PEBBLE WATCH *explores*

A series of fact sheets on topics related to potential Pebble mine development.

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Fish and Aquatic Invertebrates

U.S. Fish and Wildlife Service

About Pebble Watch

The Pebble Watch team consists of scientists and science communicators who can research and answer your questions about issues related to potential Pebble mine development — from science reports to permitting. Write staff@pebblewatch.com.

Key terms defined

Anadromous fish – Migratory fish that spends much of its life in the sea, but returns to fresh water to spawn.

Reach – Section of a stream or river. Scientists will separate streams into "reaches" to help describe specific areas.

Losing reaches – Parts of a stream that lose water as it flows downstream.

Gaining reaches – Parts of a stream that gain water as it flows downstream.

Channel morphology – The shape of a river or stream channel.

Off-channel habitat – Small tributaries, frequently spring-fed or groundwater-fed, that flow into larger channels. Can be very productive for salmonids, especially coho salmon and trout.

Instream flow – Flow of water in a stream; variable due to seasonal changes.

River habitat –

- **Riffles:** swiftly flowing, turbulent water
- **Runs/glides:** flowing water with little surface turbulence
- **Pools**: deep part of a stream or river where the water runs very slowly.

Why study fish and aquatic invertebrates?

Bristol Bay is rich with fish of many varieties. It's home to the largest sockeye salmon run in the world. The health of this fishery is at the crux of the Pebble mine debate. Many people believe development of the mine would destroy the Bristol Bay fishery–which generates approxiately $360 million each year–while others believe the mine could be built without harm.

Studying the current aquatic environment in the Pebble deposit area and along the proposed transportation corridor helps scientists understand more about the environmental factors that contribute to such a successful fishery. That understanding will help predict what impact mining activities could have on fish and fish habitat.

Pebble Limited Partnership (PLP) studies

PLP commissioned a five-year study of the area and has released an Environmental Baseline Document that includes a 6,500-page report on "Fish and Aquatic Invertebrates." PLP scientists mainly gathered data by snorkeling, supplemented by other techniques such as electrofishing, dipnetting and aerial helicopter surveys. The result is a complex accumulation of data collected along several miles of water. It includes number of fish, number of species, water flow, water temperature, riverbank vegetation, type of river habitat, and shape of stream or river. Conclusions about fish habitat and population are aided by PHABSIM (Physical Habitat Simulation), a computer model that simulates habitat based on known variables.

How does this relate to permitting?

The Alaska Department of Fish and Game requires a Fish Habitat Permit (A.S. 16.05.871) for activities that could affect anadromous fish, fish habitat and fish passage. This includes activities such as water withdrawal, temporary or permanent stream diversions, and building of tailings storage facilities, bridges or culverts. The permit application requires a description of the body of water at the site of the project, such as that provided by PLP's environmental baseline data.

Fish habitat

Features that influence fish abundance

Gravel/sedimentation

Salmon lay their eggs in a pit and then bury them in gravel. Space needs to be maintained in between the gravel pieces so that the eggs can get oxygen and so the fry can emerge through the bed surface after incubation. If fine sediments infiltrate the gravel bed, they can cut off the oxygen, trap the eggs or wash them away. Scour is another factor impacting the makeup of the streambed; as water flows, material is removed, or "scoured," from the bed and banks of the river.

Water temperature

Fish require water temperatures that are not too cold or warm. Temperature affects fish at every stage, from spawning and egg incubation to smolting and migration. Water temperature is considered as a factor of water quality by the state of Alaska. The Alaska Department of Environmental Conservation Water Quality Standards lists maximum temperatures for migration (59°F), spawning (55.4°F), rearing (59°C), and egg and fry incubation (55.4°F).

Stream flow

Fast-moving streams churn up more oxygen into the water, and carry away sediment and debris before it can settle into salmon-spawning beds. Low stream flow can increase water temperature and decrease oxygen. Seasonal changes and precipitation can affect stream flow, as can diversion or withdrawal of water from a water body.

Groundwater influence

Upwelling of groundwater helps regulate stream temperature both in summer and winter months, and it helps maintain stream flow so that water bodies do not dry up and strand fish. Groundwater plays an important role in Bristol Bay waters; we know this in part based on the thousands of "seeps" — areas where groundwater pushes up and forms pools — that have been identified in the area.

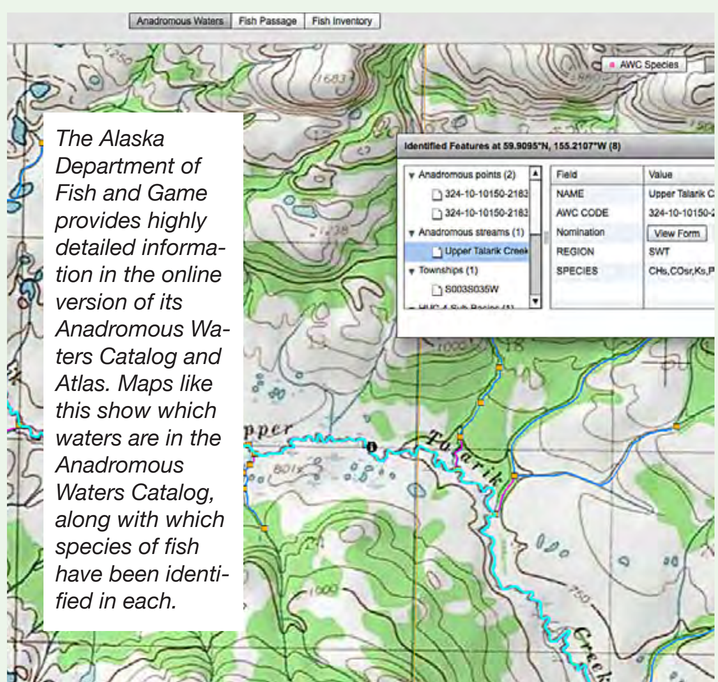
Water hardness

Whether water is "soft" or "hard" depends on the amount of minerals found in it. Naturally occuring trace metals such as aluminum, cadmium, copper, iron, lead and zinc can be toxic to fish in certain amounts. Studies indicate that soft water can increase the toxicity of these metals.

Anadromous Waters Catalog and Atlas

The Alaska Department of Fish and Game (ADFG) maintains a Fish Distribution Database of streams, rivers and lakes that are important for spawning, rearing or migration of anadromous fish. ADFG has developed an Anadromous Waters Catalog and an Atlas based on this database. The catalog currently lists more than 17,000 water bodies that are afforded special protections by state law. Qualified individuals can nominate new waters to the catalog. As a result of studies conducted for environmental baseline research, Pebble Limited Partnership scientists nominated 23.1 miles of stream to the catalog. Independent scientists who have conducted research in the same area have also nominated 28 miles of salmon-producing stream to the catalog.

ADFG estimates that 20,000 or more water bodies used by anadromous species have yet to be identified.



The Alaska Department of Fish and Game provides highly detailed information in the online version of its Anadromous Waters Catalog and Atlas. Maps like this show which waters are in the Anadromous Waters Catalog, along with which species of fish have been identified in each.

Beaver ponds

Beaver dams trap sediment, keeping it from entering spawning sites downstream. Ponds formed as a result of damming offer important rearing grounds for juvenile fish, in part because they typically host larger quantities of invertebrates — a basic food source for fish. Beaver ponds tend to be warmer than other habitat, and provide ice-free refuge during winter.

Dissolved oxygen

Salmon need dissolved oxygen at all stages of life. Much of the dissolved oxygen in a water body comes from photosynthesis of aquatic plants and diffusion of oxygen from the air near the surface of the water. This is one reason why turbulent, shallow riffles provide good salmon habitat, because the atmospheric oxygen near the surface is more easily mixed into fast-moving water. Several factors can reduce the amount of oxygen available to fish, including high water temperature and high salinity.

Vegetation

Plants growing along river banks, also called "riparian vegetation," provide excellent habitat for salmon. Vegetation provides shade, which keeps the water cool. Plant material serves as food sources for invertebrates, on which fish feed as well. Root systems help filter and slow sediments, and prevent riverbank erosion.

Food sources

Young salmon fry rely on aquatic insects and their larvae, as well as insects from nearby vegetation that fall into the water. Yearlings add younger fry to their dining options. Once in the ocean, growing salmon find larger prey such as shrimp and smelt. Salmon coming back to lay eggs typically do not eat, so food is not an issue at this stage.

Aquatic invertebrates

— those little "bugs" without backbones — are crucial to healthy fish habitat.

Mayfly larva
Source: New South Wales Government

They serve as a main food source for fish and help decompose materials in the water (including salmon carcasses), which is an important part of the nutrient cycle. Certain types of invertebrates (mayfly, stonefly and caddisfly larvae) are very sensitive to stressors like pollution and low oxygen levels. Scientists use the presence of these larvae as an indicator of water quality and stream health.

EPT Index

The EPT index is a scientific measurement of the abundance of larvae that are sensitive to pollutants. A high EPT index generally indicates water with low pollution and low disturbance. The letters **E, P** and **T** represent the scientific grouping of each invertebrate:

Mayfly (order **E**phemeroptera)
Stonefly (order **P**lecoptera)
Caddisfly (order **T**richoptera)

Grouping aquatic invertebrates by what they do

Aquatic invertebrates are important in the process of decomposition and are commonly grouped and described according to their style of feeding:

Shredders break down leaves and other particulates into smaller pieces.

Collectors break down very small pieces of organic matter.

Grazers and ***scrapers*** consume thin layers of algae or microbes attached to rocks and leaves.

Predators consume other aquatic invertebrates, as well as tiny fish and tadpoles.

Studies of invertebrates in the Bristol Bay drainages

Pebble Limited Partnership studies:
Researchers collected invertebrate samples from a range of stream sizes and habitats between 2004 and 2007. They used several standard techniques, including drift net, Surber sampling and kick net.

Sampling occurred for two weeks during the first year, and three to four days during each of the next two years. Researchers identified 235 types of macroinvertebrates within both the proposed mine and transportation corridor areas. (Variations in results over the course of study were possibly the result of using different monitoring methods among some years). There was a low percentage found of those invertebrates that are sensitive to pollution (EPT invertebrates), even though their preferred habitat — riffle/cobble — is the dominant habitat type.

University of Alaska studies:
Scientists in the University of Alaska Anchorage Aquatic Ecology program collected data between 2008 and 2010 from 78 wadeable streams in the mine claim areas of the Nushagak and Kvichak watersheds. Five of these streams were sampled repeatedly. A total of 137 types of macroinvertebrates was identified across all of the sites. Data is still being analyzed, but the presence of four EPT organisms indicates pristine conditions in more than 50 percent of the sites studied. Further analysis will determine how much invertebrate population change is due to natural variation, including the effect of riverbank vegetation and in-stream cover.

Understanding stream flow, fish habitat and models

Between 2004 and 2008, scientists working for Pebble Limited Partnership (PLP) conducted studies of fish and fish habitat in the proposed Pebble mine area. The information they gathered (some of which is summarized at right) was used to describe stream flow in various areas and predict how changes to that flow could affect fish habitat.

Stream flow affects fish habitat in a number of ways. The amount of stream flow is affected by groundwater, vegetation and precipitation. Its velocity, or how fast it moves, is determined by the gradient (steepness) of the stream bed and the resistance of materials in the stream bed (roots, logs and rocks/gravels).

With so many variables in a complex watershed system like Bristol Bay, scientists turn to models to help analyze collected data. One such model is PHABSIM (Physical Habitat Simulation, pronounced *pee-hab-sim*). It was developed by the U.S. Fish and Wildlife Service in the 1970s, and was chosen by PLP for use in analyzing habitat and flow data for its Environmental Baseline Document.

PLP's PHABSIM analysis includes spawning habitat, and juvenile- and adult-rearing habitats for various fish species in specific stream reaches in the Pebble deposit study area.

Overall, PHABSIM simulates habitat based on the physical structure of a stream, its depth and velocity. PHABSIM does not take into account water quality or temperature; those are analyzed separately.

Rivers in proposed Pebble mine deposit area

Quick view of data presented in PLP's Environmental Baseline Document	North Fork Koktuli River	South Fork Koktuli River	Koktuli River mainstem	Upper Talarik Creek
Miles studied	36 miles, divided into six reaches	40 miles, divided into five reaches	29 miles	39 miles, divided into seven reaches
Anadromous salmonid species found	4: chinook, chum, coho, sockeye	4: chinook, chum, coho, sockeye	4: chinook, chum, coho, sockeye	5: chinook, chum, coho, sockeye, pink
Resident salmonid species found	7: arctic grayling, Dolly Varden, rainbow trout, four types of whitefish	6: arctic grayling, Dolly Varden, rainbow trout, three types of whitefish	4: arctic grayling, Dolly Varden, rainbow trout, whitefish	4: arctic grayling, Dolly Varden, rainbow trout, whitefish
Non-salmonid species found	3: northern pike, sculpin, stickleback	5: burbot, northern pike, stickleback, lamprey, sculpin	2: sculpin, stickleback	2: sculpin, stickleback
Different types of invertebrates found	Lowest count: 17 Highest count: 30	Lowest count: 15 Highest count: 28	No habitat surveys were completed here, since the upper reach of the mainstem of the Koktuli River is 31 miles downstream from the Pebble deposit. However, instream flow and fish studies show the Koktuli River provides spawning, incubation and rearing habitats.	Lowest count: 15 Highest count: 26
Type of habitat	Dominated by riffles. Good spawning gravel.	Dominated by riffles and run/glide habitat.		Dominated by riffles and run/glide habitat.
Habitat features that may influence distribution and abundance of fish	Large concentration of seeps/springs, prevalent lakes, ponds, and beaver ponds.	Seeps/springs, prevalent lakes/ponds, and beaver ponds.		Prevalence of seeps/springs, lakes/ponds, and beaver ponds.
Habitat features that may limit fish abundance or productivity	Lack of shelter for rearing fishes, water temperatures that restrict active feeding/growth, soft water (can increase toxicity of trace metals to aquatic life).	Lack of shelter for rearing fishes, water temperatures that restrict active feeding/growth, intermittent stream flow, soft water (can increase toxicity of trace metals to aquatic life).		Lack of shelter for rearing fishes, water temperatures that restrict active feeding/growth, soft water (can increase toxicity of trace metals to aquatic life).
Of note	Largest run of chinook and chum of the three watersheds studied.	Spawning takes place only in lower reaches, perhaps due to the middle section that can completely dry out.	Migratory corridor for adult and juvenile salmon that use the North and South Fork Koktuli rivers.	Largest sockeye run of the three watershed studies. Counts of coho were much greater than in other rivers.

Pebble Watch says: PHABSIM is one tool for understanding stream flow and fish habitat. Many other approaches have been developed in the decades since PHABSIM was introduced. More than 200 were documented in use worldwide in 2003. Some take into account indigenous needs for key harvest species. Some focus on the importance of variability in sustaining river ecosystems. Some use multi-disciplinary "expert panels" to assess stream flow requirements. The Bristol Bay watershed system is complex, and so are factors that contribute to healthy fish habitat. Stakeholders require access to accurate information about the watershed, along with analysis that is easy to understand. PHABSIM has been an industry standard. Would a different model provide a better understanding of this watershed?