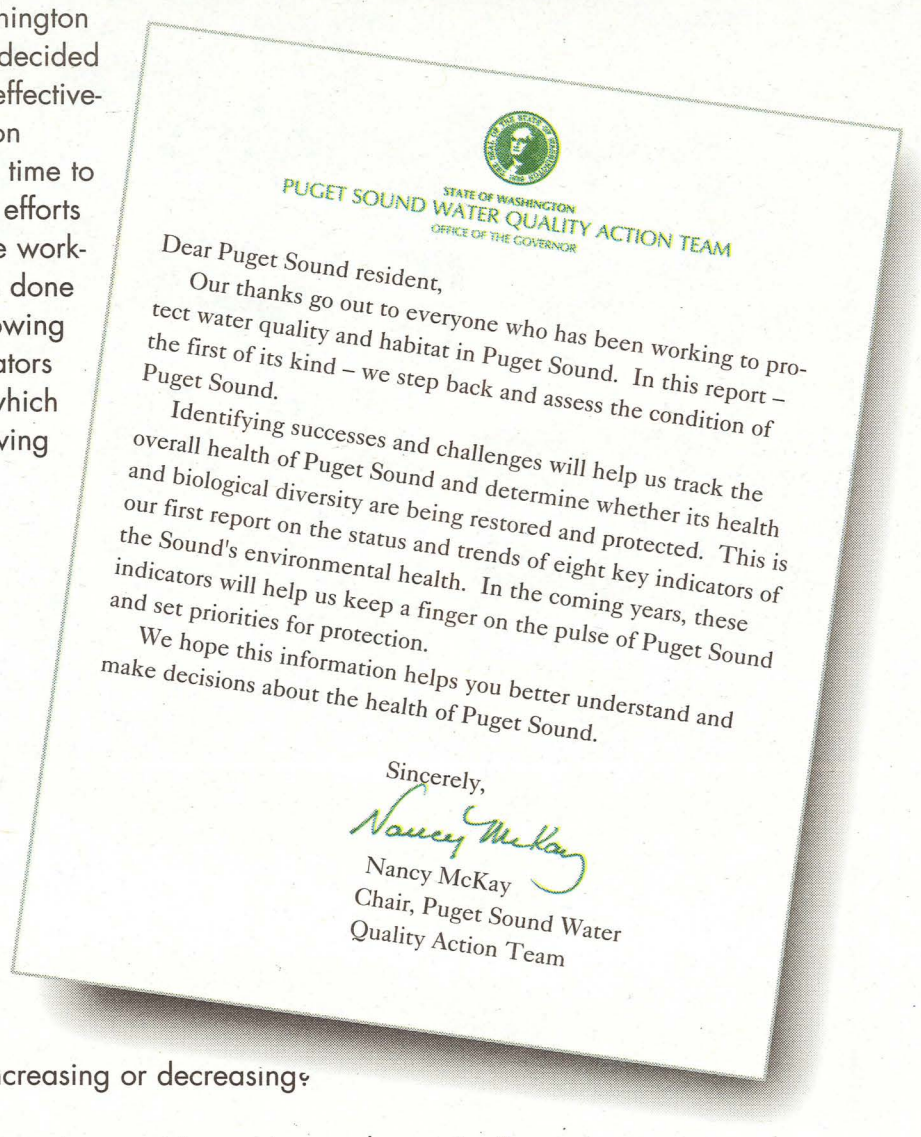
The Puget Sound Council's members represent agriculture, business, cities, counties, the environmental community, the legislature, the shellfish industry and tribal governments. The Council advises the Action Team as it develops and implements work plans, and it monitors implementation of work plans.

Production of this report was funded through a cooperative agreement with the U.S. Environmental Protection Agency. Printed on recycled paper using soy-based inks. Designed by Apple International Inc.

If you need this report in an alternative format — large print, Braille, cassette tape — please contact the Action Team's ADA representative at 360-407-7306.

About Puget Sound's Health 1998

In 1996 the Washington State Legislature decided that, in order to effectively target protection efforts in the future, it was time to evaluate how well current efforts to protect Puget Sound are working. The Action Team has done this by answering the following questions about key indicators of Puget Sound's health, which are described in the following pages.



STATE OF WASHINGTON
PUGET SOUND WATER QUALITY ACTION TEAM
OFFICE OF THE GOVERNOR

Dear Puget Sound resident,

Our thanks go out to everyone who has been working to protect water quality and habitat in Puget Sound. In this report – the first of its kind – we step back and assess the condition of Puget Sound.

Identifying successes and challenges will help us track the overall health of Puget Sound and determine whether its health and biological diversity are being restored and protected. This is our first report on the status and trends of eight key indicators of the Sound's environmental health. In the coming years, these indicators will help us keep a finger on the pulse of Puget Sound and set priorities for protection.

We hope this information helps you better understand and make decisions about the health of Puget Sound.

Sincerely,

Nancy McKay

Nancy McKay
Chair, Puget Sound Water Quality Action Team

- Are fish and wildlife populations increasing or decreasing?
- Are areas where shellfish can be safely harvested increasing or decreasing?
- Is the quality of water for recreation improving or declining?
- Is the area of contaminated sediments increasing or decreasing?
- Are toxins in the marine environment increasing or decreasing?
- Are the size and frequency of oil spills increasing or decreasing?
- Are functional wetlands increasing or decreasing?
- Is fish and wildlife habitat increasing or decreasing?

The answers to these questions will help us make better decisions by focusing attention on areas of concern and identifying problems before it's too late to reverse their effects.

An advisory group of federal, state, tribal and local governments and businesses helped the Action Team develop this report. The environmental indicators draw on information that is available from different sources, including the Puget Sound Ambient Monitoring Program.

FOR MORE INFORMATION

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Interagency Committee for Outdoor Recreation
Telephone: 360-902-3000
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National Marine Fisheries Service
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Home page: http://www.nwr.noaa.gov/

Northwest Indian Fisheries Commission
Telephone: 360-438-1181
Home page: http://mako.nwifc.wa.gov/

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Home page: http://www.wa.gov/puget_sound/

State Parks and Recreation Commission
Telephone: 360-902-8511
Home page: http://www.parks.wa.gov/

U.S. Environmental Protection Agency, Region 10
Telephone: 206-553-4423
Home page:
http://www.epa.gov/r10earth/index.html

U.S. Fish and Wildlife Service
Telephone: 360-753-9440
Home page: http://www.r1.fws.gov/

Washington State Conservation Commission
Telephone: 360-407-6200
Home page: http://www.conserver.org/wcc.html

Puget Sound: A Changing Estuary

Since the first settlers set foot on the shores of Puget Sound, human activities have been changing the estuary. We need to track how we are changing the environment and how well efforts to protect water quality and habitat are working. This report begins to answer questions that will help us chart our course for the future.

Some Facts About Puget Sound

- Puget Sounders own more than 16,000 power boats, 21,500 sailboats, 43,500 canoes and kayaks, and numerous sailboards, inflatable boats and other personal watercraft.

- The Puget Sound basin is home to 3.8 million people – two-thirds of the state's population.

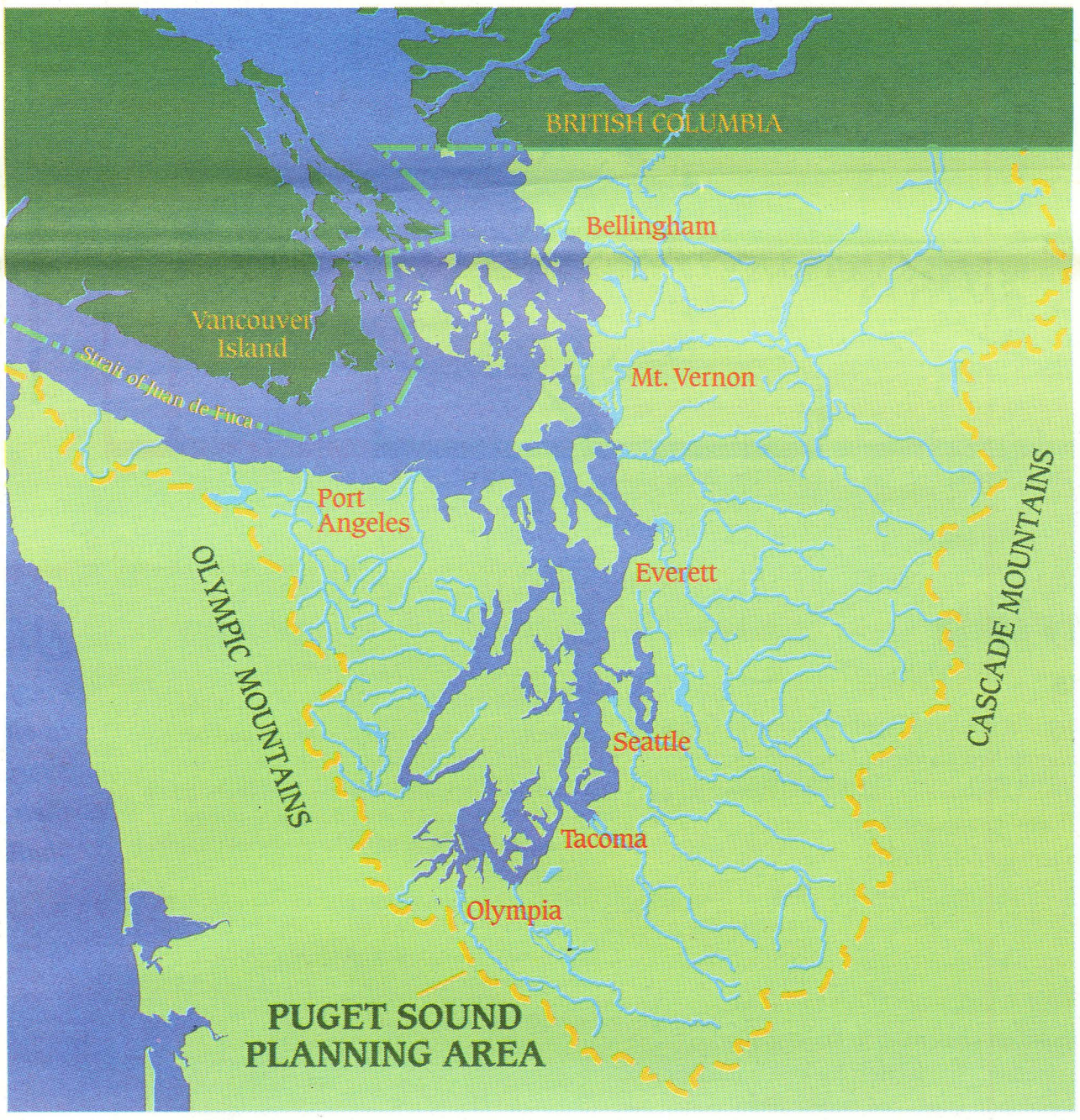
- By 2020, another 1.4 million people will settle in the basin – about the same number as currently reside in King County.

- The number of miles driven by Puget Sounders increased by 40 percent in the last 10 years.

- In 1995, three-quarters of the state's tourists visited the Puget Sound basin, spending $6.1 billion. Tourism generated a $1.3 billion payroll, supported 79,110 jobs and provided $380 million in local and state tax revenue.

- Puget Sound is a major U.S. port. On average, 3,000 cargo and passenger vessels and 560 tank ships travel through Puget Sound each year. In 1996, more than 4,000 tank barges transporting crude oil, refined petroleum products and various chemicals moved through Puget Sound.

- Fishing and shellfishing are economic mainstays for the region. Shellfish harvesting is a $30 million industry in Puget Sound. Annually, some 22,000 tons of salmon worth $44 million are harvested from Puget Sound.



Puget Sound is the nation's second largest estuary.

Its environment, climate and economy continue to attract new businesses, industry and residents. The Puget Sound planning area – which defines the area targeted for protection – encompasses over 2,000 miles of shoreline and includes 16,000 square miles of land and water.

Are Fish and Wildlife Populations Increasing or Decreasing?

Puget Sound is home to over 220 species of fish, 26 different kinds of marine mammals, 100 species of seabirds and thousands of marine invertebrate species. Some species are migratory, while others remain in the Sound year-round. Some fish and wildlife populations are increasing while others are decreasing.

Species used to indicate population size

- Herring
- Diving ducks (scoters)
- Wild salmon
- Harbor seals

Why select these species?

Wild salmon, Pacific herring, scoters and harbor seals are good indicators of Puget Sound's fish and wildlife population, primarily because each occupies a very different place in the Sound's ecology. Wild salmon are one of the few fish that need both marine and fresh water to survive. Pacific herring are eaten by many fish, birds and marine mammals. Scoters are the most abundant of Puget Sound's marine birds. Harbor seals are high in Puget Sound's food web and, as a top predator, they accumulate pollutants present in their diet.

What affects these species?

Many stresses influence fish and wildlife populations. Some we can control, such as harvest and the quality of water and habitat. Stresses we cannot control, such as natural forces like El Niño, influence weather patterns and oceanographic conditions and may significantly affect fish and wildlife populations. Habitat loss and harvest significantly affect the survival of wild salmon and herring. The quality of food affects the distribution and abundance of scoters.

Scoter photo courtesy of Frank S. Todd

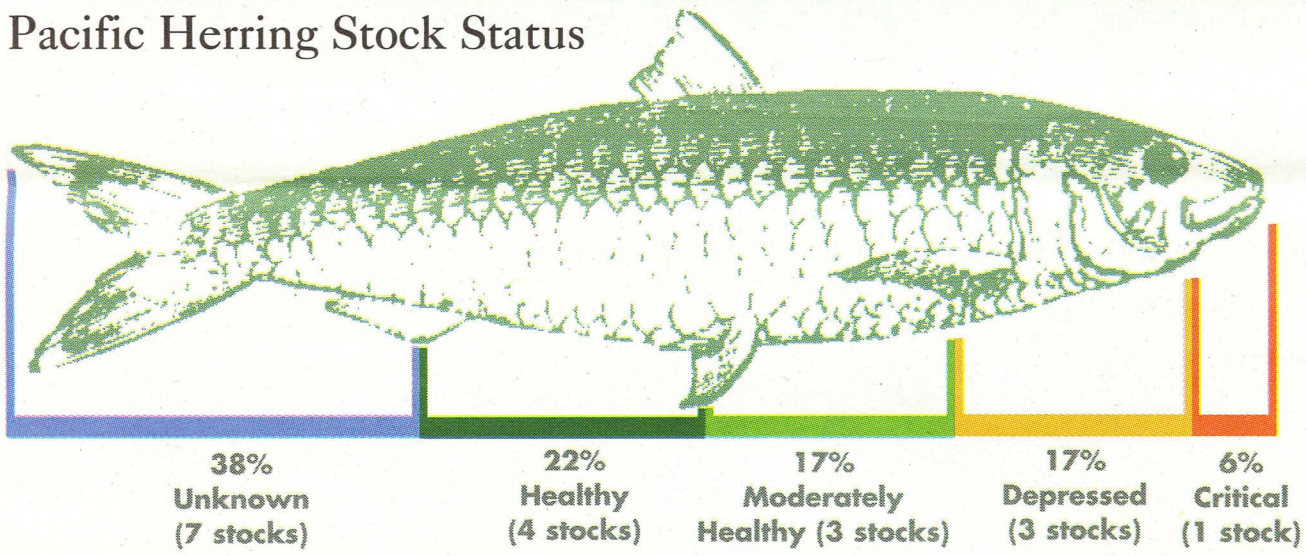
Scoters

Status

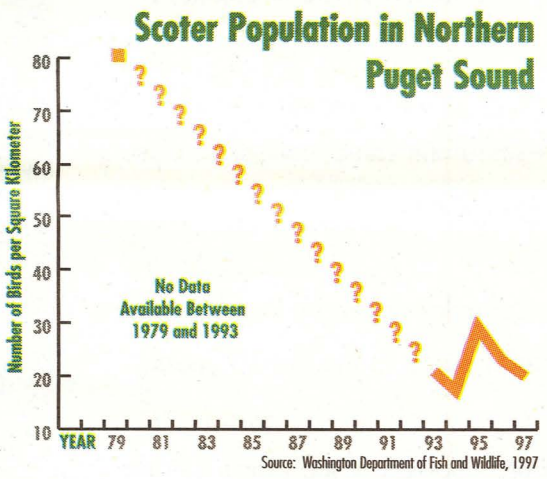
Scoters are the most numerous diving duck in Puget Sound during the winter, making up nearly half the mid-winter diving duck population.

Trends

Since 1979, the number of scoters spending winters in Puget Sound has declined by at least 50 percent. Scoters eat shellfish, unlike other diving ducks with similar habitat requirements. Scientists speculate that contaminated shellfish are affecting the distribution and abundance of these birds. Populations of other diving ducks (with the possible exception of scaup) have not declined.



Source: Washington Department of Fish and Wildlife, 1997.



Source: Washington Department of Fish and Wildlife, 1997

Herring

Status

There are 18 stocks of Pacific herring in Puget Sound. Twenty-two percent of these stocks are not faring well and are classified as depressed or critical. Thirty-nine percent are considered healthy to moderately healthy. The status of the remaining 38 percent of herring stocks is unknown.

Trends

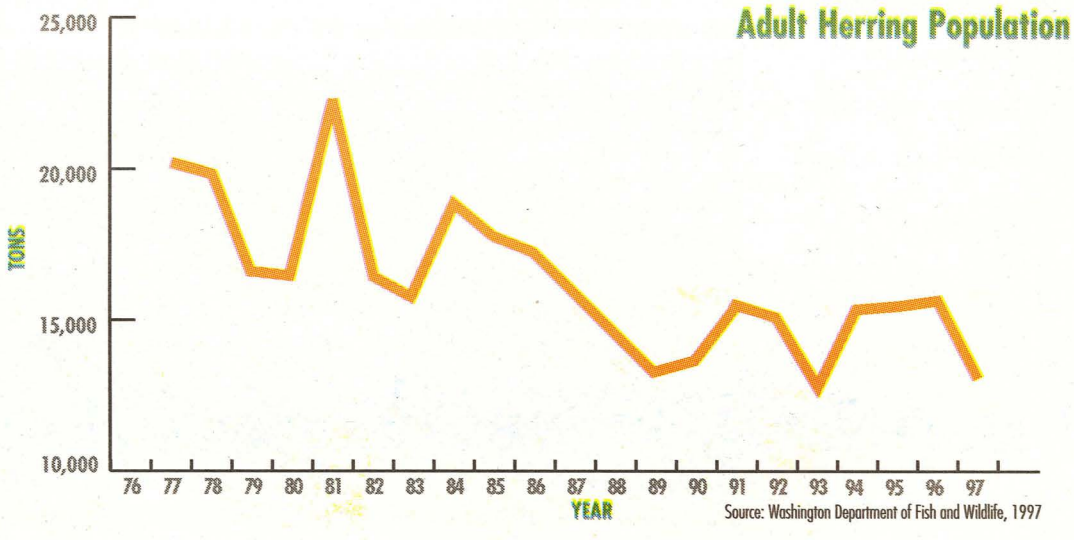
The population of herring in Puget Sound is declining steadily. The reason for this is unclear. Current population levels are sustained by average or above-average populations of young fish that have not yet spawned. Because the population is dominated by young fish, the herring stock is vulnerable. If natural or human-caused conditions killed off a large number of these fish, it would be difficult for the stock to recover.

Herring Stock Classification System

Critical: Abundance is so low that the stock has sustained or is likely to sustain permanent damage.
Depressed: Production is below expected long-term averages. Permanent stock damage is unlikely.
Moderately Healthy: Abundance is within 25 percent of expected levels.
Healthy: Stock production is at or above expected levels.
Unknown: There is not enough information to make an assessment.

Did You Know?

Pacific herring are especially vulnerable to oil and surface chemicals from February to May, when females deposit their eggs on eelgrass or seaweed in shallow waters.



Source: Washington Department of Fish and Wildlife, 1997

Wild Salmon

Status

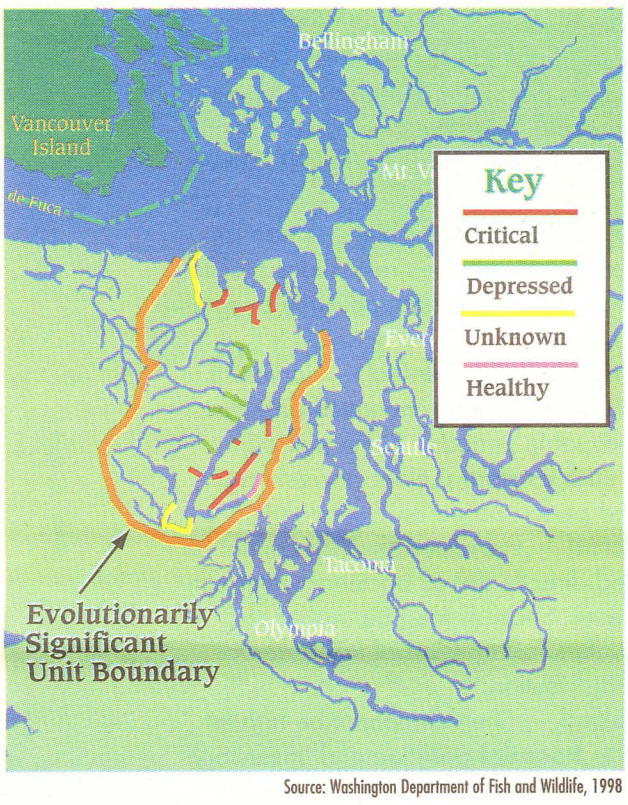
The 1992 Salmon and Steelhead Stock Inventory identified 209 stocks of salmon and steelhead in Puget Sound, including species of chinook, chum, coho, pink, sockeye and steelhead. About one-quarter were classified as critical or depressed. The status of about 30 percent was unknown.

Dramatic declines in the populations of salmon stocks prompted the National Marine Fisheries Service in March 1998 to propose listing Puget Sound chinook, Hood Canal and Strait of Juan de Fuca chum, and several other species as threatened under the Endangered Species Act. The declines are largely a result of activities such as water withdrawals, forestry, agriculture, urban development, dams, fishing and hatcheries. The state of Washington is developing a State Salmon Strategy to protect and restore wild steelhead and other salmon and trout species.

Trends

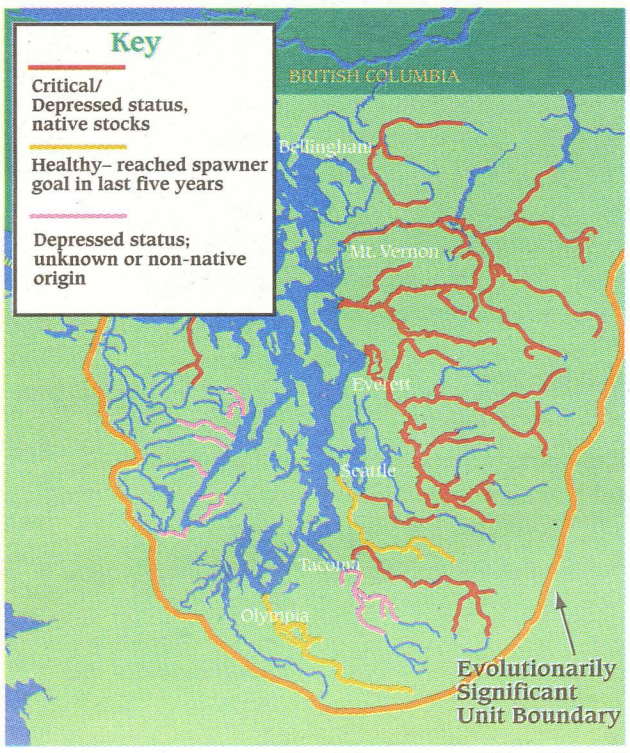
The 1992 Salmon and Steelhead Stock Inventory is under review and will be updated.

Hood Canal and Strait of Juan de Fuca Summer Chum Stock Status and Distribution



Source: Washington Department of Fish and Wildlife, 1998

Puget Sound Chinook Stock Status & Distribution (29 stocks)



Source: Washington Department of Fish and Wildlife, 1998

Salmon & Steelhead Stock Classification System

Extinct: The stock is no longer present in its original range, or as a distinct stock elsewhere.
Critical: Stock abundance (production level) is so low that the stock has sustained or is likely to sustain permanent damage.
Depressed: Production is lower than expected based on available habitat and natural variations in survival rates. Permanent damage to the stock is not likely.
Healthy: Stock production is at expected levels.
Unknown: Insufficient information exists on the status of the stock.

Did You Know?

Chinook are the largest and least abundant of all North American Pacific salmon. They live in large streams and rivers for a year before migrating to the ocean. Coho salmon spawn in small streams and live in wetlands for more than a year before migrating to the ocean. Steelhead may live in fresh water for several years before entering marine waters.

Puget Sound Salmon and Steelhead Stock Status

	Total	Healthy	Critical or depressed	Extinct	Unknown
Chinook	29	10	12	0	7
Coho	46	20	17	0	9
Chum	55	38	3	1	13
Pink	15	9	4	0	2
Sockeye	4	0	4	0	0
Steelhead	60	16	15	0	29
TOTAL	209	93	55	1	60

Source: Washington Department of Fish and Wildlife, Salmon and Steelhead Stock Inventory, 1992

Harbor Seals

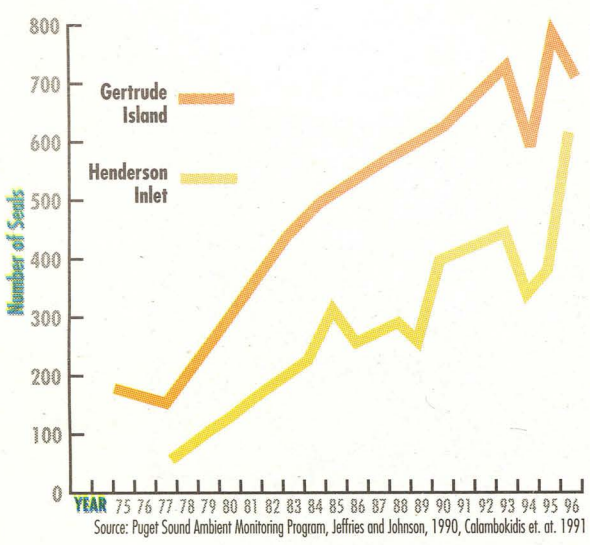
Status

In 1996, about 17,000 harbor seals lived in Puget Sound waters, including Hood Canal, the Strait of Juan de Fuca and the San Juan Islands.

Trends

The number of harbor seals breeding at Gertrude Island and Henderson Inlet in southern Puget Sound has increased approximately six percent a year since 1983. Harbor seal populations throughout Puget Sound follow this same trend.

Harbor Seal Counts



Source: Puget Sound Ambient Monitoring Program, Jeffries and Johnson, 1990, Calambokidis et. at. 1991

Harbor seal photo courtesy of Mike Johnson

Are Areas Where Shellfish Can Be Harvested Safely Increasing or Decreasing?

Puget Sound has some of the most productive shellfish growing areas in the entire nation. Six varieties of oysters and four types of clams grow in the cold waters of Puget Sound.

Why select shellfish harvest areas?

The Department of Health restricts the harvest of shellfish when water quality fails to meet stringent sanitary guidelines, indicating localized changes in Puget Sound's health. Shellfish filter large volumes of water as they feed, ingesting and accumulating bacteria and pollutants that are present in the water. Shellfish contaminated with bacteria can make people sick. Tidelands and waters closed to shellfish harvest can devastate local economies that depend on the shellfish industry.

What affects the safe consumption of shellfish?

Whether shellfish are safe for human consumption is determined by the presence of fecal contaminants and naturally occurring toxic algae in marine waters. Fecal coliform bacteria indicate the possible presence of disease-causing bacteria and viruses. Fecal bacteria originate from many sources, including improperly treated sewage, poorly managed farms, stormwater runoff, failing or poorly operating on-site sewage systems and boats. Wild game and marine mammals may also contribute to unsanitary shellfish harvest areas.

Commercial Shellfish Area Classifications

All commercial growing areas are classified using National Shellfish Sanitation Program standards. Classified shellfish include intertidal species of clams, oysters and mussels that are cultivated for commercial purposes. State law prescribes a similar classification system for recreational shellfish areas.

Approved — Harvested shellfish can be marketed directly with no restrictions placed on harvest due to bacterial pollution or sanitary conditions.

Conditionally Approved — Harvested shellfish can be directly marketed only during predictable periods. Some pollution events, such as storms, close harvest for a specified period based on local conditions.

Restricted — Harvested shellfish cannot be marketed directly due to bacterial water contamination. Shellfish must be moved to clean waters for a period of time prior to market distribution.

Prohibited — Shellfish cannot be harvested due to bacterial pollution and unsanitary conditions.

Status

About 136,000 acres of Puget Sound are available for intertidal commercial shellfish culture and harvest. Seventy-five percent of this area is approved for direct harvest and marketing of shellfish.

Large tracts of potential harvest areas in central Puget Sound cannot be certified because shellfish harvesting must be prohibited near municipal and industrial wastewater treatment facility discharges and combined sewer overflows.

There are also about 1,000 public recreational shellfish harvest areas in Puget Sound. Two hundred and seventy-seven of the highest-use areas are being classified to preventt the public from harvesting and eating shellfish contaminated by fecal bacteria.

Trends

Since 1981, close to 25 percent of Puget Sound's commercial shellfish growing areas have been downgraded in classification due to bacterial contamination. However, since 1989 the area where shellfish can be harvested safely has remained fairly constant. The largest number of downgrades occurred from 1986 to 1989. Since then, the acreage being downgraded has been roughly equivalent to the area being upgraded.

Of the 98 classified public beaches in Puget Sound where shellfish can be harvested, 53 percent have no harvest restrictions and 41 percent are closed to harvest.

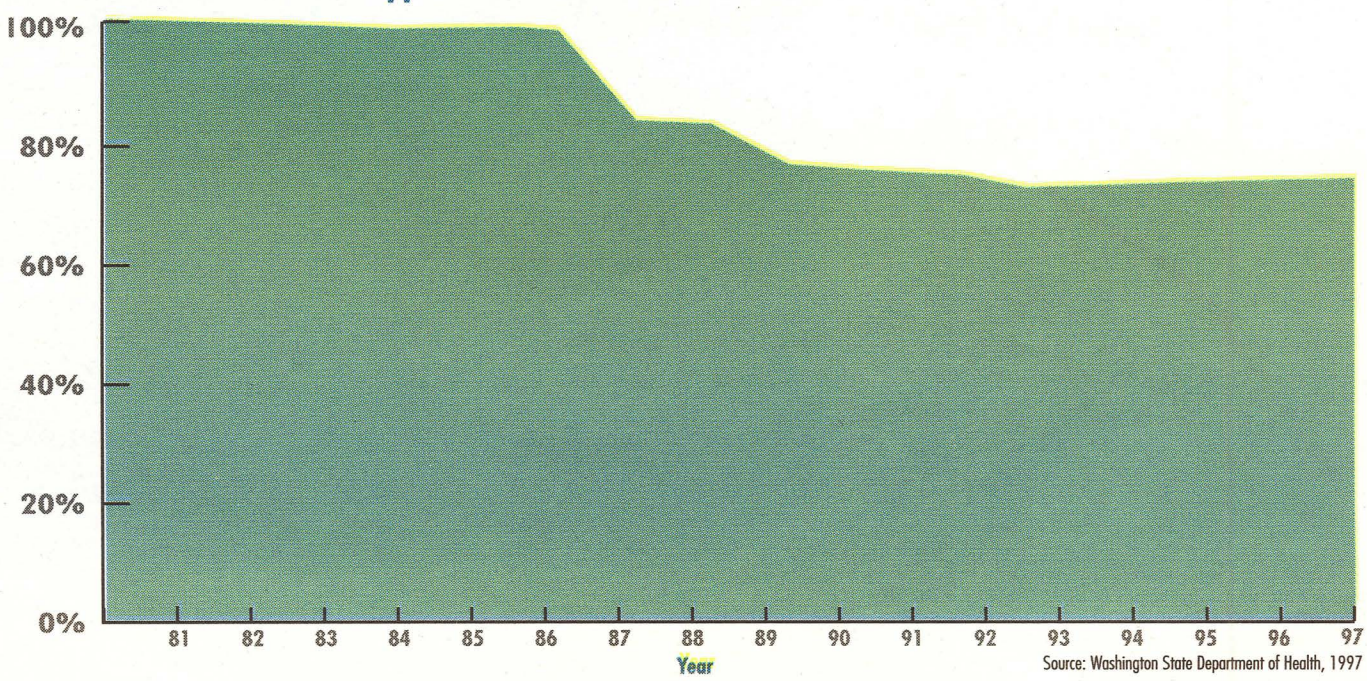
Recreational Shellfish Beach Classification

CLASSIFICATION	1994	1996	1998
Open	29	52	52
Conditionally Open*	4	5	5
Closed	37	41	41
Targeted for Classification	72	44	179
TOTAL	142	142	277

*Harvest restrictions are imposed due to predictable pollution events such as large storms, seasonal boating concentrations, etc.

Source: Washington State Department of Health 1998

Commercial Shellfish Area Approved for Direct Harvest



Source: Washington State Department of Health, 1997

Is the Quality of Water for Recreation Improving or Declining?

Annually, about 39 million acre-feet of water from more than 10,000 rivers and streams flow into Puget Sound. The quality of this water is degraded by bacteria and does not appear to be improving. Water is considered safe for recreation when levels of fecal coliform bacteria remain below state standards.

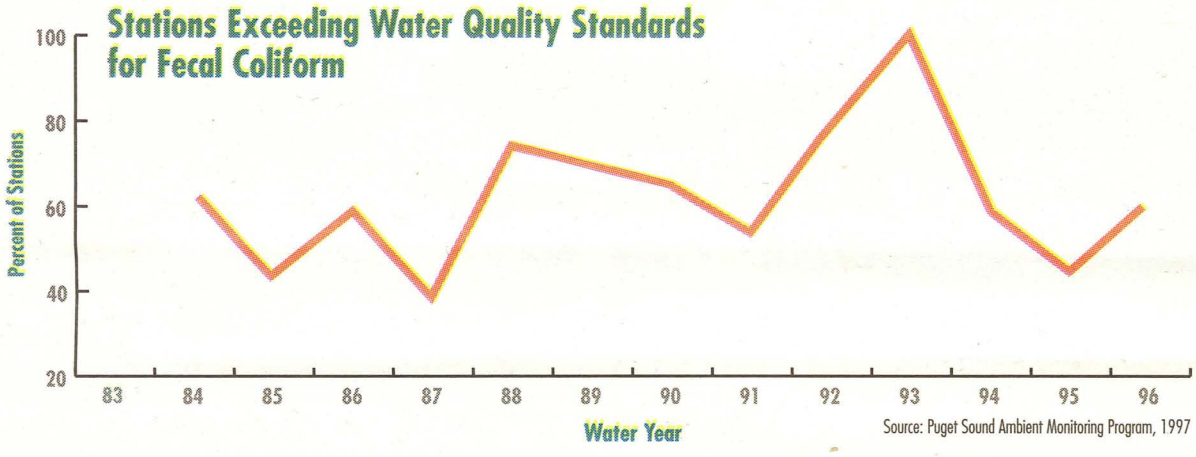
Why measure bacterial contamination of water?

Fecal coliform bacteria, common to the intestinal tracts of warm-blooded animals, indicate that disease-causing bacteria and viruses may be present in the water. When recreational activities bring people into direct contact with contaminated water, they risk contracting water-borne diseases associated with fecal wastes. To protect human health, shellfish harvesting is restricted in degraded waters.

In marine waters, fecal coliform bacteria also threaten recreational shellfish harvest areas.

What affects bacterial contamination?

Bacterial contamination comes from human, marine mammal, and wild and domestic animal fecal matter. There are many ways by which bacteria enter the water – runoff from poorly managed farms and logging areas, streets and developed areas, improperly treated sewage from boaters and failing on-site sewage treatment systems and marinas.



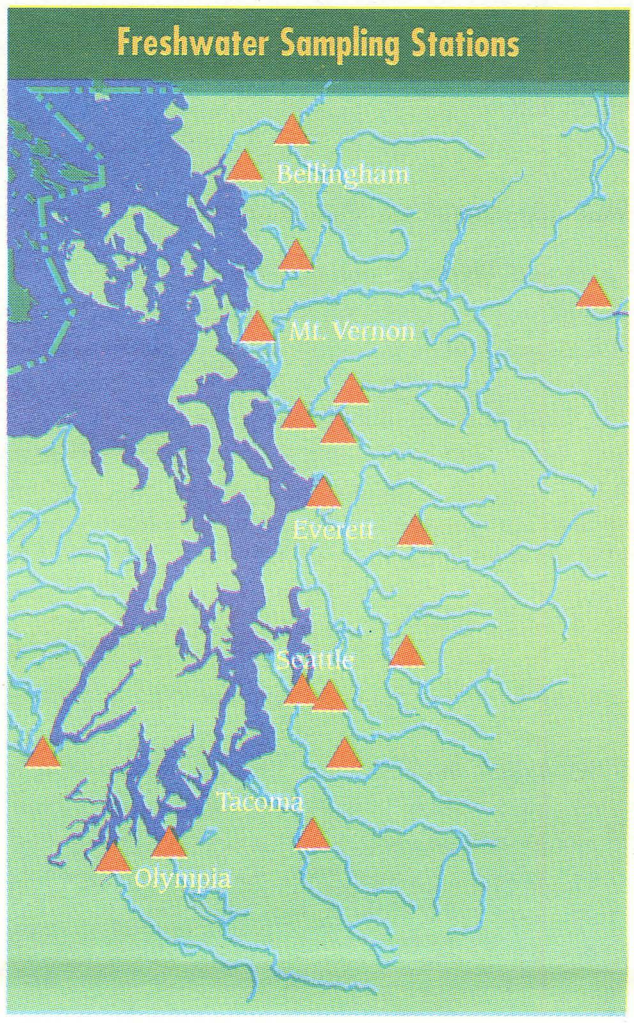
Source: Puget Sound Ambient Monitoring Program, 1997

Status

Since 1984, more than half the river stations monitored for fecal coliform bacteria violated state standards. Monitoring is conducted at 18 stations along major rivers that empty into Puget Sound.

Trends

Bacterial contamination of Puget Sound rivers has not significantly improved or declined since 1984.



Is the Area of Contaminated Sediments Increasing or Decreasing?

Puget Sound has 1.8 million acres of submerged marine beds and tidelands. Various agencies have sampled areas with the greatest likelihood of contamination, such as bays adjacent to highly urbanized and industrialized areas and historical industrial sites. Some sampling is also conducted on sediments in non-urban areas.

Puget Sound sediments are classified according to state standards for sediment quality. Contaminated sediments adversely affect biological resources and may pose a health risk to humans, depending on the contaminant.

Why measure the acreage of contaminated sediments?

Sediments provide a record of historical and ongoing sources of wastewater, spills and stormwater runoff that contribute pollutants to Puget Sound. Contaminants can bind to fine sediments floating in the water. These contaminated sediments may eventually accumulate on the sea floor. Studies show that sediment contamination affects marine life that lives or feeds in sediments. Tumors and other abnormalities have been found in bottom-feeding fish, indicating that eating contaminated portions of these fish may pose threats to human health.

What affects the acreage of contaminated sediments?

To decrease the acreage of contaminated sediments, sources of pollution must be eliminated and contaminated sites must be cleaned up. Cleaning up sediments can involve dredging or removing contaminated material and properly disposing of it in designated facilities. Cleanup can also incorporate natural recovery, in which currents deposit clean sediments on top of contaminated sediments.

Status

Of 13,845 acres surveyed, sediments in 5,083 acres are classified as contaminated. Contaminant levels in 62 percent of this area exceed cleanup trigger levels, meaning they pose a high risk to humans and biological resources. In 1996, the state targeted 49 contaminated sites, totaling 2,197 acres, for cleanup. More than half of the 49 sites identified for sediment cleanup are under investigation by federal, state and local agencies and private parties.

Trends

It is too soon to determine whether the total amount of contamination in Puget Sound is increasing or decreasing.

Contaminated Sediments in Puget Sound

Area Surveyed	13,854 acres
Contaminated Sediments Area (not meeting standards)	5,083 acres
Number of Cleanup Sites in the Contaminated Area	49

Source: Department of Ecology

Are Toxins in the Marine Environment Increasing or Decreasing?

Pollutants of concern are highly toxic, persistent in the environment and accumulate easily in living organisms. They can be measured by the levels of contaminants found in the muscle and organ tissue of marine life. Toxins have been found in some fish, shellfish and marine mammals. The levels of pollutants vary regionally, with higher levels found in marine life from urban areas.

Species evaluated for toxins: Mussels • English sole • Harbor seals

Why select these measures?

Mussels, English sole and harbor seals are common and widely distributed in Puget Sound. Each occupies a different niche in Puget Sound's ecology.

Mussels are a good indicator species for a number of reasons – they do not move, they grow throughout Puget Sound and they filter large volumes of water as they feed. Because mussels are filter feeders, toxic contaminants in the water accumulate in their soft tissue. Accumulated contaminants may harm the mussels themselves or organisms, that eat them, including humans.

English sole are sensitive to contaminated sediments, because they spend their lives on or partially buried in sand or mud. They are good indicators of contaminant levels in sediments and effects on marine life.

Harbor seals live long and are a top predator in Puget Sound. They accumulate and concentrate contaminants from the fish and other marine life they eat. Regional differences in pollution levels can be tracked by looking at different breeding populations of seals throughout the Sound.

What affects toxins in these species?

Generally, harbor seals, mussels and English sole are monitored at locations that represent and integrate many pollution sources affecting water quality and the ecosystem.

Sources of toxic chemicals include municipal and industrial wastewater discharges, spills, combined sewer overflows and stormwater runoff.

Pollutants of Concern

Heavy Metals: Humans and marine organisms are exposed to low levels of naturally occurring elements in the Sound. Higher than average exposure can cause reproductive failure. Sources include discarded batteries, spills of hazardous materials, car emissions, paints, dyes, polluted runoff, and industrial and municipal wastewater discharges.

Polycyclic Aromatic Hydrocarbons (PAHs): These chemicals result from the burning of fossil fuels and organic materials. Exposure adversely affects immunity, reproduction and genetic makeup. Sources include emissions from residential heating , car emissions, asphalt roads, tar and coal tar production, creosote-treated wood, coking plants, incinerators, and polluted runoff.

Chlorinated Organic Compounds: These chemicals do not occur naturally. They are some of the most toxic compounds known, retarding growth, reducing fertility and causing birth defects, liver damage and skin lesions. Sources include solvents, electrical coolants and lubricants, pesticides, herbicides, and treated wood. These compounds and their breakdown products persist in the environment.

Did You Know?

In the 1970s the federal government banned the use and production of toxic chemicals like butyl tin [a component ship anti-fouling paint] and PCBs [used in coolants for electric systems]. Since then, the concentration of these chemicals in the body tissue of mussels at several sites around the Sound has shown a significant and continuous decline. Concentrations of mercury, copper and zinc have also declined, although not as much as PCBs and butyl tin.

Mussels

Status

Toxic chemicals found in mussels include heavy metals, pesticides (including DDT, banned in the 1970s), chlorinated organic compounds (including PCBs) and PAHs. Concentrations of these compounds, except PAHs, in Puget Sound mussels generally are not high compared to the rest of the nation. PAH concentrations in mussels from many Puget Sound locations are higher than those in other coastal areas of the country. A few other contaminants – nickel, copper, zinc, PCBs – appear in relatively high concentrations in a small number of samples.

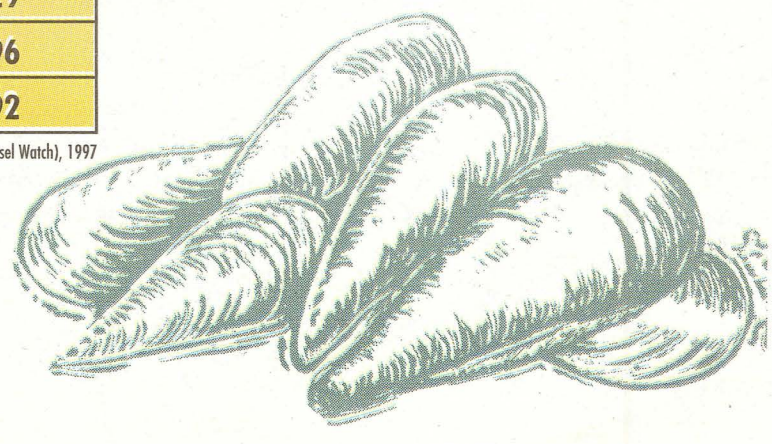
Trends

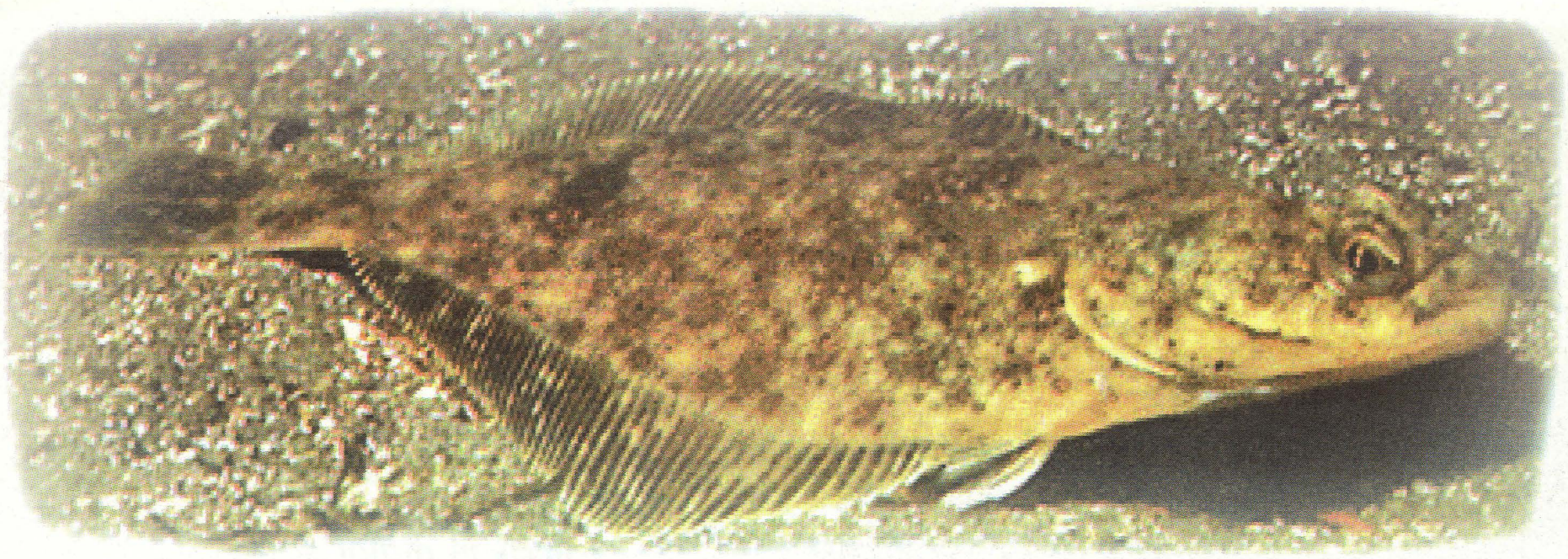
Concentrations of toxic contaminants in mussels are decreasing in many areas around the Sound. Between 1986 and 1993, the concentration of copper and mercury in mussels decreased at three of seven Puget Sound stations. Declines ranged between 24 and 54 percent depending on the site. Zinc in mussels declined at two of seven stations, as did the concentrations of organic compounds – PCBs and and butyl tin. These last two compounds showed the largest reduction (70 percent to 96 percent) from 1986 to 1993. Both compounds are heavily regulated – the production and use of PCBs was banned and the use of butyl tin is significantly restricted.

Declining Toxics in Puget Sound Mussels
Number of Stations

	Increasing Trend	No Trend	Decreasing Trend	% Decrease '86–'93
Mercury	0	4	3	32 – 54
Copper	0	4	3	24 – 44
Zinc	0	5	2	20 – 29
PCBs	0	5	2	79 – 96
Butyl tin	0	5	2	70 – 92

Source: National Oceanic and Atmospheric Administration (Mussel Watch), 1997





English sole photo courtesy of Glen Todd

English Sole

Status

English sole from urban areas of Puget Sound have higher concentrations of contaminants in their muscles and more liver lesions than sole from rural areas. This coincides with the fact that sediments in urban areas are more heavily contaminated than sediments in rural areas.

Trends

There is no discernible Soundwide trend in the amount of toxins found in the muscle tissue of English sole sampled from 1989 to 1996.

Liver lesions in English sole do appear to be increasing at two sampling locations in Puget Sound – Elliott Bay and the Strait of Georgia. There is no trend in the occurrence of liver lesions at four other locations in the Sound. An increase in liver lesions in sole from Elliott Bay is attributable to the pollutants in urban stormwater runoff. Scientists speculate that an increased trend at a Strait of Georgia location may be the result of exposure to pollution from the Fraser River. Additional study is needed to evaluate these apparent trends.

What is a Liver Lesion?

A growth in fish liver tissue that sometimes develops into a mass of abnormal tissue is called a tumor or lesion. In English sole, up to 30 percent of observed liver tumors are cancerous. Some types of liver lesions occur naturally as fish age, but when fish are exposed to contaminants, especially PAHs, the chances of developing liver lesions increase.

Liver lesions provide a general indicator of how healthy English sole are because liver lesions are associated with reproductive damage.

Trends in English Sole Liver Lesions from 1989 to 1996

Location	Increasing	Decreasing	No Trend
Commencement Bay			●
Elliott Bay	●		
Sinclair Inlet			●
Port Gardner			●
Hood Canal			●
Strait of Georgia	●		

Source: Puget Sound Ambient Monitoring Program, 1997

Harbor Seals

Status

Preliminary information shows regional differences in the levels of dioxins and PCBs in the blubber of harbor seals. Contaminants found in the blubber of seals from south Puget Sound (Gertrude Island) are about three times higher than those in the Strait of Georgia.

Trends

Studies are under way to determine whether accumulations of toxic chemicals in the blubber of harbor seals are increasing or decreasing over time.

Are the Size and Frequency of Oil Spills Increasing or Decreasing?

Washington is one of the country's primary centers for refining petroleum. Large amounts of oil and oil products move through Puget Sound daily. Oil enters and leaves the basin via tankers, barges and pipelines. In addition, about 28 ocean-going commercial vessels transit the Strait of Juan de Fuca daily. These vessels can carry up to two million gallons of heavy crude or fuel oil.

Why select oil spills?

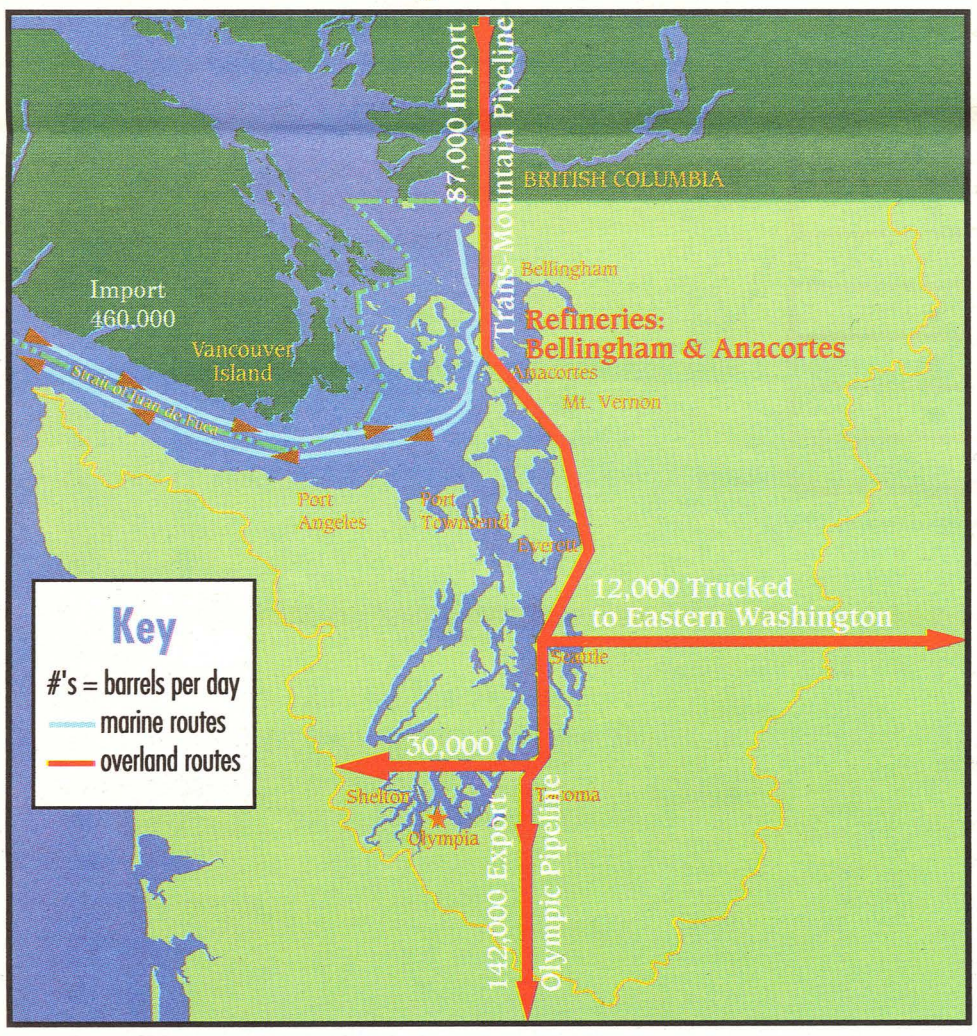
The potential for spills poses a significant threat to some of Puget Sound's most sensitive and pristine marine resources, especially in the San Juan Islands, Padilla Bay and the entrance to the Strait of Juan de Fuca.

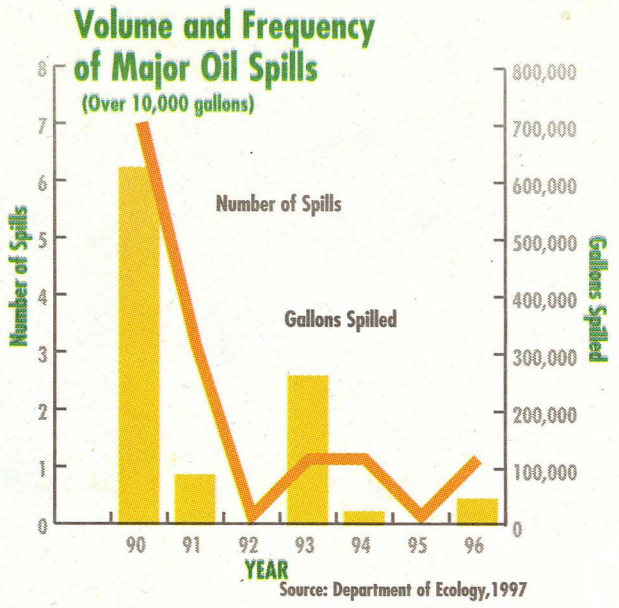
What affects the amount and volume of oil spilled?

Human error, equipment failure and lack of safe operating practices contribute to how much and how often oil is spilled.

Shore-based facilities account for 76 percent of the volume spilled over 10,000 gallons. Since 1990, seven percent of major spills were attributable to the maritime transportation industry. Although vessels pose the greatest threat of a catastrophic oil spill, heavy fuel oil and crude oil make up the bulk of the spills. Accidents during ship fueling operations generally account for 61 percent of the volume spilled between 25 gallons and 10,000 gallons. Diesel and heavy fuel oil are most frequently spilled during these accidents.

Oil Movement in the Puget Sound Basin

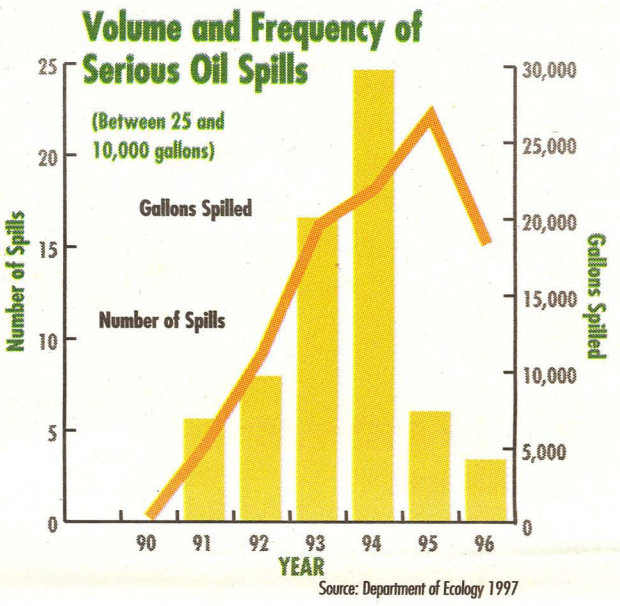




Source: Department of Ecology, 1997

Trends in major spills
(over 10,000 gallons)

The volume and number of major spills are decreasing. Between 1990 and 1996, over 1.9 million gallons of oil spilled from vessels, pipelines and facilities in the Puget Sound basin. Spills from land-based facilities accounted for the largest volume and number of spill events.



Source: Department of Ecology 1997

Trends in serious spills
(25 to 10,000 gallons)

Although the total volume of serious spills is considerably less than those of major spills, it is still very significant. Between 1990 to 1994, the volume of medium sized oil spills increased significantly from 6,800 to 20,000 gallons. The total volume spilled dropped appreciably in 1995 to 7,400 gallons and again in 1996 to 4,200 gallons.

Did You Know?

The damage an oil spill can cause to marine life depends on many factors: the type of oil, the amount spilled, the amount cleaned up, as well as weather and water conditions. While one heavy spill can create an immediate environmental problem, multiple small spills can lead to long-term problems.

– Source: The Sun, Bremerton

Are Functional Wetlands Increasing or Decreasing?

Currently there is no good measure for this indicator

Indicators to answer this question are being developed. Status and trends related to this indicator will be reported in future updates to this report.

Status

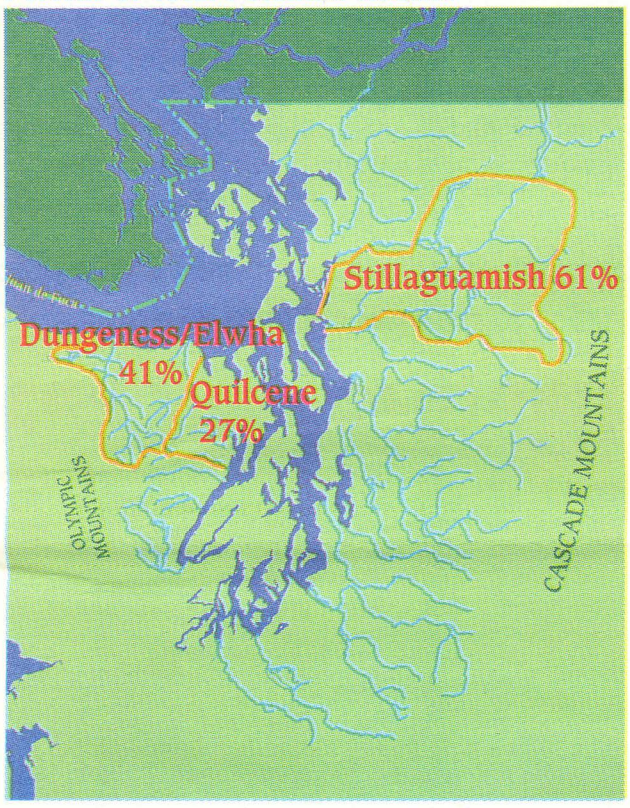
Available coho habitat was assessed in three watersheds – the Big and Little Quilcene in Jefferson County, the Dungeness/Elwha watershed in Clallam County and the Stillaguamish basin in Snohomish County.

There are 696 miles of potential coho habitat (including inaccessible habitat) in these three watersheds. Total habitat for anadromous fish, including inaccessible areas, is based on current or potential habitat use. Coho habitat is assessed because this species of salmon can generally penetrate further up rivers and streams than other fish. A little more than half of the potential habitat is available for coho use. The remainder is not accessible to coho because of known and suspected blockages.

Trends

Because this report is the first time that available habitat has been measured, not enough information has been collected to assess trends.

Accessible Coho Habitat– Percent of Total Potential Habitat



Is Fish and Wildlife Habitat Increasing or Decreasing?

There are over 10,000 rivers and streams stretching over 16,000 miles in the Puget Sound basin. For this report, we assessed habitat based on barriers to fish passage. Other indicators to answer this question will be developed and reported in future updates to this report.

An assessment of three significant watersheds around the Sound found that only about half of all potential habitat is available to salmon. Human-made barriers reduce the area of habitat available during migration. Barriers include dams, irrigation, water diversions, dikes, channelization, hardened riverbanks and road culverts.

Why measure the barriers to fish passage?

Rivers and streams are critical to the survival of migratory fish species – providing food, shelter, spawning and rearing habitat. Barriers created by humans adversely affect the ability of wild salmon and steelhead to spawn and rear their young. When access to available habitat is limited, it can cause healthy fish stocks to decline.

What affects barriers to fish passage?

Correcting barrier problems can be relatively simple or highly complex and expensive. It may involve low–cost structural and non–structural alterations or require the removal of the obstruction. About 10 percent of the barrier culverts in this state involve state roads, 40 percent involve county or municipal roads and the remainder involve federal and private roads. There are a number of current efforts to identify and restore degraded salmonid habitat and improve fish access to habitat by removing or fixing fish passage barriers. The Washington State departments of Transportation and Fish and Wildlife are prioritizing and correcting culvert barriers.

Evaluation of Potential Habitat for Coho

Watershed	MILES		
	Total Potential Habitat	Estimated Blockage	Accessible Habitat
Stilliguamish	462	39% (178)	61% (284)
Big & Little Quilcene Rivers only	41	73% (30)	27% (11)
Dungeness/Elwha	190	59% (112)	41% (78)
TOTAL	693	46% (319)	54% (373)

Source: Salmon and Steelhead Inventory and Assessment Project, 1997 (Northwest Indian Fisheries Commission and Washington State Department of Fish and Wildlife)

A Quiz About Puget Sound

1. Puget Sound's human population is steadily increasing. How many more people will live in the basin by 2020?
A. .5 million B. 0.8 million C. 1.4 million

2. How many miles of rivers and streams are there in the Puget Sound basin?
A. 11,000 miles B. 16,000 miles C. 25,000 miles

3. Has the quality of Puget Sound rivers improved for swimming and other recreational pursuits?
A. Yes, improved B. No, hasn't improved

4. Shellfish can only be commercially harvested from clean water. Is the area where shellfish can be safely harvested increasing, decreasing or remaining the same?
A. Increasing B. Decreasing C. Remaining the same

5. Puget Sound herring are essential food for salmon, other fish, marine mammals and birds. Are their numbers in Puget Sound increasing or decreasing?
A. Increasing B. Steadily decreasing C. No change

6. Has the concentration of toxic chemicals decreased in Puget Sound shellfish?
A. Yes, decreased B. No, has not decreased C. Not changed

7. Wild salmon populations are declining in Puget Sound. How many distinct spawning groups of salmon and steelhead are there for Puget Sound?
A. 59 B. 109 C. 209

8. Parts of Puget Sound's submerged tidelands are contaminated by toxic chemicals from past and present municipal and industrial wastewater and spills. Sound-wide, how large is the contaminated area?
A. 4,400 football fields B. 7,400 football fields C. 10,000 football fields

9. The number and volume of spills over 10,000 gallons of oil has significantly declined since 1990. What is the largest source of these spills?
A. Land-based facilities (i.e., oil storage areas, refineries, etc.)
B. Ships and other vessels C. Pipelines

The Answers

1.C, 2.B, 3.B, 4.C, 5.B, 6.A, 7.C, 8.B, 9.A

PUGET SOUND'S HEALTH 1998

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Office of the Governor
PUGET SOUND WATER QUALITY ACTION TEAM

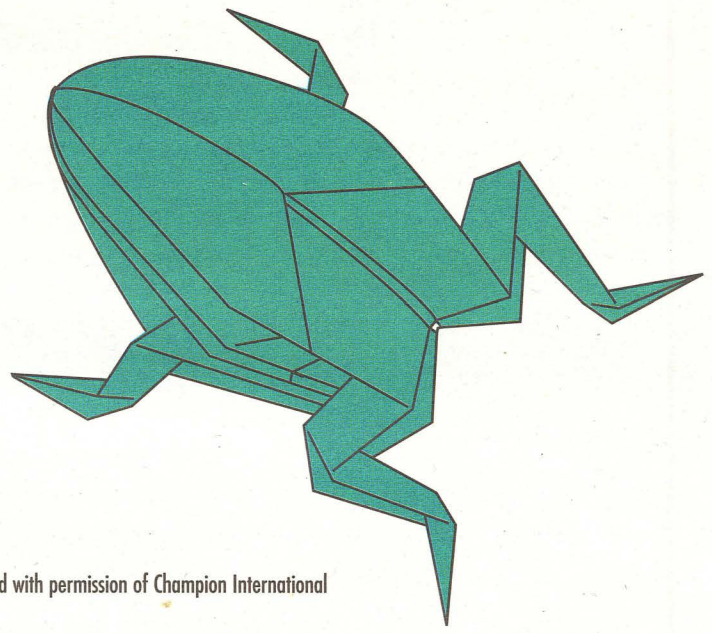
Can You Origami?

Here's a frog from the wetlands of Puget Sound.
Start with a square of green paper and follow these simple steps.

Before you begin:

Instructions for folding involve a series of basic folds. These folds, some very simple and others more difficult are explained below. Don't be discouraged if your first try isn't perfect. Origami requires practice.

As you follow the step–by–step instructions, keep looking ahead to the next diagram to see how the figure should look after you complete each fold.



Origami reprinted with permission of Champion International

Key to symbols

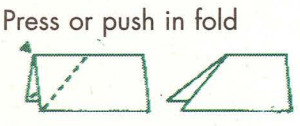
Direction of fold

Location of fold

Existing crease from previous fold

Flip the model over

Press or push in fold



Pull out

Cut, follow dotted line for direction and length

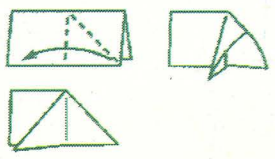
Blow here to inflate

Basic folds

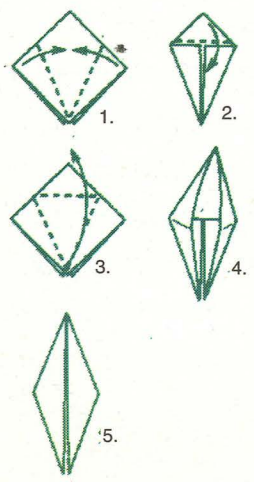
Book fold
One fold that divides a square into two equal rectangles

Inside reverse fold
Making an outside surface an inside one by a fold allowing all or part of an edge to fall inside itself

Pocket fold
Essentially an angle pleat fold in which the top layer of a double layered corner is folded out and flattened to create a two corner ed pocket



Purse fold
A point or an ear made from a diamond–shaped pocket.
1. Fold left and right corners into center. 2. Fold bottom point over those flaps and then return all flaps. 3. Lift up open end 4....allowing edge of corners to come together. 5. Flatten



The Frog

1. Book fold sheet in half, fold right corner forward, left corner back on diagonal. **2–3.** Open pocket and flatten into diamond. **4–5.** Pocket fold and flatten one of the flaps, then repeat for other three sides. **6–8.** Purse fold one of the pockets, flatten, then repeat for other three pockets. **9.** Turn over one flap. **10–11.** Fold in sides. Repeat for all flaps. **12.** Turn over one flap. **13.** Reverse inside fold the bottom two points. **14.** Create arms with two consecutive inside reverse folds. **15.** Create legs with three consecutive inside reverse folds of remaining two points. **16.** Inflate frog by blowing into space in the back.