Mining on the Stikine River and Effects on the Estuary

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Abstract

In this paper we will explore the Stikine River estuary and how the Galore Creek Project could affect its ecosystem. This mine could have potentially devastating effects on both the communities of Petersburg and Wrangell. The species that are reared in the Stikine River drive the economies of these towns, the main commodity being salmon. From our research and visits to this estuary, we have decided that in order for the mine to be able to co-exist with the estuary, significant changes must be made.

Introduction

Would the Galore Creek mine up the Stikine River have negative effects on the estuary and the organisms that rely on it for a home and for food? This paper will take that question and spread it out into many parts, such as how it will affect different species in different ways. Also, it will talk about how the mine could impact the economy of the surrounding areas such as Petersburg and Wrangell by bringing work to the area. However, the mine might not hire anyone locally. It may also affect some species of salmon that many people rely on for a living and for their subsistence.

We have also explored another estuary that had an active mine near it for 72 years. E also explored how it affected the estuary and also the lingering effects it has had on the organisms that live in it.

Description of Estuary

Estuaries are among the most biologically productive (and diverse) areas on the planet, along with tropical rainforests and coral reefs. Not only do estuaries provide a relatively large amount of food, but they also provide economic support. Estuaries are part saline water and part fresh water, so countless plants and animals (that like to live in part fresh, part saline) thrive in them. Estuaries are the beneficiaries of energy subsidies through the tidal transport of food and nutrients. The estuarine organisms convert organic waste into usable nutrients. Fish are a major food source, along with plankton (http://water.epa.gov/type/oceb/nep/about.cfm#whatis).

According to the National Oceanic and Atmospheric Association, there are many different types of estuaries, including salt-wedge, fjords, slightly stratified, and vertically mixed estuaries. Salt-wedge estuaries are the most stratified and occur when a river dispenses into weak tidal currents of the ocean. The fresh water floats above the salt, barely mixing. Fjords are deep, long, and narrow estuaries created by glaciers. As the glaciers receded, they left deep grooves, or fjords. Slightly stratified estuaries happen when salt and freshwater almost completely mix, but the top generally has a lower salinity. At the mouth of the estuary, salinity is greatest, and decreases upstream. When a slow freshwater river and a fast moving body of saltwater converge, it creates a vertically mixed estuary. The salinity in these estuaries is consistent no matter the depth (NOAA, 2008). Our study will focus on the Stikine river estuary, which, in our conclusion, is a vertically mixed estuary, because of the large tidal range, 17.4 feet at high tide to -4.2 feet at low tide.

The Stikine River begins as a small stream flowing from a glacier on a high plateau near Mount Umbach in the Spatsizi Plateau Wilderness Park in British Columbia. The river flows about 400 miles to the Pacific Ocean in Southeast Alaska. The Stikine River watershed covers over 31,000 square miles. The river is navigable for approximately 130 miles (210 km) upstream from its mouth. The Iskut River is the largest tributary of the Stikine the Iskut River and can be divided into two parts the upper and lower Iskut. Both of these rivers flow 145 miles (Stikine, 2011). The Galore Creek, the site of the proposed mine, flows into the Iskut River (Figure 1).

Figure 1: Map of the study area (http://content.edgar-online.com, 2010).

The Stikine River Delta is near Wrangell, Alaska. People are able to reach the Stikine River by waterway. The mouth of the Stikine River is seventeen miles wide, and is made of many slow moving channels, three of which are navigable (http://www.fs.usda.gov/detail/r10/specialplaces/?cid=fsbdev2_038816).

The Stikine River is home to an abundance of organisms that are very dependent on each other. One of the organisms that are awaited for every year by countless eagles, sea lions, seals, and sea gulls looking for food are the eulachon. According to Wilson et. al., eulachon live at the bottom of the ocean. Eulachon are plankton feeders, eating copepods and euphausiids, and other crustaceans. Spending most of year at the bottom of the ocean, eulachon come up during the Stikine River run between early to mid-April to spawn. Eulachon spawn overnight in places such as silt sand gravel, cobble, and detritus. Troy Thynes (pers. comm.) said that eulachon spawn in low level waters and closer to the mouth of the Stikine River. This spawning event attracts bald eagles. Other predators come as well. In total, around three million birds come to the Delta between late April and early May to eat. During this time, the Stikine River Delta holds the second highest amount of bald eagles of any area in North America. Some land mammals that reside in this Delta area are black and brown bears, moose, Sitka black-tail deer, and wolves (http://www.fs.usda.gov/detail/r10/specialplaces/?cid=fsbdev2_038816).

Other important species found in the Stikine are the Dungeness crab and salmon. Crabbing is one of the many industries embraced by the communities of both Petersburg and Wrangell. According to Joe Stratman (pers. comm) this industry brings in roughly $4,419,362 per year into Southeast Alaska. The average catch per season is 2,209,681 lbs. Of this total catch, the Stikine River produces

732,396 lbs., worth $1,464,792. These statistics only include the Dungeness crab species. All other crab species have not been included.

There are two Alaska Department of Fish and Game management districts that encompass the mouth of the Stikine River, Districts 6 and 8. (Davidson et.al., 2011) Both District 6 and 8 have a great need for the Stikine River, because the amount of sockeye salmon that are harvested make up a large percentage of total fish harvested. The amount of sockeye salmon harvested up the Stikine River in District 6 was around 32,900 in 2011, which was 23% of the total harvest. In District 8 there were about 36,400 sockeye salmon harvested from the Stikine River. This was 71% of the total harvest in 2011. (Davidson et.al., 2011)

History of Mining Up the Stikine River

Alaska has valuable gold and copper resources. To date, over 32 million ounces of gold have been mined in Alaska worth $12.5 billion in today's dollars. The amount of copper mined in Alaska has been over 625 million tons and is worth $1.51 billion. (http://www.alaskacenters.gov/minerals.cfm)

Over the past 150 years, thousands of mines have opened and closed up the Stikine (Scannell, 2010). Around 1860, mining up the Stikine started; early prospectors had found gold and this began drainage and panning up the Stikine. Gold mining had also led to the settlements at Telegraph Creek, the farthest navigable point that steamships could reach. During the same time period as the Klondike gold rush, there were many outcroppings and one of the prominent mines at this time was the Johnny Mountain Mine (Scannell, 2010).

The Johnny Mountain Mine was in operation from August 1988 to August 1990 (Scannell, 2010). The main minerals from this mine were gold, silver, copper, and zinc. High costs to operate the mine and low gold prices contributed to the early shutdown of the mine. Other mines up the Stikine were Snip Mine, Eskay Creek Mine, and the Golden Bear Mine. All of these mines produced the same minerals as the Johnny Mountain mine except for the Golden Bear mine, which only mined for gold. By 1999 Eskay Creek was owned and operated completely by Homestake Canada Inc. Even though all the mines listed have been closed or reclaimed, they have the potential to be in operation again (Scannell, 2010).

Proposed Mine

The proposed Galore Creek mine is an open-pit mine. The ore from this mine will be conveyed to a grinding and floatation circuit. Here the ore will be fed into a single gyratory crusher. After the ore has been crushed, it will be conveyed to a single coarse ore stockpile area. To get to this storage area, the ore will travel through a 14-km tunnel built through a mountain. The stockpiled ore will be ground by a conventional single line grinding flotation concentrator. The ground ore will then go to a filter plant, which will produce pure concentrates. These concentrates will then be transported to the truck loading facilities along a nearby highway. Trucks will then take the concentrates to a port facility in order to export internationally (http://www.mining-technology.com/projects/galore-creek/).

The Galore Creek project has porphyry copper systems, most of which are alkaline in nature. Most of the copper is in chalcopyrite and bornite. These minerals are found in a 10:1 ratio (http://www.mining-technology.com/projects/galore-creek/).
There is approximately 6.8 Blbs of copper in this mine, approximately 120 Mozs of Silver, and approximately 2.5 Mozs of gold (http://www.novagold.com/section.asp?pageid=15847).

The Galore creek mine will cost roughly 2.23 billion Canadian dollars, this is equal to 2.25B USD. This mine will produce 65,000 tons per day of ore and will last about 22 years. NovaGold owns 50% of this mine and Teck Resources owns the other 50%. With the current mine plan in place, 126,000 tons of copper concentrate will be produced every year (http://www.infomine.com/minesite/minesite.asp?site=galorecreek).

The current plan for dealing with the tailings is to store them in a steep canyon. This canyon is to be dammed off by volcanic rock. The water from the tailings will be discharged from the containment area directly into Galore Creek. At present, there are no plans to treat this wastewater. The water from Galore Creek will, in theory, dilute the waste enough to where it will do minimal harm to the environment. If there is excess water in the waste rock storage, then that water will also be pumped directly into Galore Creek (Scannell, 2012).

Approximately half of the waste rock is to be stored under water. The amount of waste rock is estimated at over 1 billion tons. This rock is planned to be stored underwater for perpetuity. It is estimated that the waste rock will take 23 years until it becomes acid generating. The remaining rock that is not used for road and dam building is to be used as landfill for used mine pits (Scannell, 2012).

Possible sources of estuarine contamination

If everything doesn't go as planned we need to be ready. There are several potential sources of contamination from mining operations, including the waste pit, drainage pipe, and tailings. A waste pit results from depositing hazardous waste back into a previously created pit. One of the main problems with waste pits is seepage into groundwater, effectively poisoning the water making it undrinkable and uninhabitable for fish. One of the things they dump in these pits is the by-product of cyanide gold processing, in this process sodium cyanide is used to draw the gold from the rocks and the leftovers are dumped into the pits (Brilliantearth, 2011).

The problems with drainage pipes include chemical wear and tear. Sulpheric acid is one of the chemicals that can eat through the pipes until it ruptures. The "slurry" is a mixture of rocks and water that is pumped through the pipes at high speeds; this is the cause of abrasive wear, scratching off little bits of metal at a time until it ruptures. The abrasion areas are bends in the pipe, for example 45-degree curves or elbows where the slurry hits one specific place continuously. Curves and elbows are manufactured thicker to compensate (Breitenbach, 2010).

Mine tailings are what is left over after the entire chemical processes the mining company does to extract all of the ores out of the rock. A typical tailings pile is made of finely ground rock, semi large pieces of rock, and any leftover hazardous chemicals that the company hasn't extracted. The problems that might occur with mine tailings piles are that they could collapse into a river, blocking and stopping the flow of the river. One of the other problems with the tailings piles is that they could leak hazardous chemicals into the river, killing fish and wildlife destroying the ecosystem. (Chambers, 2010). This is called "acid mine drainage."

Comparison Estuary

The former Britannia Mine site is located around 75 km north of Vancouver. The Britannia Mining and Smelting Company Ltd. operated the mine from 1902 to 1963. From 1963, the mining operation was taken over by the Anaconda Mining Company. It then ceased in 1974. The mineralization was predominantly copper as chalcopyrite, with zinc in the form of sphalerite, and pyrite. Copper was also recovered by cementation with scrap iron from mine water issuing from the 2200 Level and 4100 Level portals (http://technology.infomine.com/enviromine/ard/case%20studies/britannia.html). A portal is the entry way to the mine (http://www.britannica.com/search?query=portal). It was reported by the United States Bureau of Mine (1935) that the 2200 Level portal discharge contained 980 mg/l copper, 170 mg/l ferrous iron and 1.61 g/l ferric iron with a pH of about 3. Current knowledge would report this to be acid mine drainage (http://technology.infomine.com/enviromine/ard/case%20studies/britannia.html).

Acid mine drainage is one of the byproducts of the tailings and is created when sulphide containing rocks are exposed to air and go through an oxidization reaction. This process can be accelerated by the bacterium Ferrobacillus ferrooxidans. This produces sulfuric acid, which dissolves metal sulfides from the rock. The metal ions are then transported by water passing through the mine. The acid mine drainage is very detrimental here because of snowmelt higher up and large amounts of rain (Berry et. al., 2000).

Acid mine drainage can have negative effects on important species like salmon. It can impact the fish directly, or by disrupting their food chain. Levings et. al. (2004) investigated the effects of the acid mine drainage from Britannia Creek. Near the mouth of Britannia Creek, sediments and the water itself contained high concentrations of dissolved copper and the water was highly acidic. Compared to another location used for reference, the rockweed cover was reduced, phytoplankton biomass was lower, chironomid larvae were less abundant, and fewer gammarid amphipods colonized basket traps that were set out (Figure 2).

When the stomachs of chum salmon fry in the Britannia Creek estuary were analyzed, it was confirmed that they preferred to feed on chironomid larvae (blood worms) and gammarid amphipods (sand fleas). In conclusion, acid mine drainage from the Britannia Mine disrupted the function and structure of the intertidal ecosystem, resulting in loss of food production for fish including chum salmon fry and other species (Levings et. al., 2004).

		Dissolved copper ($mg\,l^{-1}$)	Chloro-phyll-*a* ($mg\,m^{-3}$)	Rockweed % Cover	Green algae % Cover	Barnacle % cover	Chironomid larvae (no. m^{-2})	Invertebrate abundance (no. m^{-2})	Amphipods (*E. confervicolus*) (no. $100\,g^{-1}$ Rockweed)
Stations located more than 100 m south of Britannia Creek mouth	Mean	0.0254	1.666	11.2	23.1	18.6	2.5	3171	0.5
	SE	0.0092	0.427	1.6	2.8	2.2	0.7	886	0.3
Stations located within 100 m of Britannia Creek mouth	Mean	0.5424	0.143	0.0	9.7	0.0	1.7	4074	0.3
	SE	0.0928	0.074		2.0	0.0	0.7	697	0.2
Stations located more than 100 m north of Britannia Creek mouth	Mean	0.0476	0.939	2.5	32.8	11.0	2.8	4860	9.0
	SE	0.0096	0.560	0.8	4.4	2.3	0.9	1300	4.4
All Furry Creek estuary stations	Mean	0.0100	3.074	33.0	1.5	23.8	12.6	2777	34.8
	SE	0.0007	0.852	2.0	0.3	1.2	2.5	509	22.0

Figure 2: This table relates the levels of dissolved copper to the amount of plant and animal life in various stations around Britannia Creek (Levings et. al., 2004).

Copper is a naturally occurring element, but even a small amount in freshwater can be toxic to fish. The foreshore area of Howe sound, where Britannia Creek meets saltwater, is an important area for the development of juvenile chum and chinook salmon as they migrate to the Pacific Ocean. When salmon are still smolts they change from living in fresh to salt water, which causes major biological and chemical changes. This leaves the young fish to be more vulnerable to acid mine drainage from Britannia creek mine. Other studies have shown that juvenile chum and chinook salmon, when exposed to sublethal amounts of copper, have a harder time adapting to saltwater. It impairs their ability to migrate successfully and reduces their swimming abilities. They will also have lower growth rates, impaired sensory functions, and reduced immunity (Berry et. al., 2000).

Berry et. al. took chum and chinook salmon fry from nearby streams and put them in surface pens near the mouth of the stream and found high mortality rates. This was because the copper toxicity in the stream entered the gills and affected the membrane permeability. This disrupts the ionic and osmotic balance. Research suggests that if there is any more than 5.6 micrograms/liter in the stream it will have an effect on the fish (Berry et. al., 2000).

The Britannia Creek compares to the Stikine River because they are in the same climate zone, the same species live in the ecosystems, and the same minerals will be mined using an open pit mine. We can predict that the two mines will have different effects on the environment due to the advancements in technology over the past 38 years. Along with this, we have a much greater understanding of ecosystems and how they work. Our greater understanding allows us to better monitor the potential affects of pollution created by such activities as mining.

Our Management Plan

Our goals for our management plan include maintaining levels of copper in the Stikine River below 4.0 micrograms/L in fresh water. That is below the level set by the EPA. (Berry, et. al., 2000) We feel that the health of our salmon population is vital to the economic well being of Southeast Alaska, and so a more conservative approach would be better. The range of pH should remain between 7.0 and 8.0, as this is the healthy pH for raising salmon fry (Chamber et. al., 2012). In addition, salmon populations should remain the same as they were before the mine was built.

Proposed Changes to Galore Creek Mine

Currently there is no plan for dealing with the waste produced by the mine (excluding tailings). Their plan is to pump the waste, untreated in any way, directly into the river. We know from looking at other rivers and bays with a similar plan, that the pumping of waste directly into these bodies of water makes the river acidic and can inhibit the healthy transition of salmon from fresh to salt water. In order to achieve the goals we have outlined above, we believe the drainage and the tailings runoff will have to be filtered. Dilution is not the solution here.

In addition, the plan for dealing with the tailings is to store them in a dam for permanent containment. This system is fine enough for a place that does not have access to a freshwater body of water, but building a tailings dam right next to an estuary that provides a spawning ground for salmon and a habitat for countless other species of wildlife, is problematic. Tailings cannot be stored in the vicinity of the river. The tailings must be taken away from the site of the mine. This could be done by truck or potentially pipeline. Toxic waste cannot be stored eternally without affecting the ecosystem.

Water Quality and Other Monitoring

Mining and monitoring are interconnected because monitoring can help keep contamination to a minimum. To maintain stability in the environment, changes in the aquatic system need to be identified during drainage and activities that occur downstream with mining. Waters need to be overseen before construction, during construction, during the operation of mines, during close-out, and after the mine is closed (Scannell, 2010).

Scannell (2010) believes there should be some baseline monitoring done before the mines are in operation. The Galore Creek mine should be monitored in two areas, first in receiving waters and in the lower part of the Stikine River. Biomonitoring should include periphyton, macroinvertebrates, fish presence and habitat use, and fish tissue analysis. There should also be monitoring from the discharge from tailing impoundment and discharge from the filter plant (Scannell 2010).

Although there is monitoring, the contribution of the Galore and Schaft Creek is 1% of the total flow of the Stikine River (Scannell, 2010). If the metal concentration in the creeks increased it wouldn't affect the water quality of Stikine River. Although these creeks don't have much effect to the Stikine, water quality should be collected at least once a month. There would be representatives of the range of stream flows, from low water to peak flows. Cyanide is an important factor and if used in the mining cyanide would be included in the monitoring process (Scannell, 2010).

In early mining, mines up the Stikine River have discharged sediments and metal-laden water into the Stikine's water system (Scannell, 2010). Over time the bed of the river has eroded, carrying the metals down the river into the delta where there is a different habitat than farther up the Stikine with migratory waterfowl, shellfish and juvenile salmonids. To monitor the sediment quality there should be data collected and compared to the baseline data to sediment samples that may include metals (Scannell, 2010).

There are five species of Pacific salmon that use the Stikine River for migration and spawning. Two of the most valuable salmon in the Stikine River are the sockeye and the chinook salmon. Monitoring the population of the salmon is an important component for the proposed mining projects. If the population declines it could be because of the increased metal concentrations in the water. Another approach is to monitor the bodies of the smolts in the regions of water with the metal concentration changes. These samples should be analyzed as a whole body if the fish are small and juvenile. If the fish are larger, they should only be sampled if the fish have lived in metal concentrated areas for at least a month (Scannell, 2010).

Conclusion

A mine created up the Stikine could have both positive and negative side effects to our community. The Galore Creek project would produce 500 jobs, whether or not any of these jobs would be given to Alaskans has not been declared (http://www.infomine.com/minesite/minesite.asp?site=galorecreek). Canada would benefit because the mine is based out of Canada, but our community could also benefit from the mine. Our community uses copper for making electronics and it is used for wiring. Even though we benefit, there could be a great negative effect to our community. The watershed from the mine would affect the river and essentially our fish, which is needed for subsistence and commercial fishing. While there may be positive effects from this mine, we don't believe that the positive effects will outweigh the negative. Even if our proposed changes were implemented, the risk to such an important estuary to us is too great for our community to absorb.

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