Introduction

This report reviews the potential impacts of the development and operation of a major hard rock mine in the headwaters of one of the world's most productive salmon ecosystems—Alaska's Bristol Bay. It also seeks to highlight key economic, regulatory, and historical considerations that can promote a more comprehensive evaluation of the Pebble Mine concept.

Throughout the North Pacific region, the largest cross-ecosystem movement of animals is the annual migration of wild salmon from the ocean into freshwater streams and lakes, where they spawn and die.

—"Impacts of Salmon on Riparian Plant Diversity" (Hocking and Reynolds 2011)

Why Salmon?

It is impossible to ignore the profound benefits that healthy wild salmon populations and productive wild salmon ecosystems bring to bear on human health, economies, and cultures. While the ecological threats posed by mining—and other resource-extraction industries—are not limited to salmonids, lost and degraded salmon populations threaten a range of human values that define our well-being and sustain our quality of life.

To begin with, Bristol Bay subsistence fishing has figured prominently among native peoples for thousands of years. The Athabaskan, Aleut, and Yup'ik peoples of Bristol Bay harvest roughly 150,000 salmon annually, which they eat fresh and dry, smoke, salt, pickle, can, and store for winter sustenance (Fall et al. 1996, 2006, ADFG 2008a). This subsistence way of life not only results in a flexible seasonal work pattern that allows for communal time, it also provides spiritual empowerment, cultural understanding, deep connections with natural rhythms, intergenerational education, and a sense of hope and pride (McDiarmid et al. 1998, Thornton and Wheeler 2005, Haley et al. 2008, Haley and Magdanz 2008). Ultimately, these benefits forge an irreplaceable cultural identity, while stimulating a sense of reciprocity, trust, and cooperation among community members (Martin 2004, Haley et al. 2008, Haley and Magdanz 2008). Subsistence fisheries, therefore, are not just a food source, but rather the linchpin to a traditional way of life that has linked native generations in Bristol Bay for 3,000 to 4,000 years (Bristol Bay Borough 2010).

While the cultural and spiritual relationships of Alaska's more recent settlers with salmon are less pronounced, the economic value derived from over a century of commercial and recreational harvests is similarly remarkable. In addition to the subsistence harvest, Duffield (2009) estimates annual expenditures of $318 to $572 million on services supplied by Bristol Bay's wild salmon ecosystem, resulting in an average of 4,837 full-time equivalent jobs and $196 million in annual gross income. The majority of these benefits were generated from commercial fish harvest. On average, roughly 33 million salmon return to Bristol Bay each year, and according to ADFG (2010a), the 31 million salmon harvested in the stronger-than-average returns of 2010 produced a preliminary ex-vessel value of over $153 million. Despite this tremendous harvest, in the same year 11.5 million sockeye escaped the nets and returned to their natal waters to spawn.

While salmon sustain human populations, they are also a keystone species, providing a vital source of food to marine, freshwater, terrestrial, and avian communities. At least 138 animal species, from killer whales to owls, depend on salmon for sustenance to some degree (Willson and Halupka 1995, Cederholm et al. 2001). In the United States Pacific Northwest, salmon declines have adversely affected many other species, including bald eagles, grizzly bears, black bears, ospreys, harlequin ducks, Caspian terns, and river otters (Willson and Halupka 1995, Cederholm et al. 2001). Salmon are also a critical source of nutrients in many watersheds. Marine-derived nutrients, which are carried by salmon from the ocean and deposited by spawned-out individuals, are supplied to nutrient-limited lakes and streams, supplementing the base of the food web and maintaining future salmon production (Kline et al. 1993). While these nutrients are readily used by a variety of aquatic organisms, trees and other vegetation also benefit significantly from the marine-derived nutrients provided by returning salmon. In fact, Hilderbrand et al. (1999) found that 15.5% to 17.8% of the total nitrogen in spruce foliage within 500 meters of the stream was derived from salmon that had been consumed by bears and was redistributed through urine and feces in the riparian area. A recent study examining nutrient loading from Pacific salmon in British Columbia found that nutrients from decaying salmon taken up by terrestrial plants shifted entire plant communities, significantly affecting the diversity and productivity of salmon-bearing ecosystems (Hocking and Reynolds 2011).

The Forest for the Trees

Mine proponents may assert that an analysis of mine impacts on salmon and the environment is premature until additional exploration and assessment have been completed and mine operation plans have been finalized. We contend that delaying evaluation of the

Bristol Bay resident (photo by Ben Knight).

project until these activities are complete significantly diminishes opportunities for both the public and decision-makers to assess the Pebble proposal in its entirety. Because of the extraordinary scope of the Pebble Mine proposal, broad public review and targeted agency analyses of permit applications will focus on hundreds or perhaps thousands of individual development activities. Just as the ecological impacts of a clear-cut cannot be determined by scrutinizing the felling of each tree, a proposal of the magnitude of the Pebble Mine cannot be properly evaluated by breaking it down into its component parts. While an environmental impact statement, which will be required when PLP applies for dredge and fill permits, must evaluate impacts relative to the whole project, the sheer volume and complexity of the information presented will make a thorough review virtually impossible under the timeline provided by the public review comment period. The opportunity for a thorough independent review and widespread understanding of the full proposal—not merely its constituent parts—is critical. In this report, we hope to highlight key considerations for evaluating a development concept of this magnitude in a region of extraordinary health and productivity.

Sufficient information currently exists from which to complete an informed preliminary analysis of the overall Pebble Mine concept. Site specific data on the ore deposit, information provided to permitting agencies and investors, reviews of modern mining technology and techniques, and knowledge of stream ecology form the backbone of this analysis. While this report recognizes and highlights cultural, economic, and regulatory considerations of the Pebble Mine concept, it focuses primarily on the mine's potential ecological impacts. In doing so, this report attempts to provide a succinct summary of the most common environmental issues arising at metal mines and their biological consequences. The potential impacts reviewed here occur routinely at similar sulfide metal mines around the world.

Report Assumptions

Developers of the Pebble Mine prospect have not yet filed permits for mine construction. Therefore, this report assumes the following:

- The Pebble Mine will be operated by competent, diligent mine operators and consultants, using state-of-the-art technology for design and operations.
- Potential environmental impacts of the mine will be evaluated and the mine will be permitted under existing state and federal statutes and regulations.
- The company developing the Pebble prospect will seek permits for open pit mining, underground mining, or both. It is possible that the company initially may mine the two major deposits, Pebble East and Pebble West, sequentially. In this case, the operators may seek permits first for an open pit mine and apply later for an underground mine.
- Whether operating an underground mine or an open pit mine, mineral extraction from low-grade Pebble ore deposits will generate billions of tons of acid-generating waste.

Chum salmon (photo by Paul Vecsei).

This report is not an attempt to discredit mining, resource development, or the significant economic and social benefits that this important sector generates. Mining systems and technology have improved markedly in recent decades, and many leading mining enterprises take their social responsibility commitments seriously. Indeed, PLP appears to be going to considerable lengths to promote "a healthy, respectful and sustainable co-existence with the environment and Southwest Alaska culture" (PLP 2011a). However, if this mine is developed, significant resource trade-offs will occur between non-renewable mineral resource development and the renewable salmon resources of Bristol Bay. Information presented in this report is intended to aid the public, resource managers, and decision makers in understanding the potential environmental consequences resulting from these trade-offs, particularly as they relate to the currently abundant wild salmon resources in the Bristol Bay watershed.

We encourage the public and decision makers to take this opportunity to view the Pebble Mine concept as a whole and to ask several overarching questions when considering the final plan:

- **Has a mine of this size and type ever operated in a similar salmon ecosystem without adversely impairing aquatic resources?**
- **What is the cumulative risk of all of the scientific and policy uncertainties with respect to mine development, operations, and closure?**
- **Given these uncertainties, are precautionary principles being applied to decision-making, and where does the burden of proof lie?**