Can Biofuel Become a Sustainable Resource for Dillingham?

Dillingham High School

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Management of Fish Waste for Betterment of the Nushagak Bay Estuary

Abstract

In Dillingham, Alaska, commercial fishing of salmon and the revenue it brings to the town are a primary source of income. After being caught, the salmon is brought to the local processing plant, the Peter Pan Cannery, to be prepared for worldwide shipping. Peter Pan exports canned salmon, frozen filets, salmon eggs, and gutted salmon. However, there is a great deal of fish remnants created from these procedures. This waste is pumped out of the plant, and deposited into the waters of the Nushagak Bay. This waste is a potential resource. The question this research project seeks to answer is how can we better manage it as a raw material. Thirty percent of fish waste will be removed, and then the ecosystem will be monitored for changes to the overall health. The thirty percent of waste removed may be put to best economic income by conversion to biofuel.
Introduction

Nushagak Bay is an estuary and pelagic environment located near the southwest coast of Alaska. The Nushagak Bay is surrounded by Wood Mountain and tundra. There are three main rivers that flow into the Nushagak Bay: Nushagak River, Wood River, and Snake River. Because of the large amount of fresh water included in the bay from these rivers, the amount of salinity is low. According to Dr. Todd Radenbaugh, fresh water is encountered as far seaward as Clark's Point, which is only about 100 miles from the salt water of the Bering Sea. Tide differences in Nushagak Bay can be in excess of 10 m (30 ft.). As a result of the tide differences around Nushagak Bay the currents are strong and fast going in and out of the Bay.

Dillingham Tsunami Bowl members collected data on water quality, and the physical characteristics of the Nushagak Bay beaches to better understand the estuary. The water quality measurement suggests the bay has a greater influence from the rivers, which flow into the Nushagak Bay than the salt water from the Bering Sea. The locations at which we tested had suspended sediment, with the turbidity being at 310 NTU at Kanakanak Beach and 349 NTU at the City Dock beach. The other quality tests taken were water temperature and the pH. The average water temperature for the Nushagak bay was 8 degrees Celsius. The pH of the City Dock was 6.8 and the pH of Kanakanak beach 7.03. The beaches were characterized as follows: Kanakanak beach’s results were; 30% fine sand, 5% medium sand, 30% coarse sand, 25% gravel and 10% rock, the City Dock’s results were; 30% fine sand,
15% medium sand, 25% coarse sand and 30% gravel. The characteristics of the Nushagak Bay determine the health of the wildlife.

Members of the Dillingham Tsunami Bowl collected data on the water quality of the Nushagak Bay, to better understand the state of the estuary. The water quality measurement suggests the bay has a greater influence from the rivers that flow into the Nushagak Bay than the salt water from the Bering Sea. The locations tested had suspended sediment, with the turbidity being at 310 NTU at Kanakanak Beach and 349 NTU at the City Dock beach. The other quality tests taken were water temperature and the pH. The average water temperature for the Nushagak bay was 8 degrees Celsius. The pH of the City Dock was 6.8 and the pH of Kanakanak beach 7.03.

Nushagak Bay is host to many forms of wildlife both oceanic and land bound. The bay is part of one of the largest fisheries in the world and part of the biggest producer of sockeye salmon. According to research done by (Radenbaugh) and other university of Alaska researchers, the creatures that make up the bottom level of the estuary include Bay shrimp, isopods, and amphipods. After the beach seining field study of the local beaches on the Nushagak the Tsunami bowl team found that there were juvenile salmon, smelt, amphipods, and flounder. In the upper part of the estuary you may find creatures such as amphipods, shrimp, and smelt in high abundance. You may also find flounder but in smaller quantities compared to the other species. The diversity in the upper section has been measured at 1.656 H’ and the lower section has 1.011 H’. H’ is the Shannon Diversity which is the value used to measure the diversity of an Area. (Radenbaugh, 2007)
The history of Nushagak Bay begins with settlement by Native Alaskans, specifically, the Yu’pik tribes. The Yu’pik have used the estuary and its resources for generations. There is traditional value for many species of plants and animals found within the region. These beliefs still play a vital role in the Yu’pik culture.

Eventually, the region was colonized by outside explorers. Many small towns sprung up around the region. Often, canneries were erected as a means of creating income for a town. The industry grew, firstly to account for national, and then international desire for wild Alaskan salmon. Today, canneries still line the shores of many towns, and most still bring economic value to the communities. However, there is a great portion of waste created from these processes.

Fish waste is the inedible portion of the harvested fish. When fish is purchased from fishermen, it is inspected for quality. Then canneries begin to remove the edible parts of the fish, first by filleting the fish, then beheading, evisceration, scaling, and removing all fins. Only about a third of the fish body is used for food and the rest is thrown away. Beheading is a necessary part of the process since it is considered inedible. For most fish, the head is approximately 10-20 percent of the overall body weight. Not only do they need to remove inedible parts, but they also need to remove the slime found on fish. Many canneries clean their fish using water and scrubbing machinery. When fish waste is processed, it is sent through a mechanism that makes it smaller by slicing it into little chunks. After the fish waste is chopped up, then it is sent through a removal system. The fish waste is then deposited into the bay.
In other areas, expulsion of fish waste has caused dead zones. In these regions, the nutrients were in too high of abundance, and instead of acting as nourishment, it acted as a pollutant. This waste was deposited in areas with little tidal influence, and was not distributed throughout the water. An estuary that has had trouble with fish waste discharge was Chesapeake Bay. Omega Protein Corporation in Reedville has been dumping 13,000 pounds or more of organic waste into the middle of the bay every day from May to December. With those calculations, about 58.5 tons of organic waste was dumped during the fishing season in 2009. During the menhaden season, Omega's vessels use water from the bay to keep fish cold while on the bay. Before return, the crew discharges the water, along with fish blood and waste back into the bay. When on the dock, the boats use fresh water, or "bailing water" to pump the fish off the boat into the processing plant. This water is reused until it becomes too thick, then it is dumped back into the bay or the ocean itself. Omega has permits to dump the refrigeration water, but not the bailing water. This water can be up to 200 times more potent than even raw sewage. (Marirose Pratt et al., 2009)

In our estuary, the tide is able to circulate the fish remnants. Powerful currents disperse and distribute the waste throughout the water. The nutrients from the fish support the small benthic organisms, such as amphipods and isopods. It also creates a habitat that supports prosperity of all organisms there. (Radenbaugh, 2012)

Currently, the waste is considered beneficial to the ecosystem. Small bottom dwelling animals such as amphipods, starry flounder, isopods and smelt flourish off
of the additional nutrients presented to the environment. These creatures provide a base for the food web, as they are consumed by countless other animals. In this sense, the fish waste is helpful to the estuary. (Radenbaugh, 2012)

In a healthy bay, the benthic organisms are important. The benthic creatures make up the lower part of the food chain, and larger organisms feed them upon. These organisms live in the estuary year round. The presence of benthic creature make is possible for large marine life to flourish.

People benefit from marine mammals, such as whales, seals, and belugas as sources of subsistence foods. For the bay to be considered healthy there needs to be an abundance of the fish and animals. In the Nushagak Bay examples would be salmon, smelt, beluga, seals, and whales. Currently the Nushagak Bay is considered a healthy ecosystem and for it to remain healthy a similar population must remain at all trophic levels.

The benthic creatures can easily be affected in estuaries by the trophic cascade. Trophic cascade is when there is a sudden increase or decrease in top predatory animals and changes the population of the food chain. For example, when an animal population low on the trophic cascade is decreased, the next step such as the rainbow smelts will starve. Their decrease would affect salmon and the pattern continues until the top predators decrease or a predator over feeds on another species.

The trophic cascade especially affects the small organisms in estuaries. Taking the fish waste from the estuary can affect the isopods. The isopods eat the nutrients from the fish waste, and taking the fish waste from the isopods would
force them to have to find new nutrients to eat from. The amphipods would than have a population decrease and cause a trophic cascade following up to seals and cause the population of seals to decrease. After the amphipods adapted to the fish waste it would be harmful to take too much fish waste from their habitat.

There are many uses for the fish waste. Some uses are vitamins, fishmeal, fertilizer, and biofuel. Compressing fish oil into gels would create vitamins. Fishmeal and fertilizer are both made by drying and then grinding the fish scraps. (Chambers, 2012) Biofuel is made by taking the fish waste and putting it through a process called esterification. (ChemWiki, 2012)

However, it must first be determined how, if at all, the removal of the fish waste needed for these processes would affect the ecosystem. The environment itself is diverse and resilient enough to account for varying degrees of flux. The organisms within the ecosystem should be able to adapt to this change. Our management plan seeks to utilize fish waste for economic profit, while still keeping the estuary healthy.

**Management Plan**

There are few ways to reuse fish waste for profit. A possible option for this waste is to convert it into fishmeal for use as food for domestic animals as well as for fertilizer. In order for this to be a successful endeavor, a processing plant would need to be constructed. This would likely be built in Dillingham, to reduce the likelihood of the fish waste spoiling before reaching the new facility. However, this may be difficult, as there is already limited space around the plant.
Once the fish waste is brought to the plant, it would undergo a series of processes in order to be properly converted into fishmeal. This would involve cooking the waste, then pressing excess liquids from the finished pulp. After this, the waste would be dried into cakes, and then ground into a fine meal.

Once the waste is fully processed into meal, there is the issue of what to do with it. It is possible that the most economical income from this product would come from re-selling within Dillingham and the surrounding area for use as dog food. There is some controversy over the use of fishmeal in dog food, due to buildup of potentially harmful toxins. Salmon are less likely to have these toxins, due to less pollution of the salmon’s home watersheds, and the fact that these salmon are not farmed. There may also be some market value as fertilizer, but this is unlikely, as few people farm on a large scale in Dillingham. (Chambers, 2012)

Dillingham is an expensive place to live. Fuel is incredibly expensive. Electricity costs 43 cents per kilowatt-hour because it uses diesel. Heating fuel is also expensive; the current cost per gallon is $5.64. A cheaper alternative to diesel could make Dillingham a less expensive place to live. By this logic, if we could use fish waste to generate an alternate source of energy, it would be beneficial to the residents of Dillingham.

To make the production for biofuel a feasible project in Dillingham there would need to be suitable location for the plant, a competitive construction cost, up-to-date machinery and the amount of fish waste that would not harm the bay. One possible location would be between the Peter Pan fishery and the boat harbor. The reasoning behind putting it between these two locations would be that the resource
needed to make the biofuel would be right next to the Cannery so we would not have to pay much to move the fish waste between the two locations. Another reason behind this is if the plant would make enough of the biofuel, it could be sold to the Nushagak Power plant, which is only about .19 of a mile away from the intended location of the biofuel location.

For the creation of the biofuel plant, the building would be approximately 150 ft. in width, 175 ft. in length, 20 ft. in height. After inspecting similar buildings for such use the total cost of the building alone would be approximately $30,000.00. For the actual equipment needed such as the Biofuel processor, any heating or cooling in the building, forklifts, and any other items of interest the cost is estimated to be about $30,000.00 with a total cost of $60,000.00 for both and about $120,000.00 when actual construction costs are added.

Biofuel has the potential to be a valuable economic source for Dillingham. Biodiesel is a fatty acid methyl ester; it is produced from a chemical reaction called trans-esterification. 18 tons of fish oil would need to be heated along with 3-5 tons of methanol, and 0.07-0.15 tons of sodium hydroxide to create thirteen tons of biofuel and 3-5 tons of glycerol. The processors have to heat up the raw materials to 40-50 degrees Celsius. During the heating, the methanol is mixed and is the catalyst for the trans-esterification operation. Fish oil molecules are consisting of three carbon chains and hydroxide. Under esterification, the chains of carbon are taken off and the hydroxide is combined with the methanol to make glycerol. After the fish oil goes through esterification, glycerol is washed out and is washed with soap water. The rest is a series of carbon chains that is ready-for-use biofuel. (ChemWiki, 2012)
Biofuel would also create a substantial amount of income for the local cannery. If a processor had processed approximately 3 million salmon, about 2.1 million pounds would be left for extraction. From that amount of waste, 36,000 gallons of biofuel can be produced and leaves an annual profit margin of $204,000. The initial year would produce no such profits as the building would cost $30,000 and we would still have to pay electricity and the workers in the plant. The B500 Stand Alone Batch Biodiesel Processor would also add $10,111.90 to the expenses. After each year, the only expenses would be to pay the workers at the plant and to pay for the electricity. These changes would also not have a major effect in the ecosystem and we have steps to ensure this.

However, biofuel also has ecological importance. Compared to regular diesel, biofuel lowers the carbon dioxide emissions by 78%. The carbon monoxide emissions will also reduce by 41 percent. The production of sulfate emissions would even be reduced to nothing. The lubricity of the biodiesel is even 30 times higher compared to fossil fuels. Workers would only have to mix the biodiesel with regular diesel to prevent freezing in the colder months. (Enerfish, 2012)

Thirty percent of the fish waste dumped into the bay will be used for the production of biofuel. Thirty percent was chosen because it would create a substantial profit margin and was assumed that it would not create an extreme harm to the ecosystem. Considering that only the benthic animals rely upon the nutrients presented into the environment, the food chain would not change drastically. If the benthic animals started to decrease, fish waste could simply be dumped back.
To ensure that no extreme changes are being exerted upon the estuary, a series of biannual tests will be conducted. The first series of tests would occur in May, when the ice has retreated. The second series of tests would be in late September, before the ice sets in. In May, there will be very little fish waste in the water, as the cannery is inactive over the winter. In September, fish waste would have been deposited in the estuary over the entire summer, putting levels at the highest.

One factor these tests will watch for is change in the abundance of small benthic animals. Seining from the beach as well as from boats could gauge the populations of animals such as amphipods, isopods, smelt, and starry flounder. Population levels should not fluctuate more than 15% from those currently established. In addition, studies could be used to monitor the quantities of salmon returning to spawning streams, and the abundance of marine mammals.

Tests will also watch the quality of the water, both immediately within range of the cannery, and further out in the bay. Tests would include, but not be limited to, pH level monitoring, and analysis of nutrients found in the water.

A few potential sources that could conduct the testing and monitoring is the Bristol Bay Campus staff. The Bristol Bay Campus could get information from the tests and record them for future references. The information collected could show differences, if any, between the past, present and future. Another potential source that could test and monitor is U.S. Fish and Wildlife. Togiak Fish and Wildlife could potentially test and monitor Nushagak Bay after the removal of fish waste. Togiak Fish and Wildlife monitors fish levels in many areas throughout this region.
Funding will be required to test and monitor. One possible source for funding could be the Bristol Bay Campus. Another possible source could be from the Togiak Fish and Wildlife. Profit from biofuel or grants could also be used to support the studies.

If any of these studies shows that the ecosystem is suffering from the removal of fish waste, there would be cause to reinitiate the disposal of fish waste into the estuary. Economic profit should be watched. Although fish waste holds potential economic value, the estuary is of far greater importance. If removing fish waste from the estuary improves the ecosystem, the fish waste will stay out of the estuary. Even if biofuel proves to be non-profitable, alternate uses for the waste will be found. The estuary health will remain top priority.
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