TOXIC LEGACY:

Toxic Chemicals and Marine Life in Puget Sound

A Report from RE Sources and the North Sound BayKeeper

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Illustration & photo credits:
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Funding made possible by:
- Bullitt Foundation
- Hugh and Jane Ferguson Foundation
- Harder Foundation
- Horizons Foundation
- Northwest Fund for the Environment

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RE Sources is a non-profit environmental education organization which provides information on local environmental issues and opportunities for active citizen involvement.

North Sound BayKeeper is a marine advocacy and education program of RE Sources and Puget Soundkeeper Alliance.

Publication date: December 2001

Printed on chlorine-free100% post-consumer recycled paper

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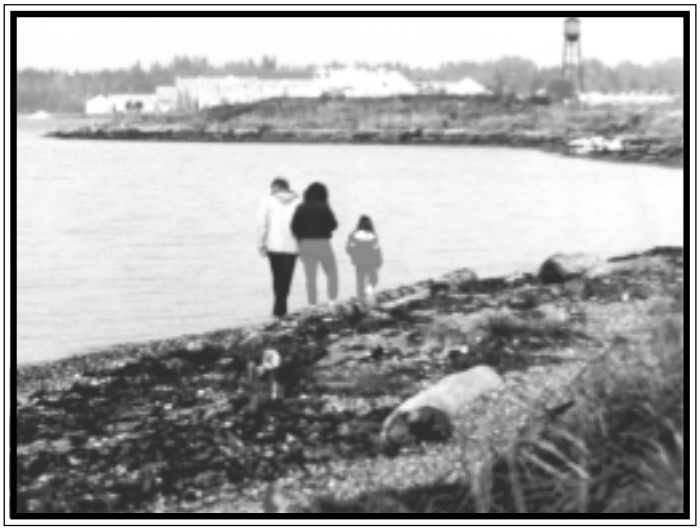
TOXIC LEGACY:

Toxic Chemicals and Marine Life in Puget Sound

Puget Sound is a natural treasure that supports a diverse and vibrant ecosystem of plants and animals. It also serves the needs of millions of people who live near and visit its shores. Sadly, this precious marine ecosystem is beleaguered by pollution. Although there has been a decrease in toxic contamination in some areas of the Sound, other areas are still highly polluted or are showing an increasing trend in toxic contamination.

Some of the sources of toxic contaminants to Puget Sound include stormwater runoff from urban areas; discharges of municipal and industrial wastewater; pesticide runoff from agricultural, residential and park land; leaching of contaminants from shoreline structures and vessels; channel dredging and dredge material disposal; and atmospheric deposition of air pollutants. In many cases, these pollutants settle to the bottom, contaminating sediments. There are over 90 contaminated sediment sites in the Sound and Straits.



Concern over many toxic chemicals relates to their ability to cause or promote the development of cancer, interfere with normal hormone functioning, or cause reproductive problems. Many toxic contaminants cause additional problems, because they accumulate in the tissues of organisms and become magnified through the food web when predators eat contaminated prey.

Toxic pollution is pervasive throughout the Puget Sound ecosystem. We should each evaluate how we contribute to this pollution problem, because ultimately, harm caused to Puget Sound affects us all.

Our Diverse Environment

Approach the Sound from any direction and its grand design – a sinuous union of land and inland sea – is revealed. Glacially carved mountains, lush lowland terrain, and water provide the ingredients for spectacular landscapes. Puget Sound, the long inland arm of the Pacific Ocean, reaches its way east through the Strait of Juan de Fuca and south down between the Cascades and the Olympics.

The protected inland waters of Puget Sound were created through the repeated advances and retreats of continental ice sheets from Canada during the Pleistocene Epoch which began nearly 2 millions years ago. Named for glacial deposits left on Vashon Island in central Puget Sound, the glaciers of the Vashon ice phase covered all of the Sound to just south of Olympia with an ice sheet 3,000 feet thick. About 14,000 years ago, the massive Vashon ice sheet began to retreat, leaving high jagged ridges and U-shaped troughs behind. The glaciers deposited piles of gravel and fine sediments, and carved new channels that eventually became the rivers, creeks, and streams of the Puget Sound region.

A Promised Land

As continental ice sheets began to retreat, humans arrived on the North American continent. The earliest artifacts of inhabitants in the Puget Sound country date to around 8,000 years ago. The indigenous coastal culture came into extravagant bloom not more than 3,000 years ago and was at its height when the first Europeans came on the scene.

There is little doubt that the primary motive for Europeans' journeys to the Northwest Coast was to find wealth. They sought furs, precious metals, and other raw materials to support a sophisticated culture already steeped in a tradition of subduing wilderness. Even in the beginning of the twenty-first century, a distinguishing feature of the Pacific Northwest economy remains its heavy dependence upon the production of raw materials.

But this is not without consequences. Salmon species are now listed as endangered due to overharvesting and loss of habitat. Orca whale numbers are plummeting and important forage fish populations, such as herring, are severely depressed. Human population growth within the region is straining natural resources and impacting wildlife with habitat destruction and pollution. The challenge our communities face focuses on how we can minimize our impact on the environment.

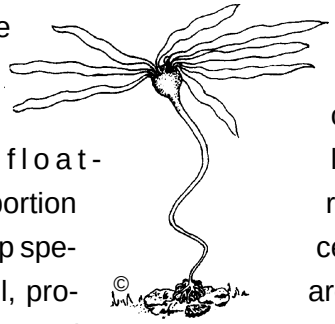
Biological Resources

More than 220 species of fish, 26 different kinds of marine mammals, 100 species of seabirds and thousands of marine invertebrate organisms are found in Puget Sound. Some of these species are migratory, while others remain year round. Populations of many important plants and animals in the Puget Sound ecosystem have declined in recent years from over-harvest, habitat loss, and pollution.

Eelgrass provides habitat and food for salmon, marine fish, birds and other wildlife in the nearshore environment of Puget Sound. Eelgrass meadows are a vital marine resource, supporting nearshore food web relationships in water up to 22 feet deep. With its high productivity and rapid growth, eelgrass forms the food-base for fish, shellfish and waterfowl. In addition, eelgrass softens the impact of waves and currents preventing coastal erosion and stabilizing shorelines. Dredging, shoreline construction, decreased water quality from logging, stormwater runoff and pesticides are just a few of the human activities that have led to a 33 percent loss of eelgrass in the Sound. Resource managers and environmental groups recognize the ecological importance of eelgrass beds and have begun to protect and restore these areas.

eelgrass

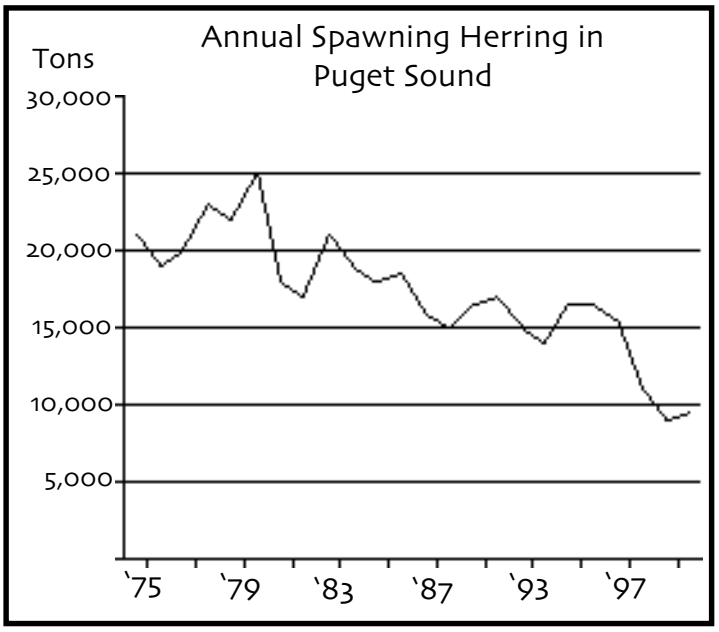
Bull Kelp is another important plant in the waters of the Sound. The canopy layer of a floating kelp bed is formed by two species – giant kelp and bull kelp – that have float-like structures to hold the upper portion of the plant at the surface. Other kelp species dominate the understory level, providing a dense layer of vegetation used as a shelter for small invertebrates and larval fishes. This habitat, which occurs in water depth between 18 and 90 feet, has nearly the highest primary production of any ecosystem on earth. Many factors, both natural and human, affect the extent and composition of kelp beds, such as, elevated water temperatures, sea urchin grazing, boat propellers, and sewage runoff, which decreases water quality.



bull kelp

A sense of the amazing diversity of **local fishes** can be gained from a sampling of the suggestive and colorful names of the 58 families into which they are classified. Sturgeons, lefteye flounders, lampreys, drums, and sandfishes are just a few of the fishes that inhabit Puget Sound. Saltwater fishes vary in size and shape from the large and sleek salmon, trout, and sharks to the little blennies and sculpins of tidepools. Each is closely linked to a specific habit and habitat. Just as on land, the inland sea features a multiplicity of habitats, each home to its particular breed of exploiter.

Pacific herring is a vitally important forage fish species in Puget Sound. It acts as a food base for many finfish, marine mammals, and sea bird populations, as well as being a significant resource for commercial and subsistence fisheries. Unfortunately, Pacific herring populations have been in steady decline since the mid-1970s. The Cherry Point herring stock, historically the largest stock in Puget Sound, has declined a dramatic 91 percent over the last 25 years. Average hatch success rates in the lab are close to 70 percent, while at Cherry Point, hatch rates are alarmingly low averaging only 18 percent.[21] An ecological risk assessment conducted by the Washington Department of Natural Resources found a multiplicity of factors contributing to this decline including rising ocean temperatures, decline in food supply, predation, over-fishing, habitat loss and toxicity. In addition, studies have shown that industrial wastewater discharged by aluminum smelters and oil refineries in the Cherry Point vicinity, wash over spawning grounds before being



The Cherry Point herring stock has declined a dramatic 91 percent over the last 25 years.

carried away by tides. This may be adding to the toxicity factor. The Washington Department of Fish and Wildlife continues to monitor contamination levels of herring in the Sound to help determine how exposure to pollutants impact, survival of the herring.

Two major groups of **marine mammals** are represented in Puget Sound: Order Carnivora (seals and sea lions) and Order Cetacea (whales and porpoises). Surveys conducted by the Washington Department of Fish and Wildlife (WDFW) have documented an increasing harbor seal population since 1978, but there has been an apparent slowing of population growth in some regions of the Sound. This slowing of population growth suggests the harbor seal population may have reached the limits that can be supported by Puget Sound.

Orca populations have also been in decline. Between 1995 and 2000, the number of resident orcas in Washington waters has dropped 17 percent - from 98 individuals to 82. Scientists suggest a combination of factors have led to this decline, including dwindling salmon stocks, heavy boat traffic and toxic contamination. Studies of blubber taken from orcas off the Washington and British Columbia coast were found to have concentrations of PCBs so high it puts them among the most contaminated aquatic mammals in the world. This decline has led the Canadian government to list the orca as a threatened species. Many biologists feel that the Puget Sound orcas should also be listed under the U.S. Endangered Species Act.

Persistent Toxics in the Environment

Humans have created a variety of compounds that have been released either intentionally or unintentionally to the environment. Some, such as pesticides, are intended to be toxic and are introduced to the environment to kill or damage unwanted plants and insects. Other chemicals, many of which are by-products of industrial processes, are not designed specifically as killers, but are toxic when released into the environment (e.g. polychlorinated biphenols, or PCBs, from industrial processes). Another group of toxic compounds are not purposefully generated, but are toxic byproducts of society's activities . Finally, there are heavy metals such as lead and mercury, which are released into the air and water from industrial activities, incineration and solid waste disposal. Many of these toxic creations are persistent, meaning that they remain in the environment and are not broken down, or that they break down very slowly. Many of these persistent chemicals have proven extremely dangerous to fish and the environment.

Pesticides can be highly toxic, causing numerous problems in aquatic environments - interfering with fish behavior and health,

The Puget Sound orcas are among the most contaminated marine mammals in the world.

These magnificent creatures are adored locally and by tourists who journey many miles to see them. As orca populations drop, people are finally starting to take notice of the whale's plight. Multiple factors contribute to this decline. Research to discover the role of toxic chemicals in population declines is now underway.

Increasing evidence shows that PCBs have caused reproductive impairment, skeletal abnormalities, immune deficiency and endocrine disruption in marine mammals. Polychlorinated biphenols (PCBs) are produced by adding chlorine atoms to molecules of benzene, resulting in a chemical compound with low flammability. This made PCBs very useful for insulating electrical equipment, such as transformers and capacitors. They were also used in hydraulic fluids, lubricants, inks, dyes, pesticide preparations, adhesives, carbonless-copy paper and wood preservatives.

In the 1960s, significant levels of PCBs began to be detected in air, soil, water, sediments, fish, wildlife and humans throughout the world. By the 1970s, it became known that PCBs persisted in the environment, accumulated in the food chain, and posed a hazard to animals at the top of the chain, including orca whales.

In the mid-1970s manufacturers in the U.S. stopped sales for PCB products which might be expected to leak into the environment, but not before producing over a billion pounds of the toxic chemical. One-third of that amount has been released into our global environment.

A study of the orcas off the coast of Washington and British Columbia found surprisingly high PCB levels - so high in fact that these orcas can now be considered the most contaminated whales in the world.[2] Orcas, being at the top of the food chain, are exposed to PCBs in the food they eat. The resident whale population dines almost exclusively on salmon, while the transient population of whales that moves up and down the coast, eats other marine mammals, such as seals and porpoises, in addition to fish. The mammal-eating transient whales are particularly contaminated with PCBs, which reflects their behavior of eating high on the food chain.

This study also found that PCB accumulation is strongly related to age and gender of the animal. PCB levels in female orcas drop considerably when they reach calving age at approximately 15 years. Low concentrations continue until approximately 50 years of age, at which timePCB concentrations increase.

This drop can be attributed to the offloading of considerable levels of contaminants to orca young during pregnancy and lactation. Up to 60 percent of an orca's PCB burden can be passed to her calf during lactation.[3]

Finally, this study also found that PCB accumulation is higher in industrialized areas. Orcas farther north had comparably less chemical accumulation than those in the more industrialized southern region.

and at worst having lethal effects (see Pesticides and Salmon page 8). As pesticides breakdown they can sometimes become even more toxic than the original compound. This can cause problems because scientists typically look in waterways for the compounds that make up a pesticide, and when these compounds aren't found, it is usually assumed the pesticide is not present. However, the breakdown product may still be present, posing a danger to aquatic organisms.

Commonly Used Pesticides	
2,4-D	an herbicide sold in products such as Weedone® and Weed-b-gone®
MCPP	an herbicide also known as Mecoprop® and a variety of other trade names
Diazinon	an insecticide
Pentachlorophenol	a fungicide sometimes known as penta
Atrazine	an herbicide also known as Atrex® and a variety of other trade names
Simazine	an herbicide also known as Princep® and a variety of other trade names

***Pesticides** can be highly toxic, causing numerous problems for fish, interfering with their behavior and health, and at worst causing lethal effects.*

Another problem occurs when chemicals are undetectable in the water itself, but found at high levels in the sediments below the water. For example, glyphosate, found in the common pesticide Roundup, has been publicized as an environmentally friendly herbicide that breaks down shortly after application. Experiments have shown, however, that glyphosate may persist in the environment for as long as 3 years.

Polychlorinated biphenols (PCBs) are among the most widespread and persistent chemical contaminants in the marine environment. They are strong, stable, non-burning chemicals used in insulating materials, coolants, and lubricants. Up until 1977, when the federal Toxic Substances and Control Act banned new uses of PCBs in the U.S., they were used worldwide in electrical equipment such as capacitors and transformers. Although the use of PCBs has been outlawed, they still enter the food chain. It has been estimated that almost a billion pounds of PCBs have been produced, and 30 percent have been released into the environment to date, much of it through leaks, illegal dumping, and incineration.

Pentachlorophenol (PCP or penta) has been banned in 26 countries because of its highly toxic nature, but is still used in the United States. It is not found naturally in the environment, but is a manufactured chemical that was used widely as a pesticide until 1987. Today, penta is used solely as a wood preservative for utility poles, fences, porches, piers, bridges, etc. Penta increases the life of the wood, inhibiting decay and repelling worms and other burrowing creatures. Unfortunately, once penta is applied to wood, it does not necessarily stay there. Penta can leach out into the air or water, working its way into the food chain. It is also released during the wood treatment process. Nearly every person on the earth carries penta in his or her body.

Aromatic hydrocarbons (AHs) enter the environment from fossil fuel combustion and burning wood, as well as from power generation. AHs are not always considered "persistent pollutants" because of their extensive metabolism by fish and mammals. Some aromatic hydrocarbons, however, are resistant to

Pollutant	Sources	Potential Effects to Fish
Aromatic hydrocarbons (AHs), Polycyclic aromatic hydrocarbons (PAHs)	vehicle emissions, power generation, burning of oil, gas, garbage; oil spills	cancer, reproductive dysfunction, immune system suppression
Dioxins/ Furans	by-products from the manufacture of pesticides, preservatives, disinfectants, pulp and paper; incineration; backyard burning	reproductive dysfunction, immune system suppression
Lead	industrial facilities, disturbance of old structures containing lead based paint; prior to 1996, gasoline.	leads to dysfunction of blood-forming systems and the reproduction system
Mercury	industrial processes such as chlorine manufacture and refining; consumer products such as thermometers, barometers, batteries, etc.	reproductive dysfunction, impaired growth, developmental and behavioral abnormalities, and death
Pentachlorophenol (PCP or penta)	prior to 1987 it was used as a pesticide; currently used as a wood preservative for utility poles, fences, porches, piers, and bridges	reproductive abnormalities; lethal to many fish; A 1991 spill in Bellingham traveled to Whatcom Creek, killing 50,000 steelhead in the hatchery
Polychlorinated biphenyls (PCBs)	found in insulating matetials, coolants, lubricants, electrical equipment, banned from new uses in 1977	reproductive dysfunction, immune system supression, hormonal and behavioral changes, abnormal development of young

microbial breakdown and do persist in an aquatic environment. The rapidly increasing concentration of these pollutants in coastal environments due to urbanization is of growing concern to scientists.

Polycyclic aromatic hydrocarbons (PAHs) are a type of aromatic hydrocarbon of particular concern because of their effects in Puget Sound. These contaminants do not dissolve in water, but attach to solid particles and settle to the bottom, resulting in sediment contamination in many locations. Over a hundred different PAHs are formed from the incomplete burning of coal, oil and gas, garbage, or other organic substances. Through their exhaust, automobiles contribute a very large amount of PAHs to our area's waterways. They may also enter the water through wastewater treatment plant discharges.

Another important group of toxics are **dioxins** and their cousins, **furans**. This family of chemicals is not manufactured deliberately, but are by-products from the manufacture of pesticides, preservatives, disinfectants, and pulp and paper. In addition to being discharged in wastewater, they are also released to the environment when materials such as gasoline, paper, plastic, and wood are burned at low temperatures. Incinerators, pulp mills, power plants, steel mills and backyard burning are some of the sources of airborne dioxin.

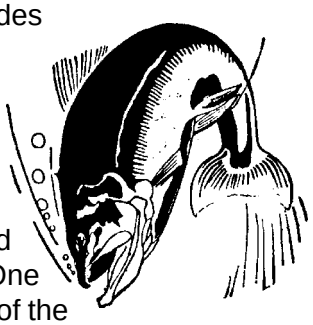
Pesticides and Salmon

2.8 million pounds of pesticides are applied in the Puget Sound area each year. This wide array of chemicals is used in agriculture, parks and residential landscapes to kill unwanted plants and insects. After they are applied, pesticides can seep into groundwater or be washed off fields and lawns into storm drains and streams. Problems arise when consumers don't follow label directions and apply more than necessary. Even when applied properly, these chemicals can harm fish.

A study by the U.S. Geological Survey (1999) conducted in King County detected twenty-three pesticides in the urban streams near Puget Sound, five of which exceed federal limits to protect aquatic life.[4] The study suggests a link between residential use of pesticides such as 2,4-D, MCPP and diazinon as the source of water quality degradation.

Recent listings of endangered and threatened fish species under the Endangered Species Act have drawn attention to the multiplicity of factors that add to their decline. The report *Diminishing Returns: Salmon Decline and Pesticides*,[5] documents the following lethal and sublethal effects of pesticides on salmon.

- **Fish Kills and Acute Toxicity:** Pesticides are capable of killing salmon and other fish directly and within a short period of time when they are exposed at concentrated levels. Instances have been documented in which hundreds to thousands of fish have been killed as a result of pesticide application and spills. For example, in 1996 on the Rogue River in Oregon, the herbicide acrolein was responsible for the death of over 100,000 fish.
- **Impaired Swimming Performance:** Laboratory studies have shown that pesticide pollution can reduce swimming speeds in salmon. Scientists speculate that certain pesticides may damage gill structures, decreasing the level of oxygen available to fish and slowing swimming speeds. This can inhibit salmon during crucial activities such as feeding, avoiding predators, defending territories and maintaining position in a river.



- **Increased Risk of Predation for Juvenile Salmonids:** Effects from pollution such as disease, metabolic problems, impaired swimming, and decreased schooling behavior can cause salmon to be more vulnerable to predators. One study found that juvenile coho salmon exposed to sublethal concentrations of the fungicide TCMTB were 5.5 times more likely to be consumed by rockfish than those not exposed to the contaminant.[6]
- **Altered Temperature Selection:** Multiple studies have suggested that when salmonids are exposed to some pesticides at low concentrations they try to lower their body temperature to reduce effects, and at higher concentrations they seek warmer temperatures to stimulate detoxification. These effects can continue for a considerable time after exposure, causing fish to seek abnormal water temperatures and leaving them at a higher risk of disease and predation.
- **Interference With Migration:** One study in New Brunswick radiotagged salmon as they entered two different estuaries.[7] As fish entered an unpolluted estuary they swam quickly upstream into the river system, while in a heavily industrialized estuary the fish spent time swimming back and forth attempting to avoid polluted water, increasing their migration time and making them more susceptible to other dangers.
- **Reduction of Food Supply:** Pesticides also indirectly affect salmon by altering their food supply. As pesticides are meant to kill insects, it is not surprising that they kill many of the terrestrial and aquatic insects that become food for salmon, which reduces growth and survival of salmon.

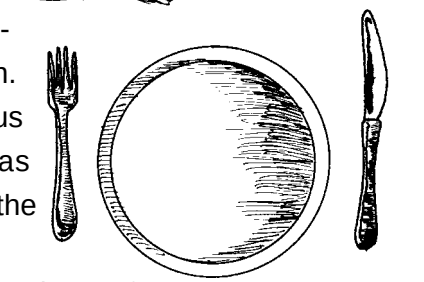
The most toxic chemical in the dioxin family is 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD). It is released to the environment through stack emissions from incineration, bleaching wood pulp, automobile exhaust, and from improper disposal of certain chemical wastes. TCDD is often found as suspended material or in bottom sediment.

Heavy metals such as mercury and lead also contaminate the water and soil of the marine environment. They are released during the burning of coal and oil, and during industrial processes including ore refining and cement production. They also leak from old landfills, as both lead and mercury are found in many consumer products and old paint. Unlike many organic pollutants, heavy metals do not break down with exposure to sunlight or heat, they persist and remain a threat for fish and shellfish.

Bioaccumulation and Biomagnification

An important process through which chemicals can affect living organisms is bioaccumulation. **Bioaccumulation** is an increase in the concentration of a chemical in an organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and stored in an organism's body faster than they are broken down (metabolized) or excreted. Some chemicals are not broken down at all and are simply stored in body fat or organs, building up over time. Understanding the process of bioaccumulation is very important in protecting organisms from the adverse effects of chemical exposure.

In addition to bioaccumulation, biomagnification is an important concept. **Biomagnification** occurs when a chemical becomes more and more concentrated as it moves up the food chain. A typical food chain includes several algae eaten by a water flea, several fleas are eaten by a minnow, in turn a trout eats several minnows, and finally an osprey eats the trout. If each step results in increased biomagnification of a given toxic contaminant, then an animal such as an osprey at the top of the food chain may accumulate a much greater concentration of a chemical than was present in any single organism lower on the food chain. Biomagnification has serious implications for humans as well, since they are often at the top of the food chain.



A classic example of biomagnification was described in Rachel Carson's *Silent Spring*.[9] DDT was used in the battle against Dutch elm disease in the 1950s. After spraying, the chemical formed a film over the bark and leaves of the tree and was not washed away by rainwater. In the fall, the leaves fell from the trees and were then eaten by earthworms. When robins returned the following spring, they ate the earthworms and accumulated the DDT in their bodies. Analysis of the reproductive organs of the robins showed extremely high levels of DDT, which led to a reduction in the number of robins returning the following years.

Biomagnification: *When toxic chemicals make their way into our waterbodies they settle into the sediment, where they are ingested by bacteria, microscopic plants and animals at the base of the food chain. These microscopic organisms are eaten by larger creatures - bugs, frogs, fish, etc. - which retain the chemical in their body fat and tissues. As these toxic chemicals make their way up the food chain they can eventually end up on your dinner plate.*

A study using DDT in a model ecosystem demonstrates how readily a pesticide can biomagnify through the food chain. DDT was applied to the grain crop sorghum, which was eaten by a salt marsh caterpillar. Waste from the caterpillar was consumed by diatoms, which were subsequently eaten by species of plankton. The plankton was eaten by mosquito larvae, which were eaten by *Gambusia*, the mosquito fish. After one month, 54 percent of the chemical applied to the sorghum was found in the fish. The concentration of DDT was 84,000 times greater in the fish than in the water, while the concentration of DDE, a breakdown product of DDT, was 110,000 times greater in the fish than in the water.[11] The longer aquatic life has been exposed to toxic contaminants, such as pesticides, the greater the chance that some biological effect will happen to either the organism or its offspring.

Pollution Sources

Point Source Pollution

Point Source Pollution is discharged from a single and direct source such as an industrial facility or sewage treatment plant.

Sewage is not just made up of human waste and water. It can contain hundreds of toxic chemicals and metals, which enter the system from households, businesses and industrial operations. Think of the make-up, art supplies and detergents you wash down the drain at home; many of these contain arsenic, lead and other metals. Tons of food wastes from sink grinders add to the load.

Conventional pollutants from sewage include fecal coliform bacteria, oil and grease, and suspended solids. Treatment of sewage has historically focused on these conventional pollutants, which can all cause problems and upset the ecological balance of the area where the sewage is discharged. Oil and grease can poison marine life, birds, and mammals. High levels of fecal coliform bacteria can contaminate shellfish, which has led to closure of many shellfish areas in our region.

Unfortunately, many metals and manmade organic compounds are not removed by conventional sewage treatment methods. Toxic contaminants found in sewage include metals (such as mercury, arsenic, lead, chromium, copper, cadmium, and silver), hydrocarbons, man-made organic chemicals, and chlorine. Some of the metals and organic compounds can bioaccumulate in organisms and be passed up the food chain.

Industries throughout the Puget Sound region such as aluminum and steel manufacturers, electronics plants and pulp mills are also contributing to toxicity in the marine ecosystem. Over the years, most industrial facilities have installed better treatment systems, but many effluents still fail to meet water quality standards or are toxic to marine organisms.

Heavy metals from these facilities, especially lead and mercury, are still discharged in industrial wastewater. According to the Environmental Protection Agency's Toxic Release Inventory, 820 pounds of lead and lead compounds were discharged into the Puget Sound released to water and air during production of circuit boards, electronic components and glass panels for computers. Even if concentrations and volumes of these chemicals released by individual facilities are small, in combination the quantities are quite significant.

- **Refineries:** The five oil refineries in the Puget Sound region refine millions of gal

Controlling Point Source Pollution In Washington State -A Permit System-

In 1972, The Clean Water Act set a national goal to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" and to "eliminate the discharge of pollutants" into navigable waters by 1985.

To achieve the goals set by the Clean Water Act, the federal government set up the National Pollution Discharge Elimination System (NPDES), which requires facilities that discharge pollution to obtain a permit. In 1973, Washington became one of the first states to be delegated the authority to issue federal NPDES permits. Permits are written and administered by Washington Department of Ecology engineers and scientists. These permits limit discharge concentration and quantities. Permits may also require monitoring, reporting, treatment, spill prevention planning, and other activities. Permits are updated approximately every five years with the goal to continually reduce pollution levels until they are eliminated.

Who needs a permit?

- **Washington state wastewater discharge permits** are required for anyone who discharges waste materials from a commercial or industrial operation to the ground or to a publicly owned water treatment plant and for municipalities who discharge to the ground.
- **NPDES permits** are required for anyone who discharges wastewater to, or has a significant potential to impact surface waters of the state.

Types of permits:

- **Individual permits** are issued for specific facilities, such as aluminum smelters, refineries, and wood treatment plants.
- **General permits** cover a category of similar dischargers. This means only one permit is issued for all boatyards in Washington, for example. Similarly, general permits cover other categories such as dairies, or hatcheries.

How can you get involved?

With over 230 permitted dischargers in Whatcom and Skagit Counties alone the permit process may seem overwhelming. Start small and don't be discouraged. Begin by looking into the status of permits for facilities in your neighborhood. Notify the Department of Ecology that you would like to be a party of interest for these facilities. This will ensure that you receive notice of permit activities. Each time a permit is up for renewal, the Department of Ecology will release a draft to the public. There is generally a thirty day period during which you may comment. Permit writers then take all comments into account when writing the final permit. Voice your support for stronger permits that will better protect our waterways.

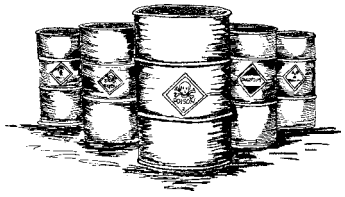
lons of crude oil a year. They use many toxic metals, organic solvents, acids and other chemicals in the refining process. These facilities also use millions of gallons of water a day in the refining process. Some of the oil and chemicals used at the refineries remain in the wastewater. Some chemicals are in the crude oil itself – such as heavy metals, sulfides, and phenols – while others are created during the refining process – such as cyanide, dioxin, and furans. Pollutants in refinery wastewater include solid particles, oil and grease, fecal coliform, ammonia, sulfides, phenols, and heavy metals such as chromium. All of these chemicals are highly toxic to aquatic life at low concentrations.

- **Pulp and Paper Mills:** To make paper, cardboard, and other products, pulp mills turn wood or wastepaper into pulp by cooking the wood in strong acids or caustics. Many pulp mills also use chlorinated compounds that form toxic by-products, such as dioxin and chloroform. While the wastewater from mills is treated to remove solids, organic materials and other chemicals before discharge, not all pollutants are removed. Not only is dioxin discharged via wastewater, but it is also emitted into the air via wood burning boilers and seeps into the soil from sludges that are landfilled.

- **Shipyards:** Shipyards use many solvents, paints and oils in their operations. The paint used contains high levels of toxic heavy metals such as copper and zinc. Because much of the maintenance and painting is performed outside or on dry-docks, these chemicals have a high potential to reach Puget Sound in storm water run-off when it rains, by air deposition while sandblasting, or when ships are launched. Starting in 1989, shipyard discharge permits have significantly addressed the control of heavy metal discharges, the contamination of sediments and the treatment of pressure wash water and storm water. However, discharge of heavy metals from many shipyards still exceeds state water quality standards, even with the implementation of Best Management Practices.

Pollution Prevention vs. Pollution Treatment

While improved wastewater treatment and on-site Best Management are important to controlling pollution discharges from industrial facilities, it should be noted that it is preferable to avoid making the pollutant in the first place. Changing manufacturing processes to avoid the production of pollutants rather than treating to remove pollutants is preferable for many reasons. If the pollutant has been created through an industrial process, but recovered out of the waste stream, the pollutant still exists. It may be that it has been captured before release into the Sound, but that may simply mean that the chemical is now sludge in a treatment lagoon, which still requires disposal. By moving to cleaner manufacturing processes that do not produce toxic contaminants in the first place, the whole problem of wastewater treatment is removed.



Non Point Pollution

Non Point Pollution does not originate froma single source or point, but from runoff from streets and stormdrains. Non-point pollution arises from many everyday activities that take place in residential, commercial, and rural areas and is carried by stormwater runoff to waterways. Examples of non-point pollution include soil erosion from farmland and construction sites, rural and urban pesticide and fertilizer runoff, failing septic systems, animal waste, and motor oil, and antifreeze running off roadways. Today, non-point pollution remains the largest cause of water quality impairment in the United States.

When it rains, pollutants are washed from lawns, driveways, and roads either directly into local waterways or into storm drains. Since storm drains empty into streams and rivers, whatever washes into the street will also enter local waterways. Although individual homes might contribute only minor amounts of non-point pollution, the combined effects of an entire community can be serious.

Nonporous urban landscapes such as roads, bridges, parking lots, and buildings don't let runoff slowly percolate into the ground, which can filter out contaminants. Because concrete and asphalt don't absorb rainwater, runoff from urban and suburban areas is much greater than

Pentachlorophenol (penta or PCP) has been banned in 26 countries, but is still used in the United States. It is not found naturally in the environment, but is a manufactured chemical that was used widely as a pesticide until 1987.

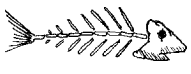
Today, penta is used solely as a wood preservative for utility poles, fences, porches, piers, bridges, etc. Penta increases the life of the wood, inhibiting decay and repelling worms and other burrowing creatures.

Penta is released into the air and water during the wood treatment process and throught the life of the product. Once penta is applied to wood, it does not necessarily stay there. Penta can leach out into the air or water, working its way into the food chain. Most people are exposed through foods such as milk, fruit, and meat. While exposure rates are generally high for those who work in wood treatment facilities and other related occupations, nearly every person on the earth carries penta in his or her body.

The Environmental Protection Agency has classified penta as a probable human carcinogen. Penta can also interfere with development and other body processes by harming the liver, kidneys, blood, lungs, nervous system, immune function and gastrointestinal tract.

As if penta weren't bad enough on its own, most of it is contaminated with dioxin. The EPA considers penta-treated products to be the largest known source of dioxin release into the environment. (See page 23 on dioxin)

Two wood treatment facilities in Bellingham release penta directly into local creeks: Brooks Manufacturing and Oeser Company. The Oeser facility grounds made the national EPA Superfund list of contaminated sites requiring clean up. In 1997, Little Squalicum Creek, which receives waters from the site, was so contaminated that no fish could survive. The EPA initiated excavation and disposal of PCP-contaminated soil and is waiting to see whether the stream will recover. Further clean up of this facility may be necessary as time goes on.



There are alternatives to using highly toxic chemicals in wood treatment. Some companies are using different materials such as steel, fiberglass or concrete to make poles and pilings. Others are starting to bury telephone lines underground. It is possible to prevent chemical leaching by covering treated wood with plastic liners. Some homeowners have begun to use lumber made with recycled plastic and dock pilings of PVC or concrete.

from undisturbed areas with adequate vegetation. Water remains above the surface, accumulates, and runs off in large amounts. Urbanization also increases the variety and amount of pollutants transported to receiving waters. Sediment from disturbed soil at construction sites; oil, grease, and toxic chemicals from automobiles; nutrients and pesticides from turf management and gardening; viruses and bacteria from failing septic systems; and heavy metals are examples of pollutants generated in urban areas.

BMP's

A wide range of "best management practices" offers homeowners and landowners ample opportunity to protect water quality. To actively undertake voluntary actions and to continue supporting policies aimed at protecting the ecological health of Puget Sound, citizens will have to better understand the real cost of a degraded Sound – not only the loss of aquatic resources, but the more intangible effects on quality of life.

According to the 1994 *National Water Quality Inventory*, polluted run-off from agricultural sites is the leading source of water quality impacts in the United States. Agricultural activities that cause non-point pollution include confined animal facilities, grazing, plowing, pesticide spraying, irrigation, fertilizing, planting, and harvesting. The major pollutants that result from these activities are sediment, nutrients, pathogens, pesticides, and salts. Incredibly, toxic industrial wastes from pulp mills, steel mills, tire incinerators, and cement kilns are made into fertilizers and legally spread on farms throughout Washington. This practice is allowed despite the fact that these wastes contain dangerous levels of lead, mercury, cadmium, dioxin, and other poisons. These heavy metals, in addition to pesticides, herbicides, and fungicides can run-off the land, and find their way to Puget Sound.

Individual boats and marinas usually release only small amounts of pollutants. Yet, when multiplied by the thousands of boats on the Sound, they can cause distinct water quality problems. The U.S. Environmental Protection Agency has identified high toxicity in the water, increased erosion rates, increased nutrient loading, and high levels of pathogens as a few of the potential environmental impacts from boating and marinas.

Poorly flushed waterways, boat maintenance, and discharge of sewage from boats are just a few sources of water pollution that can cause these impacts.

What You Can Do about Non-Point Pollution

Unchecked, non-point pollution is a continual threat to Puget Sound. Successfully eliminating this threat will require considerable citizen efforts to curtail each individual's contribution. We can all work to reduce and prevent non-point source pollution.

Whenever we mow our lawns, drive our cars, or use hazardous household chemicals, we face the potential of adding airborne or waterborne contaminants to Puget Sound. When we buy products whose manufacturing results in the discharge of toxic pollutants, we are further adding to the load. These diffuse, or nonpoint, sources are much more difficult to control than the more notable industrial, or point, sources. There are few permits or other regulatory limits on many of these activities, some of which are simply part of daily life. We can, however, control discharges of non-point pollution by changing our habits.

Sediment Contamination in the Sound

For much of the past 100 years, residents, businesses, and industries have dumped their waste into the waters of Puget Sound. Industrial activities, combined sewer overflows, old shoreline landfills, storm water discharges, and military operations have all contributed substantial amounts of toxic chemicals to our waterways. Most of the chemicals that enter the Sound attach to fine particles and eventually settle to the bottom. The species that live in or upon marine sediments are at most risk of experiencing the affects of these contaminants. These organisms often concentrate contaminants in their tissues and then pass them up the food chain. Consequently, major monitoring programs such as the Puget Sound Ambient Monitoring Program (PSAMP) emphasize sediment sampling when attempting to assess toxic contamination and the health of the marine environment.

Of over 15,000 acres of Puget Sound sediments that have been studied, 5,750 acres have been found to be contaminated above the state's Sediment Quality Standards. Of these, over 86 sites, spanning 3,200 hundred acres have been deemed as requiring cleanup under federal law.

"Among 100 stations evaluated by Ecology-NOAA in 1997, 18 stations had at least one chemical concentration above a guideline value, at least one toxicity test that indicated highly toxic conditions, and some degree of

Diazinon, a common insecticide, has found its way into rivers and streams around the Puget Sound. This chemical is used in urban and rural areas to control pests such as ants, aphids, carpenter ants, crane flies and fleas.

Very small amounts of Diazinon - a fraction of one percent of the amount of applied - have been found to cause many problems in humans and fish, interfering with crucial biological functions such as growth, development and reproduction and causing elevated risks for cancer. The U.S. Environmental Protection Agency has announced a phase out of manufacturing of retail products containing diazinon for use on lawns and gardens by June 30, 2003 because of these risks posed to consumers:[8]

Alternatives to Diazinon at Home

Ants: Prevention is key. Remove food sources (the honey jar, the cat food dish, etc.). Keep food in containers with tight lids. Caulk entry points into your house. To prevent carpenter ants, keep wooden parts of the house dry, repair leaky plumbing, store wood away from the house, and trim trees to keep branches away from the house.

Aphids: Aphids don't often survive on healthy plants. Use plant varieties well-adapted to your area. Provide optimal irrigation and fertilization. Encourage beneficial insects that prey on aphids. For large populations, wash aphids off plants with a strong stream of water.

Crane flies: It takes a lot of crane flies to noticeably damage a lawn. To find out if you have a crane fly infestation, dig up a small section of lawn in the spring and count crane fly larvae. If there are fewer than 25 to 40 larvae per square foot, no treatment is necessary, because their populations will not be high enough to damage your lawn. You can treat a crane fly problem non-chemically with deep but infrequent watering, aeration of the lawn and the use of parasitic nematodes (similar to tiny worms).

Fleas: Focus treatment on your pet and the areas where they sleep rather than broadcast insecticides. Flea combing is effective to remove fleas from your pet. Frequently vacuum and wash your pets' bedding, since flea eggs and larvae are often found there. Commercial flea traps that use a light to attract fleas to a sticky surface are also available.

reduced abundance of the sediment dwelling community."

All of these stations are located in waters of the Northern Puget Sound, including the waters around Everett, Fidalgo Bay, Padilla Bay, Bellingham Bay, and Drayton Harbor. The highest chemical concentrations in sediments of the northern Sound were found in Everett and Bellingham Bay.

Sediment Contamination in Bellingham Bay

Bellingham Bay is contaminated with heavy metals such as mercury, copper, chromium, lead, nickel, and zinc; polychlorinated biphenols (PCBs), inorganic toxics, PAHs, phthalates, DDT, phenols.

As with many locations in the Sound and Straits, the sediments beneath the Bellingham Bay are contaminated with a variety of heavy metals and chemical compounds. The major contaminant is approximately 26,000 pounds of mercury, discharged by the Georgia Pacific chlorine production plant that operated at the pulp and paper mill in downtown Bellingham from 1967-1999. Bellingham Bay is also contaminated with polychlorinated biphenols (PCBs), inorganic toxics, PAHs, phthalates, DDT, phenols, and other heavy metals such as copper, chromium, lead, nickel, and zinc from a variety of historic and current practices.

While many of these sources of contamination, such as the Georgia Pacific chlorine facility, are no longer discharging, the contaminants persist in the environment, posing a threat to fish, shellfish, birds, and humans. Some of the organic and inorganic contaminants are a result of a leaking landfill on the shores of the bay, and others come from runoff from streets and parking lots.

To understand how these contaminants affect the ecosystem of Bellingham Bay, and ultimately human health, a review of the path they take through the environment is helpful. Mercury, for example, is heavier than water, so it sinks. It is also positively charged, so it binds to small, negatively charged sediment particles. Once mercury settles, it may be taken up by plants or small animals living in the sediment (these are called benthic organisms). When fish or crabs eat these contaminated plants or animals, the toxins are transferred to their bodies. They then pass the contaminants up the food chain when they, in turn, are eaten.

Filter feeders, including oysters, clams, and mussels, consume toxins that are bound to the fine particles that make up their diet. When predators eat these animals, any toxins in the prey are concentrated in the flesh of the predator. The animals on the top of the food chain (including eagles, marine mammals and humans) receive the highest doses of toxins when they eat contaminated seafood.

Biological Effects

Liver disease, reproductive damage, and immune system disruption are just a few of the problems detected in studies conducted on fish species in the Puget Sound basin. Many toxic chemicals cause additional problems because of their bioaccumulative nature, exposing high-level predators, such as Orca whales and bald eagles, to very high concentrations of contaminants.

Scientific studies from as early as 1977 found that a variety of fish were being affected by the contamination of their habitats, specifically from organic chemicals such as PCBs, PAHs, and dioxins. Researchers have found that contaminants can affect organisms at the

The Bellingham Bay Demonstration Pilot

The Bellingham Bay Demonstration Pilot Project is an inter-agency effort addressing the problem of contaminated sediments in Bellingham Bay. The Pilot's objectives are to protect human health and safety, and to protect and restore ecological health and ecosystems. The Pilot Team is considering the following options to remediate the contaminants.

- **Cap in Place:** Contaminated sediments are left in place and capped with clean sediment. The goal of such a cap is to isolate contaminants so that sediment-dwelling benthic organisms and other bottom dwellers are not exposed.
- **Confined Aquatic Disposal (CAD):** A CAD unit is, in essence, an underwater landfill. Engineered berms are built to create a large basin into which dredged contaminated sediments are dumped. These contained sediments are then capped with clean material.

Capping material being placed on top of contaminated sediments at the Georgia Pacific Log Pond.

- **Upland Disposal:** Contaminated materials can also be disposed of in an upland landfill setting. Under this scenario dredge spoils would either be shipped to an existing landfill or a new landfill could be created, possibly using a portion of the Georgia Pacific treatment lagoon.
- **Treatment:** There are a variety of emerging technologies that allow for the treatment of contaminated material. These include locking contaminated sediments within a concrete matrix or "glassifying" it, incineration, and using an electro-magnetic system to pull contaminants out of the sediments.

There are concerns about all of these options. Re-suspension of contaminants during dredging is a primary concern. When sediments are dredged or otherwise disturbed, the contaminants are re-suspended into the water or are pulled up into the "biologically active zone" of the sediments, which is where the benthic organisms live. This makes the contaminants more readily available, and can send a pulse of toxics through the food chain. This can be avoided by using hydraulic dredges instead of traditional clamshell dredges or not dredging at all.

Another concern about all of these remedies is whether the contaminants will be adequately isolated. Caps and CAD units must be designed so that burrowing benthic organisms, such as clams and ghost shrimp, cannot reach to contaminated area. This means that caps must be extra thick. Puget Sound and the Straits are grey whale habitat. These animals feed by foraging the bottom. There are concerns that such foraging by whales in the bay may disturb CAD and cap sites.

To be kept informed of progress of the Pilot, contact Lucy McInerney at theWashington Department of Ecology, (425) 649-7272.

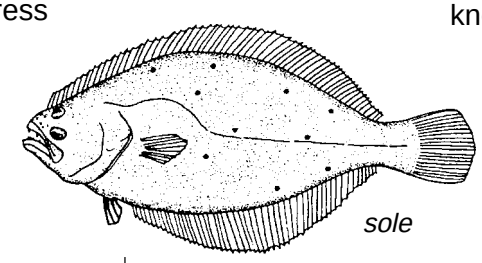
cellular and molecular levels with impacts on the reproductive and immune systems of fish and shellfish. Researchers are making impressive progress in uncovering the effects of toxic substances on aquatic organisms. It is clear that the array of chemicals entering our waterways can stress the fabric of the Puget Sound ecosystem in countless, often unpredictable, ways.

Immune Systems Suppression

The environment is alive with biological threats, including pathogens (disease-producing organisms). To cope with such threats, all living organisms are equipped with a number of defense mechanisms. Destruction of foreign invaders inside the body is a function of an animal's immune system. The functions of the immune system are to recognize, selectively eliminate, and remember foreign invaders. If an animal has a defective immune system, its resistance to bacterial pathogens is reduced, susceptibility to disease increases, and the chance of death increases. Immune systems in fish attack foreign agents in their bodies with the same response mechanisms as mammals. In polluted waters, fish are subject to many man-made chemicals, which can suppress immune function and impair their ability to fight disease.

Elevated concentrations of toxic contaminants in urban rivers and estuaries have raised concern along the West Coast. Several studies have shown detrimental effects in immune system function in juvenile salmon exposed to PAHs and PCBs. One such study analyzed the spleen and anterior kidney of salmon for response to complex chemical interactions.[13] The results suggest a connection between the aromatic hydrocarbons ingested by the fish, the suppression of their immune system, and their lack of resistance to disease.

Researchers with the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service conducted a study in 1998 to examine the link between exposure to contaminants and immune dysfunction.[14] Eight-month-old chinook salmon were collected, studied for exposure to chemical contaminants and subsequently faced a disease challenge. Scientists collected these juvenile salmon from four different sites in Puget Sound; two industrial areas and two nonurban areas. Upon examination of liver and stomach tissue from the sample population, researchers determined that contaminants such as PAHs and PCBs were indeed elevated in salmon from the industrialized Duwamish Waterway, relative to those from the nonurban Nisqually River estuary. The salmon were then exposed to the marine pathogen *Vibrio anguillarum*. Results concluded that juvenile salmon in urban areas have increased susceptibility to infection due to contaminant-associated immune system dysfunction.



sole

Marine flatfish commonly known as "bottom fish" because they feed in bottom sediment, often use nearshore habitats as nursery or breeding grounds. Because of their proximity to human uses, nearshore habitats are often the locations where environmental degradation is the greatest. Two studies show English sole from industrialized areas in Puget Sound take up and accumulate chemical contaminants, such

Polycyclic aromatic hydrocarbons (PAHs)

PAHs have been found throughout the environment of the Puget Sound basin. Over one hundred different types of PAHs are formed through the burning of fuels and other materials in power generation, industries, cars, wood fires, tobacco products and barbecues. Concern about this family of toxic chemicals has arisen because of their potential to cause cancer and impair immune defenses, reproductive processes, growth and development in wildlife and humans.

PAHs are emitted through natural processes such as volcanoes and forest fires, but they are increasingly the result of pollution associated with the American lifestyle. They enter the air through the burning of fuel such as coal, oil and gas - with the greatest contributor being automobile exhaust. PAH particles attach to solids entering the aquatic environment through stormwater runoff. PAHs are a problem because they do not dissolve in water. Instead, they settle to the bottom, resulting in widespread sediment contamination in the urbanized areas of the Sound.

Additionally, PAHs are bioaccumulative in nature. This means that over time, PAHs will increase in concentration in living organisms because the toxin is absorbed faster than it is broken down. Some PAHs are not broken down at all, but are simply stored in body fat or organs, forever. Because of this, contamination levels can be much higher in an organism than in the surrounding water or sediment.

Many PAHs, such as benzo(a)anthracene, benzo(a)pyrene, and chrysene, are carcinogenic, causing tumors in fish and other animals, and are acutely toxic to some organisms. Noncarcinogenic PAHs, such as fluoranthene, phenathrene, and pyrene, are also toxic to some organisms.

Growing evidence shows the strong relationship between PAH-contaminated sediments and health effects in bottom fish of Puget Sound. Increases in tumors of the liver, immune dysfunction, increased susceptibility to disease, and reproductive impairment have been correlated with high PAH contamination. Studies comparing English sole from urban and near-urban locations with those from less contaminated areas have been conducted.[11] English sole exposed to PAHs showed reproductive dysfunction such as interference with hormones and ovarian development. PAHs were also shown to be the major risk factor for liver lesions in English sole. The fish in contaminated areas were more likely to develop liver lesions, than those from clean reference areas. Prevalence of these tumors in the fish from non-urban areas was 3 to 8 percent, while in contaminated areas such as Elliot Bay and Commencement Bay, tumor prevalence was much higher, ranging from 25 to 40 percent.

PAHs are also a threat to endangered salmon. Recent studies examined juvenile salmon migrating through urban estuaries.[12] These studies showed elevated levels of many contaminants, including PAHs, in the liver and bile in juvenile salmon from urban estuaries as compared to those in relatively uncontaminated estuaries. Because young salmon can spend several months in estuaries during outward migration, the biological effects of chemical contaminants could potentially lead to reduced survival rates.

I**n order to reduce PAHs we must look at our lives to reduce our dependence on fuel burning activities.** On a societal level this means transitioning to cleaner energy sources and reducing industrial emissions. On an individual level the greatest change we can make is by driving less, and instead carpooling, biking or taking the bus. Then we can look to other areas in our lives. In the yard this would mean using an electric or push mower, instead of one with a fuel burning engine and composting instead of burning yard waste. While it may seem like a challenge at first, as we make these changes, the benefits to health and the environment will be overwhelming.

as PAHs and PCBs.[6] These studies present evidence of altered immune function and increased susceptibility to infectious disease. More studies are currently underway to better asses the linkages between contaminant exposure and suppressed immune function in fish.

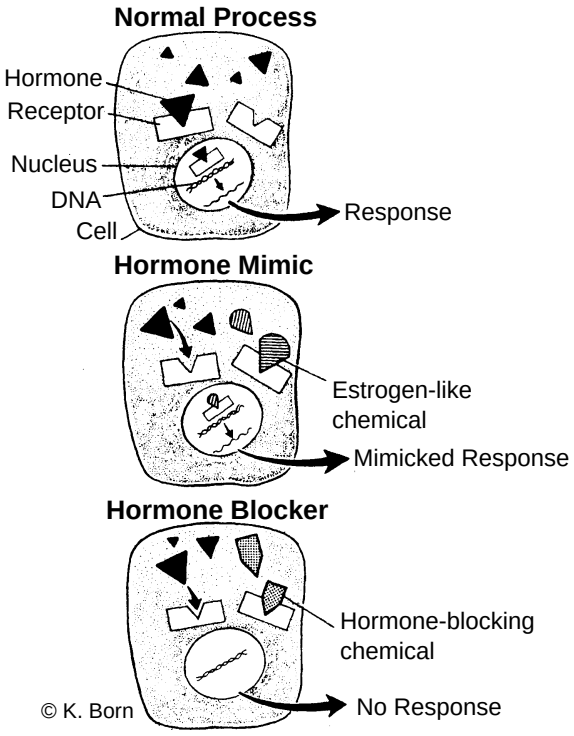
Endocrine Disruption

In the late 1970s, researchers found that fish collected from a small coastal stream in the panhandle of Florida had a strange characteristic: They were all male.[16] On further inspection, another oddity was noted. Many of the apparently male fish showed signs that normally indicate a female with internally developing young. These "male" fish were actually females with male traits! A few months later, a second population of females with male traits was discovered in a stream approximately 180 miles east of the first stream.[17] In both streams, the fish were found downstream of paper mills. Chemicals in the pulp mill discharge were later implicated in altering the endocrine systems of these fish. This discovery led to further research on toxic chemicals and endocrine disruption.

Endocrine disrupters may cause the following outcomes:

- **mimicking of sex hormones or estrogens**
- **masculinization of female fish**
- **interference with bone formation and growth, resulting in malformed adults**
- **reproductive impairment**

Endocrine Mimicking and Disruption



The endocrine system is a complex network of glands and hormones that carries messages from one part of the body to another to keep an organism functioning properly. It is responsible for controlling blood sugar levels, growth and function of the reproductive system, regulation of metabolism, brain and nervous system development and overall growth and development of an organism. For some time, scientists have been noticing changes in fish that may be attributed to dysfunction of the endocrine system.

The resulting research, conducted over the past twenty years, indicates that at least 45 synthetic chemicals are potential endocrine disrupters. These chemicals mimic hormones naturally produced in the body and can cause a wide array of outcomes. Research of endocrine disrupters in the aquatic environment focuses on determining whether this problem is occurring in fish and if so, if it is widespread.

According to a 1994 study, vinclozolin - a fungicide used widely for grapes, ornamental plants, and turf grass - can cause feminization of male fish.[18] The fungicide binds to hor-

MERCURY

Fish consumption advisories because of mercury contamination are in effect for more than 3,000 waterbodies in 41 states across the country reports the Environmental Protection Agency (EPA). Concern arises, because exposure to mercury can cause permanent harm to humans, including damage to organs such as the brain and kidneys. These effects are evident in young children whose organs are still developing. Additionally, the EPA has categorized mercury as a possible human carcinogen.

While mercury is a naturally occurring metal produced by volcanic activity, its concentrations have increased greatly with industrial growth. Half of the mercury found in water is generated by human activities including: leather tanners, chemical manufacturers such as chlorine and wastewater treatment plants. Mercury is also released into the air through solid waste incineration, fossil fuel combustion, mining, smelting, industrial production, and improper disposal of consumer products such as thermometers.

In Whatcom County, there are no longer any facilities that discharge mercury, but a legacy of contamination remains. Both Bellingham Bay and the Nooksack River exceed water quality limits for mercury. One of the major contributors was Georgia-Pacific's Chlor Alkali Plant, which discharged 26,000 pounds of mercury into the bay and an unknown amount to the air over the years it operated. Another major source of mercury emissions to the air was the Recomp of Washington trash incinerator, located near Ferndale.

Mercury in Lake Whatcom

In Lake Whatcom, mercury concentration levels in smallmouth bass are higher than the national average. The Washington Department of Health has released an advisory for Lake Whatcom that warns pregnant women and children under six to refrain from eating smallmouth bass and to limit consumption of yellow perch to less than 4 to 6 ounces per week, depending on body weight.

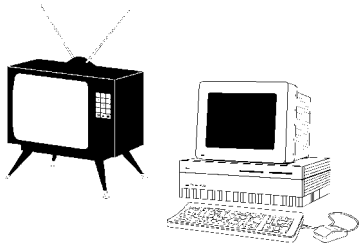
Range of mercury concentration levels in fish (parts per million)	
Washington lakes and rivers	0.02 to 0.54 ppm
Lake Whatcom bass (average)	0.49 to 1.84 ppm
U.S. bass (average)	0.09 to 0.78 ppm
canned tuna (average)	0.17 ppm

Specific sources of mercury in Lake Whatcom are unknown, but government officials speculate impacts from airborne sources or dumpsites in the lake. Further studies are being undertaken to determine sources.

How can you prevent mercury exposure or pollution?

Properly dispose of the following products containing mercury:

- fluorescent light tubes and bulbs
- thermometers
- pressure or temperature gauges
- car and gadget batteries
- televisions
- computer monitors



For more information on proper disposal call the Whatcom County Recycling Hotline (360) 384-8040.

mone receptors and enters the cell's nucleus, blocking normal responses. This results in suppression of the normal production of essential male proteins.[19]

Potential Endocrine Disrupters	
CHEMICAL GROUPS	SPECIFIC CHEMICALS
Herbicides	atrazine, 2,4-D
Fungicides	vinclozolin
Insecticides	DDTs, carbaryl
Nematocides	aldicaryl
Industrial Chemicals	phenols, PCBs, dioxins

Chlorinated hydrocarbons (i.e. dieldrin), organophosphates (i.e. malathion, parathion), crude oil, and heavy metals have all been implicated in bone abnormalities in fishes.[20] Researchers believe that the damage is done in the egg or early fry stage, possibly by effects on neuromuscular interactions during early development.

Some researchers suggest that endocrine-disrupting chemicals in the environment may profoundly alter the sex ratios and breeding capabilities of our native fish. At the very least, such abnormalities in the fish populations should provide a warning for the presence of endocrine disrupters in Puget Sound.

Reproductive Impairment

In most species of fish, sperm and eggs develop in separate individuals. Fertilization can be either internal or external. Males and females may look similar, or they may look very different. Male/female differences may include size, coloration, external reproductive organs, head characteristics, and body shape.

Field and laboratory studies conducted in Puget Sound have shown that exposure to chemical contaminants such as pesticides, PCBs, PAHs, and dioxins are associated with several types of reproductive dysfunction in fish.[21]

Further studies must be undertaken to determine the long-term impact that reproductive impairment might have on the survival and abundance of affected fish. This is an issue of great concern, especially at this time of increased human population and urbanization, which will ultimately lead to increased pollution.

English sole are an excellent species to study because, as bottom dwelling fish, they take up and metabolize or accumulate toxic chemicals from sediments and are particularly sensitive to their impacts. Study samples of English sole taken from industrial sites with high concentrations of PAHs and PCBs showed evidence of lower levels of estradiol, inhibited spawning ability, and reduced egg and larval viability.[22]

Reproductive dysfunction can include:

- **inhibited gonadal development**
- **lower levels of estradiol (a reproductive steroid)**
- **reduced spawning success**
- **reduced egg size**
- **lower egg and larval viability**

This research was then expanded to investigate the effects of contaminant exposure on reproductive processes of other species, including rock sole.[23] Results were similar to those found for English sole and suggest that industrial and non-point pollution poses a potential threat to fish stocks in urban areas. An-

other study examined rock sole to determine whether exposure to AHs or PCBs was associated with altered or reduced spawning success.[24] The findings showed that rock sole exposed to these chemicals produced eggs with significantly less weight, and overall spawning success was significantly impaired.

Dioxins have also been linked to reproductive impairment in fish. Research conducted on Great Lakes trout shows female fish accumulate dioxin-like chemicals in their bodies and transfer some of these chemicals to their eggs. This study found that, at high enough concentrations, these contaminants can cause all of the fish's offspring to die within weeks of hatching.[25]

Dioxins have been found to decrease the growth rate of fish and detrimentally affect their sac fry. Sac fry, or alevin, is the life stage of a salmonid after it hatches from the egg. While developing under a protective layer of gravel, the tiny salmonid depends on the yolk

Dioxin is thought to be one of the most toxic chemicals ever made by humans. Testing on animals has shown that the size dose that can cause disease is lower than that for any other man-made chemical. Dioxin is created as an unavoidable by-product in industrial processes using chlorine, such as paper bleaching. Often the manufacturing of pesticides, such as Agent Orange, 2,4,5-T and pentachlorophenol, requires chlorine, which can cause them to be contaminated with dioxin. PVCs are also a big contributor.

Dioxin distribution has become widespread throughout the environment. While most dioxin emissions are released to the air, they can then travel great distances before settling into the soil and water. Most humans are then exposed to dioxin through the food they eat, especially meat, fish and dairy products.

There are 75 different forms of dioxins, with varying levels of toxicity. The most toxic forms, specifically TCDD, have been shown to cause cancer, birth defects, immune system supression and learning and behavioral problems. Most disturbing is that dioxin has the greatest affect on children. Dioxin exposure has been associated with increases in IQ deficits, depression and hyperactive behavior in children.

Local dischargers of dioxin include: Both of Bellingham's wood treatment facilities - Brooks Manufacturing and Oeser Company; the oil refineries ARCO and TOSCO in Whatcom County, and Texaco and Tesoro in Skagit County. Dioxin was formerly discharged into Bellingham Bay from Georgia-Pacific's paper pulping operation.

Today it is important to become flexible in our practices to reduce health and environmental effects of dioxin. This will require the phase out of chlorine processes such as bleaching paper. Instead we can adopt Totally Chlorine Free (TCF) technology. As consumers, we must take a stand by buying unbleached paper products, or those brightened with a TCF process. We also need to eliminate the use and manufacture of dioxin-contaminated pesticides. You can start by avoiding the use of pesticides in your yard. Pick weeds by hand and use other natural techniques. For more information on environmentally-friendly weed and pest control, call RE Sources (360) 733-8307. In addition, be sure to dispose of pesticides properly. For more information call the Disposal of Toxics (360) 380-4640.

sac on its belly for nutrients. Dioxin can cause the sac fry to die from an accumulation of excess fluid in the yolk sac and around the heart, obstructed blood flow, hemorrhaging, and a deformed skull.

TCDD, the most toxic form of dioxin, caused observable increases in sac fry mortality at levels as low as 30 parts per trillion in lake trout eggs. 100 percent mortality occurred at TCDD levels above 100 parts per trillion. With concentration levels of dioxins up to 0.5 parts per trillion, effects at this level can occur in discharge waters downstream from industries such as paper pulp mills. Because of bioaccumulation, the fish found in these waters can contain levels at nearly 200 parts per trillion in their flesh. Research like this shows that in the early stages of life, fish are particularly vulnerable to the toxic effects of dioxin, which can greatly impact health and size of population.

Liver Disease

The liver is a digestive gland that secretes bile and is involved with the formation of blood. There is increasing evidence that toxic contaminants adversely affect the livers of fish in Puget Sound. Since the 1970s, studies have shown a strong relationship between chemical contaminants in sediments and increases in liver disease, including cancer, in bottom fish in Puget Sound. The research found significant correlations between the levels of AHs in the fish bile and the prevalence of lesions (tumors).[26] Other research showed higher levels of liver lesions in fish exposed to PAHs, PCBs, and DDT.[27] This cause-and-effect relationship between PAHs and liver lesions in English sole has been confirmed in laboratory studies.[28]

Ongoing studies by the Washington Department of Fish and Wildlife and the National Marine Fisheries Service show English sole from urban and near-urban locations are more likely to develop liver lesions from exposure to man-made chemicals than English sole from clean reference areas. Exposure to PAH-contaminated sediments has been shown to be the major risk factor affecting the development of liver lesions in English sole. Moreover, the increasing trend in liver lesions in fish in Puget Sound suggests that PAH exposure is on the rise as human populations increase.

Fish do not necessarily need to spend a lifetime in one location to experience effects from toxic chemicals. Recent studies examined juvenile salmon migrating through urban estuaries.[20] These studies showed elevated levels of AHs and PCBs in the liver and bile metabolites in juvenile salmon from urban estuaries as compared to those in relatively uncontaminated estuaries. Because young salmon spend one to several months in estuaries during outward migration, the biological effects of chemical contaminants could potentially lead to reduced survival. Further studies are necessary to examine the link between the accumulation of toxic chemicals in migrating salmon and adverse biological effects.

The long-term impact that liver lesions and other diseases have on the survival of Puget Sound's bottom fish is not known. Although chemicals undoubtedly make some contribution to overall mortality, their importance in relation to other causes of mortality is not entirely clear. An important question to consider is whether disease and reproductive impairment associated with chemical contaminants have the potential to contribute to declines in fish populations. Each pollutant, with

its own impacts, may add layer upon layer of stress to aquatic organisms. So while one pollutant may not be enough to seriously harm a fish population, the impacts of multiple pollutants, with all of their effects, may.

Looking Ahead

There is a mounting body of evidence that shows links between toxic pollution and adverse biological effects in the animals of Puget Sound. Research has shown that even small amounts of toxic chemicals can cause interruptions to normal bodily functions and behavior in all levels of the aquatic food web. The wide array of effects that has been demonstrated is cause for concern. The magnitude of the problem from toxic chemicals is difficult to assess. Further research is necessary to better understand the distribution of problems and to characterize the effects that toxic contaminants might have on the Puget Sound ecosystem.

But must we wait until exhaustive research is complete? Certainly, we can take steps now to prevent further degradation. Supporting common-sense regulation is one step towards change. The state can and should require immediate compliance with current water quality standards at the point of discharge by abolishing the use of mixing zones, an area near a discharge pipe where concentrated effluent has an opportunity to mix with receiving waters and dilute. This is particularly important

Shellfish such as clams, oysters, mussels, and scallops are an important part of the marine ecosystem. Shellfish filter their food from the water. When heavy metals are present, they are taken in by the shellfish and can concentrate in their tissues. State and local health departments monitor water quality to determine which areas are safe for harvest. Contamination due to heavy metals has led to the closure of certain beaches around the Sound to commercial and recreational shellfish harvest, especially those in more industrialized areas.

The National Oceanic and Atmospheric Administration (NOAA) has a national Mussel Watch program that includes 14 monitoring stations in Puget Sound. Between 1990 and 1996, 10 of the 14 stations showed concentrations of one or more contaminants that were high relative to concentrations seen elsewhere along the nation's coast (see chart). This frequently included concentrations of PAHs, zinc and nickel.

Contaminants present at high concentrations in at least one-half of Mussel Watch samples from 1990 to 1996

Station (years sampled)	PAHs	Zinc	Nickel	Lead	Butyl tins
Point Roberts (5)			*		
Bellingham Bay (5)	*	*	*		
Everett Harbor (2)	*	*		*	
Possession Sound (5)			*		
Elliot Bay - 4 Mile Rock (5)	*	*			
Elliot Bay - Duwamish Head (2)	*				*
Sinclair Inlet (5)		*			
Main Basin,South Seattle (5)	*				
Commencement Bay (5)	*				
Port Townsend (5)	*				

Source: NOAA, 1998

for toxic and bioaccumulative chemicals. Another important step is to establish a deadline for ending the release of all persistent bioaccumulative toxics (PBTs) and holding dischargers accountable for meeting that deadline. Within the next few years, the Washington Department of Ecology hopes to move forward with a modest plan to begin phasing out PBTs. There are compelling reasons for the state to move forward with this program and others that seek to reduce or eliminate toxic chemicals in our environment.

Additionally, we can change the way we make decisions about manufacturing processes and the development of new products and chemicals. Currently, if an action, such as the manufacture of a new chemical, cannot be definitively shown to cause substantial harm, then it is approved for manufacture and use. Companies do not need to prove that their products are safe, only that there is not enough evidence to show that the product causes harm. This is a problematic approach, because new chemicals receive relatively little testing. The long-term effects of a chemical, particularly the impacts of bioaccumulative chemicals, are not assessed. Additionally, such testing does not take into account what happens when these chemicals interact with other chemicals in the environment. New chemicals are rarely tested for their effects in combination with other chemicals. This means that testing is not assessing real world impacts.

Some countries, such as Sweden and Germany, address this problem by adopting what's known as the "precautionary principle." In essence, this means that rather than trying to definitively prove that a product or chemical causes harm before its use is limited or banned, regulators require that it be proven safe before its approval. The burden is placed on the manufacturer to provide adequate proof demonstrating safety or harmlessness prior to approval. This subtle but powerful difference in attitude and regulation could radically change the way that we think about pollution. If the precautionary principle had been applied to the registration of new pesticides, the crash of bird populations due to DDT accumulation would have been prevented.

If we are to survive and live in a healthy natural system that supports all life, including that of humans, we must recognize that the natural world is interconnected. Humans are a part of the natural order, and like other life forms in the ecosystem, we are affected by degradation. The long-term viability of Puget Sound is threatened by continued human population growth and the pollution humans create. By listening to the science we have available and using a precautionary approach to decision making, we have the opportunity to make the right environmental decisions to protect and restore the natural treasure we call Puget Sound. This is important not only for the rights of the creatures that live in the Sound, but also for the health of our children and their children.

Glossary

Acute toxicity - the ability of a substance to cause biological harm or death soon after a single exposure

Alevin (fry sac) - the life stage of a salmonid between egg and fry; looks like a fish with a huge pot belly, which is the remaining egg sac

AHs (aromatic hydrocarbons) - a series of compounds characterized by the presence of one or more benzene rings; these chemicals enter the environment from fossil fuel combustion and burning wood

Androgen - the male sex hormone

Benthic organisms - organisms that live in the mud or other bottom material of lakes, streams, and marine ecosystems

Bioaccumulation - an increase in the concentration of a chemical in a biological organism over time

Biomagnification - increase in concentration of a pollutant from one link in a food chain to another

BMP (best management practice) - a range of methods designed to prevent, reduce or treat polluted runoff

Chronic toxicity - the capacity of a substance to cause long-term health effects in humans, animals, fish and other organisms

DDT (dichloro diphenyl trichloroethane) - an insecticide widely used in the past but now illegal in the United States

Dioxin - a family of organic compounds that contain chlorine; they are impurities and by-products from the manufacturing of pesticides, preservatives, and pulp and paper; has been called “the most toxic substance known to science”

Endocrine system - the complex network of glands and hormones that carry messages from one part of the body to another to keep an organism functioning properly

Endocrine disrupter - a chemical that interferes with the normal functioning of the body’s hormone system

Estrodial - a reproductive steroid

Estrogen - the female sex hormone

Fungicide - a chemical designed to kill molds, mildew, and fungi

Herbicide - a chemical that kills plants

Insecticide - a chemical that kills insects

Liver lesions - growths of abnormal tissue in the liver (tumors)

Non-point pollution - pollution which does not originate from a single source or point but from runoff from streets and storm drains

Organic chemicals - the vast array of compounds that include carbon and hydrogen; including toxic chemicals such as aromatic hydrocarbons, dioxins, and furans

PBTs - persistent bioaccumulative toxics

Pesticide - man-made chemicals used for control of target organisms; includes insecticides, herbicides, fungicides, and other biocides

PCBs (polychlorinated biphenols) - strong, stable, non-burning chemicals used in electrical equipment such as capacitors and transformers, and by-products of a variety of industrial products

PAHs (polycyclic aromatic hydrocarbons) - a specific type of aromatic hydrocarbon released naturally from volcanoes and forest fires; a pollutant from automobile exhaust, oil spills, and burning of coal, oil, gas, and garbage

Point source pollution - pollution from a single source such as an industrial facility or a sewage treatment plant

Solvent - a liquid capable of dissolving other substances

Toxicity - the harmful effects produced by a substance

VOCs (volatile organic compounds) - carbon-containing substances, released by both natural and human sources that produce fumes

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