Tidal Power Potential in the Remote Aleutian Islands Region

A paper prepared for the Alaska Tsunami

National Ocean Sciences Bowl

2014 Competition

The Caballers

Ruby Steedle[1] - Captain

Johnny Connolly, Johnny Elliot, Stephen Mell, and Megan Sheufelt

Brian Stoody[2] - Coach

Juneau-Douglas High School

10014 Crazy Horse Drive

Juneau, Alaska 99801-8529

This paper was written as part of the Alaska Ocean Sciences Bowl high school competition. The conclusions in this report are solely those of the student authors.

1 – to whom correspondence should be addressed (ruby.steedle@live.com)

2 – secondary contact (mfr_stoo@yahoo.com)

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Abstract

The changes in the global ocean are directly tied to the changes in the environment as a whole, many of which are the result of increased consumption of fossil fuels for power generation and transportation. In this paper, we assess the potential of the Aleutian Islands as a location for tidal power, a viable solution to the long-standing issue of high energy costs caused by the use of diesel fuel for the power generation. The towns and villages of the Aleutian Islands, including False Pass and Unalaska, which are highlighted in this paper, are reliant on diesel power, which must be transported by barge to their communities, resulting in a cost of power that is significantly higher than the average costs for Alaska and the United States. Tidal power has the potential to provide sustainable power to these communities, while lowering the extreme cost of living currently endured by the region's residents. The method on which we focus, in-stream tidal power generation, captures the kinetic energy of tidal currents with turbines installed directly on the seabed, eliminating disturbance of the surrounding ecosystems caused by systems requiring damming. However, further research is needed to determine the exact ecological impacts before a project could be permitted and implemented. A proposed project at False Pass can be used as a reference to identify other sites for tidal power, such as Unalaska, the largest town in the region. Despite the large investment required to put tidal power generation in place, tidal power is economically feasible in the Aleutians as a long-term solution due to the lower recurring costs. Initial costs, including purchasing and installing the turbines, could be shouldered by for-profit or non-profit Alaska Native organizations that strive to protect traditional Native culture, which is threatened by the high living costs that drive individuals away from villages. Tidal power and other alternative energy sources will improve the quality of life of residents of the Aleutian Islands, protect the cultural heritage of Alaska Natives, and reduce the harm to the environment and the oceans caused by the use and transportation of fossil fuels for power generation.

I. Introduction

The global dependence on fossil fuels and non-renewable resources poses a serious threat to the ocean and the ecosystems it supports. Pollution from shipping and spills, and the acidification of the ocean due to an increase of CO_2 in the atmosphere are all consequences of energy consumption through unsustainable means. Use of alternative energy sources is one key step towards the prevention of continued ocean disturbance. The communities of the Aleutian Islands represent a region where alternatives for fossil fuels are especially needed. Currently, all Aleutian cities and villages are dependent on diesel and other fossil fuels for heat and power for their communities (James Fitch, pers. comm.). However, many of these towns have the potential for alternative energy that can reduce their cost of living and impact on the environment.

The high cost of living in the small villages of Alaska is a concern to those interested in cultural heritage and the preservation of the traditional Alaska Native way of life, as inhabitants of small villages are pressured to leave by unbearably high energy costs and the limited economy within rural villages. Individuals in rural areas of Alaska report that up to half of their monthly income goes to energy costs and heating their home. Dependence on fossil fuels is not only environmentally unsustainable; it is also expensive to the point of crippling their way of life (http://energy.gov/article s/helping-alaska-native-communities-reduce-their-energy-costs).

We propose that tidal power is a means by which clean, sustainable energy can be provided to small communities in the Aleutians. Tidal power generation reduces power costs, eliminates the need to transport fossil fuels for power generation and the associated potential for environmentally damaging spills, and does not contribute to the environmental damage of burning fossil fuels, such as ocean acidification. One location in the Aleutians that has been previously identified as a potential site for tidal energy is False Pass, a town of roughly thirty-five people on Isanotski Strait (Figure 1) (Doug Johnson, pers. comm., http://factfinder2.census. gov/faces/nav/jsf/pages/community_facts.xhtml). Using False Pass as a reference,

we can identify other sites in Alaska that might benefit from tidal power, such as Unalaska, the largest community in the Aleutians, with the largest power demand and fossil fuel consumption.

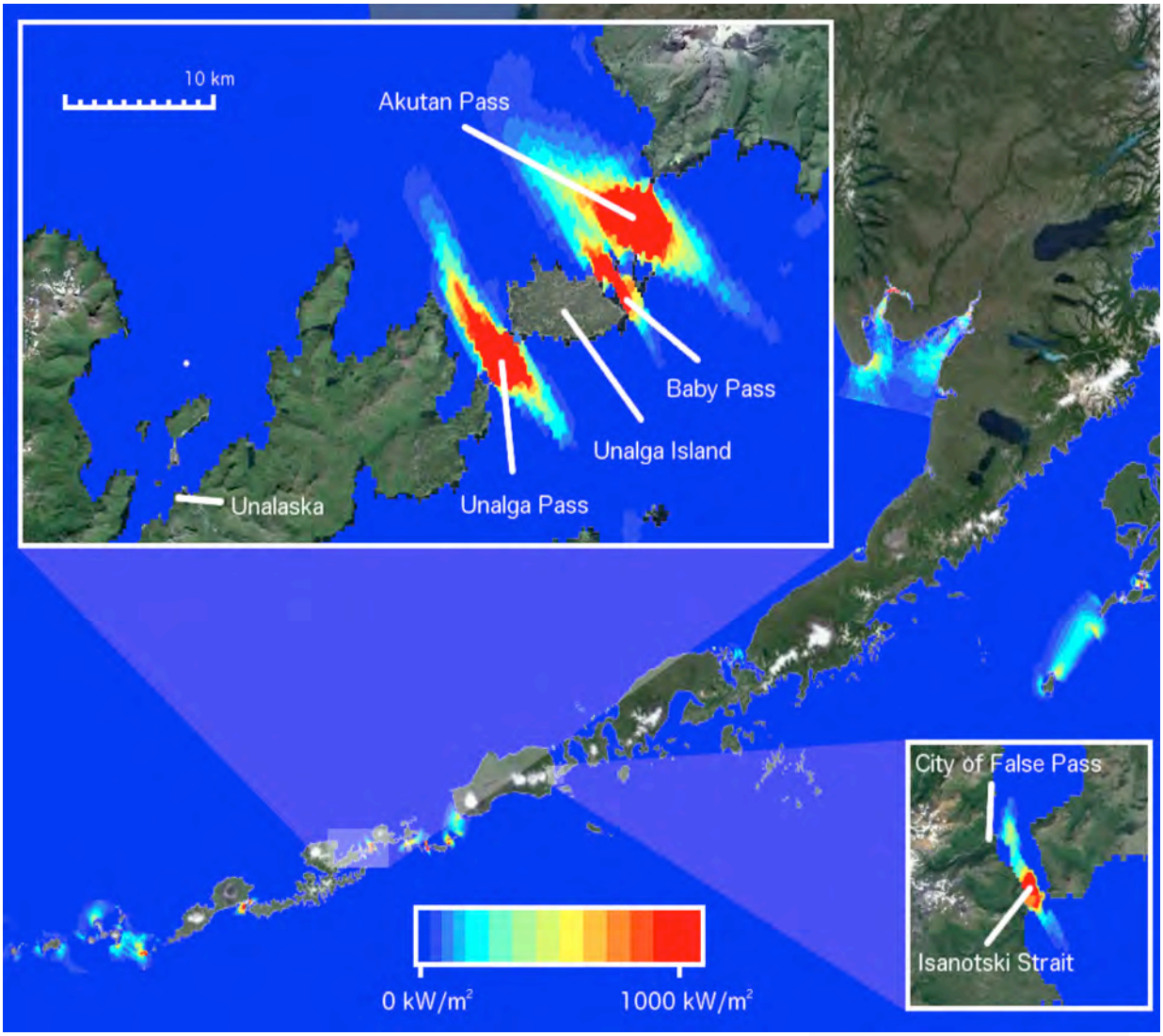

Figure 1. Location and tidal power potential of False Pass and Unalaska. Created using map data from Google Earth (http://google.com/earth/) and Haas et al. (http://www.tidalstreampower.gatech.edu/).

II. The Aleutian Islands

The Aleutian Island chain, an island arc in Southwest Alaska spanning over 1,000 miles, was formed by the ongoing subduction of the Pacific plate under the North American plate, and is one of the most geologically active island chains in the world. It is composed of 14 large and approximately 55 small islands, as well as hundreds of small islets. The maritime climate is cool, wet, and windy, with frequent storms, especially in the winter (Hunt, 2005).

Three ocean currents flow past the Aleutians: The Alaska Coastal Current, the Alaskan Stream, and the Aleutian North Slope Current (Figure 2). The Alaska Coastal Current, driven by winds and freshwater input, and the Alaskan Stream, a western boundary current of the North Pacific sub-Arctic gyre, both flow westward on the south side of the islands. The Aleutian North Slope Current flows eastward on the north side of the archipelago. The Alaska Coastal Current splits at Unimak Pass; the less saline, inshore portion turns northward, while the saltier offshore portion continues west to Samalga Pass, where it joins the Aleutian North Slope Current. West of Samalga Pass, the Alaskan Stream is the predominant current south of the archipelago. The differences in source water result in different physical and chemical conditions in the passes between the islands. The flow of water through the passes is dominated by the tides. In smaller, shallower passes, the tidal currents mix the entire water column. In larger passes, there is a two-way flow, to the south on the west side of the pass and northward on the east side. However, in all of the passes except Kamchatka Strait, net water flow is to the north (Hunt, 2005). In addition, the Islands of the Aleutian region all experience mixed tides, which are predominantly semidiurnal (Huang et al., 2011).

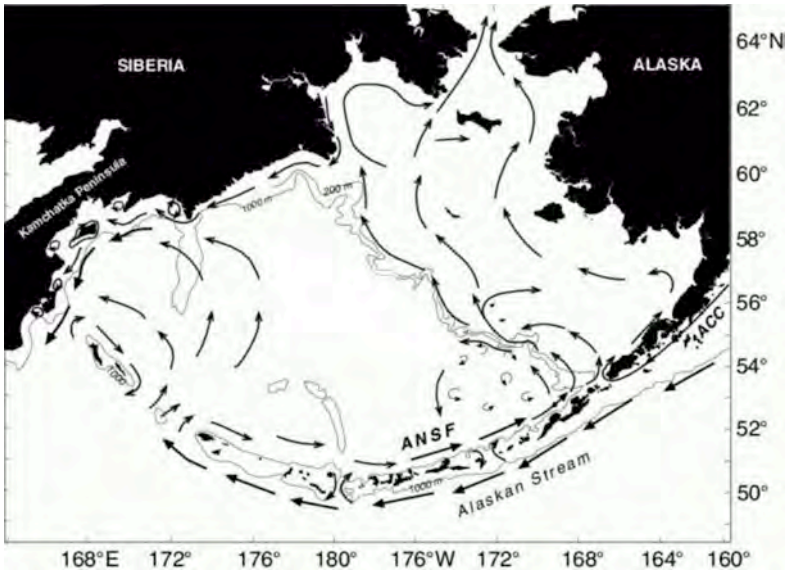

Figure 2. Ocean currents in the Aleutian region (based on Stabneo et al., 2005).

III. The People of the Aleutians

The Aleutian region is sparsely populated, with only 8,702 residents reported in the 2010 census (http://factfinder2.census.gov/faces/nav/jsf/pages/community_facts.xhtml). The Aleut, also called Unangan, are indigenous to the Aleutians, and have inhabited the area for 6,000 years, coming as part of a second wave of migration, likely traveling by boat rather than over the Bering land bridge. The Aleut people traditionally

lived in small villages, and subsisted primarily on sea lion (*Eumetopias jubatus*) and various species of whale. The extreme lack of wood on the islands led to innovations and lifestyle changes including eating raw food and living in partially subterranean homes with grass roofs (Veltre and Veltre, 1982). Traditional Aleut values include respect for the Creator, knowledge of one's family and ancestors, regard for the land and sea, and maintenance of balance in life (http://www.firstalaskans.org/index.cfm?section=Census-Information-Center&page=Regional-Fact-Sheets&viewpost=2&ContentId=602).

The Russians were the first people from the old world to visit the Aleutians, in 1741. They became interested in the islands for the valuable fur of seals and sea otters (*Enhydra lutris*). The Aleut people were forced to hunt fur seals (*Callorhinus ursinus*) and sea otters under the rule of the *promyshlenniki,* the Russian fur traders. The Russian government's limited control over the traders resulted in a dramatic decline in the Native population until the creation of the Russian-American Company in 1799. The traditional way of life was entirely disrupted by 1830 despite attempts to salvage it (Haycox and Mangusso, 1996).

Caucasian settlers in the Aleutians were scarce, even after Alaska was purchased by the United States in 1867. The population was primarily Native until the beginning of World War II, when military bases were constructed throughout the Aleutians to guard against a potential attack by the Japanese, which did occur on Adak and Attu Islands. In addition to military expansion, the federal government evacuated most of the Natives to Southeast Alaska, where many died due to poor living conditions in the internment camps and canneries where they were housed. Upon returning to their homes, many Aleuts were shocked to find their houses and churches had been destroyed or ransacked by soldiers (Haycox and Mangusso, 1996).

The Alaska Native Claims Settlement Act (ANCSA) of 1971 created for-profit Native corporations on regional and local levels. Twelve regional corporations were each granted a portion of almost one billion dollars and forty million acres of land, to be utilized in a manner most beneficial to the shareholders of each corporation, the indigenous peoples of the area (http://www.ankn.uaf.edu/Curriculum/ANCSA/ane.html). The Aleut Corporation, the regional corporation for the Aleutian region, last reported a net income of over

twenty million dollars, before taxes, in 2010, and experienced growth between 2008 and 2010, despite the nationwide recession (http://www.aleutcorp.com/images/stories/11263%20aleut2010annualreport_lowres).

Today, much of the non-Aleut population throughout the Aleutians, especially within the city of Unalaska, is of Asian descent, primarily because Asian workers were recruited for jobs in fish-processing plants. According to the 2010 census, the population of Unalaska is 30.6% Caucasian, 31.4% Asian, 19.9% American Indian and Alaska Native, and the remaining portion is divided between people of multiple races and other categories (http://factfinder2.census.gov/faces/nav/jsf/pages/c ommunity_facts.xhtml).

IV. Tidal Power

Tidal power is an alternative energy source that uses the kinetic energy from the tidal motion of seawater to generate power. Tidal power is regarded as a clean energy source; the power generation methods are sustainable and do not cause lasting damage to the environment (Polagye et al., 2011). Tidal power is also reliable and predictable, as unlike wind or solar, the tidal pattern of an area is regular and does not vary greatly with weather or other variables. In this paper, we focus on in-stream or tidal current turbines, as opposed to tidal barrages. Tidal barrages are large dam structures that block the entrance to an estuary or other partially-enclosed area, and employ turbines much like hydroelectric dams to harness the energy of the tidal outflow. Unlike hydroelectric dams, tidal barrages allow water to flow in both directions to create a power potential; however, energy is generated only during ebb tides. Tidal barrages often harness a greater amount of energy than in-stream turbines, but result in much greater environmental damage because of the damming required to generate power. Barrages have been found to change the salinity ranges of estuaries, and also reduce the amount of intertidal habitat available to organisms and change both bottom water properties and current patterns within and outside the enclosed area (Pelc and Fujita, 2002).

In-stream turbines generate electricity as tidal currents pass through them in a manner similar to the method of generating power from wind energy. The turbines are installed on the seafloor, and generate energy from currents and tidal movement, without blocking an estuary mouth or otherwise altering the

surrounding region. Narrow straits produce swift currents because of the large volumes of water moving between landmasses, and therefore create the most desirable locations for in-stream tidal generation. Many such locations with strong currents exist, including those in the Aleutian Islands (O'Rourke et al., 2010).

The amount of power generated is dependent on the area of water intercepted by the device, the cube of the water velocity, and how efficient the device is at converting the kinetic energy into electrical energy. The power generated by the turbine can be expressed in the equation $P=(1/2)nV^3Ae$, where P is the power generated by the turbine, n is the density of the seawater , v is the velocity of the tidal current, A is the area of water of water intercepted by the device, and e is the efficiency of the device. The efficiency and cross-sectional area change for turbines designed by different companies (Polagye, 2010).

The proposed project at False Pass would use the TidGen Power System (Figure 3), an in-stream turbine system designed by Ocean Renewable Power Company (ORPC). This system was implemented in the first commercial tidal power operation connected to a local utility grid in North America. The installation of one TidGen system in Cobscook Bay, Maine, in 2012, has generated enough energy to power 25 to 30 homes, and the project will be expanded over the next three years to generate a total of 5 megawatts, enough for up to 300 residences or businesses (http://science.energy.gov/sbir/highlights/2013/sbir-2013-01-e/).

Throughout this paper, we refer specifically to the TidGen system, not because it is definitively the best or most cost-effective method of tidal power generation available, but because the TidGen system is the only method that has been seriously proposed so far in the Aleutians, and is the only system that currently operates within the United States. Other devices and implements for in-stream tidal generation exist, and may be more efficient or economically viable than ORPC's TidGen system, however, none of these options have been presented within the Aleutian region thus far.

Because in-stream turbine installation does not require the damming or other blocking of estuaries or other marine areas, sediment disturbance or current pattern changes are typically not significant concerns (Pelc and Fujita, 2002). Frid et al. (2011) indicate that the sediment disturbance caused by the installation of turbines has not posed any significant threat, as most areas with enough tidal power potential to support a tidal generator have strong enough currents that the sediment is disturbed naturally more than by the turbines. However, this effect may not be negated by natural currents as the number and size of turbines in an area is increased. The sediment disturbance is a threat to benthic organisms that rely on nutrients from and the habitat of ocean floor sediments, potentially resulting in a change in benthic community compositions if sediment disturbance is prolonged (Polagye, 2010).

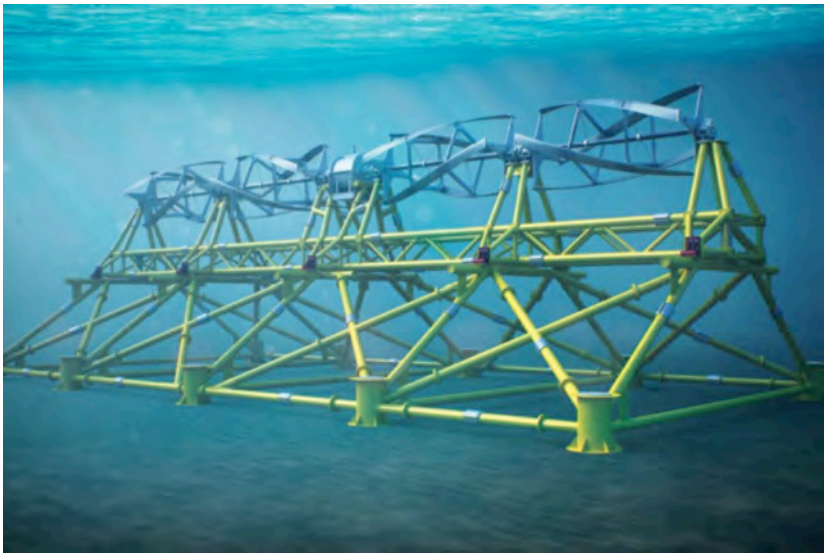

Figure 3. The TidGen Power System. Courtesy of Ocean Renewable Power Company.

The primary concern arising from the installation of in-stream turbines is the potential for negative effects on marine organisms. Conclusions on the potential for interactions between nekton and in-stream turbines are mixed. Reports indicate high mortality rates from direct contact between fish and turbines, but other sources have also reported that small to medium fish are often able to swim through turbines and remain unharmed (Frid et al., 2011). Additional studies have reported that marine mammals and diving birds generally avoid rotors, the chances of them being hit by a blade are low, and any contact that were to occur would be glancing and not seriously harmful (Fraenkel, 2006). Reports on the TidGen system installed in Maine suggest the turbines do not have negative effects on marine life, but each site is unique, so these findings may not be generally applicable. Because False Pass and Unalaska both have marine mammals

and endangered species, including Steller sea lions, gray whales (*Eschrichtius robustus*), humpback whales (*Megaptera novaeangliae*), killer whales (*Orcinus orca*), we feel that further research and monitoring of the interactions between marine mammals and in-stream turbines would need to be, and should be, conducted.

While other renewable sources have been considered as potentials for reducing energy costs in the Aleutians, tidal power stands out primarily because of its reliability (Bruce Wright, pers. comm.). Unlike wind and solar power, tidal power is not dependent on the weather conditions and can operate at all times of the day, excepting the period of time when the area experiences slack tide. The two locations highlighted in this paper do not have sea ice present at any time of year, so tidal power turbines would be operable throughout the winter months (Doug Johnson, pers. comm.).

V. False Pass

False Pass is a small community located on the eastern shore of Unimak Island with a population of approximately 35 individuals. The city is a port on Isanotski Strait, which is used by thousands of vessels traveling between the Gulf of Alaska and the Bering Sea every year. The location was identified as a potential tidal power site by local mariners, who observed an exceptionally high current velocity, and in the summer of 2013 a study was conducted by ORPC to confirm the tidal potential that had been reported anecdotally (ftp://ftp.aidea.org/White-McMahon/862False%20Pass%20Tidal%20Energy%20Study/False%20Pass%20Tidal%20RE%20Rd%20V%20App.pdf). Funding for the study was provided by the Aleutian Pribilof Islands Association (APIA), the tribal organization of Alaska's Aleut peoples, through a tribal energy grant from the US Department of Energy (http://www.uaf.edu/files/acep/2013_REC_False%20Pass%20Assessment_Monty%20Worthington.pdf). ORPC hopes to have the TidGen turbine unit in the water in the fall of 2014, however APIA doesn't believe the permitting process will be completed by that date (Bruce Wright, pers. comm.). Additional, extensive bathymetric surveys are needed before this can occur. Throughout the process, ORPC will be monitoring in conjunction with the relevant agencies for any

environmental impacts that might occur. Underwater video monitoring will be used to determine safe placement for the turbine (Doug Johnson, pers. comm.).

Currently, the city of False Pass generates electricity by burning diesel fuel. The proposed single TidGen unit at False Pass would supply at least 30% of the electrical and heating needs of the community; enough power to save 37,000 gallons of diesel fuel annually. It would also cut the high energy costs caused by the high cost of fuel and the expense of transporting it (City of False Pass Electric Utility, 2011). The residents of False Pass pay between 15 and 42 cents per kWh for electricity, depending on whether they receive the Power Cost Equalization subsidy from the State of Alaska. The Power Cost Equalization program lowers the cost of energy for residents of rural communities where energy costs are potentially as high as three to five times the statewide average (http://www.akenergyauthority.org/PDF%20files/PCEProgramGuide_August13.pdf). This program relies on appropriations from the Alaska State Legislature and the expenditures for the 2012 fiscal year - the most recent data available - totaled $39.1 million (http://www.akenergyauthority.org/PDF%20files/pcereports%5CFY12statisticalrptbyuty.pdf). Residents of the City of Unalaska received $1,065,287 of the subsidies, while residents of the City of False Pass received $22,176 (Alaska Energy Authority, 2013). Even with the subsidy, the cost of electricity is much higher than the national average of 12.51 cents per kWh. Electricity costs the City of False Pass $187,060 per year, and this is expected to increase as fuel prices continue to rise. In contrast, the estimated operating and maintenance costs for the TidGen system would be $35,750 per year, according to ORPC (ftp://ftp.aidea.org/White-McMahon/862 False%20Pass%20Tidal%20Energy%20Study/False%20Pass%20Tidal%20RE%20Rd%20V%20App.pdf).

A challenge posed by the use of tides for power generation is their intermittent nature. Power can only be generated while water is flowing, either in or out. Slack water leaves a recurring gap in power output. ORPC is looking at several energy storage technologies for use at False Pass that would alleviate this issue. Batteries, particularly liquid metal ones, and compressed air are both possibilities for storage. The production of ammonia or hydrogen while the tide is flowing is an option, which would later be combusted to

provide energy. Water could also be pumped into an elevated reservoir onshore to be used for traditional hydroelectric power generation during slack tides. Furthermore, constant power output over the period of the tide may not be necessary for False Pass. Much of the power usage in False Pass goes to the production of ice for use by local fish processors. By making additional ice when energy is available, it would be possible to reduce power demand when energy is scarce (Doug Johnson, pers. comm.).

VI. Unalaska

Unalaska is the largest community in the Aleutian Islands, with a population of 4,376 reported in the 2010 census (http://factfinder2.census.gov/faces/nav/jsf/pages/community_facts.xhtml). Like many towns in the Aleutians and other regions of Alaska, the population varies with the time of year and the profitability of the fisheries, sometimes reaching as high as ten thousand. Unalaska, along with all other communities in the Aleutians, relies on diesel generators for power. The municipal power utility provides power for the entirety of the town except the four major fish processors, all of which have separate diesel generators. Alyeska Seafoods and Westward Seafoods share power generation of 6,200 kW for their Unalaska processing plants (Stuart Law, pers. comm.). Unisea Inc generates 7,000-8,000 kW during the peak fish processing season (February through March and September through December) and 2,000 kW throughout the off-season (Todd Shoup, pers. comm.). Bering Fisheries reports a 32 kW power generator, which is primarily used to make ice (Fred Cecena, pers. comm.). One small-scale fish processing plant, operated by Copper River Seafoods, relies on power provided by the city. The majority of the city's power generation goes to the shipping industry, which is one of the largest components of Unalaska's economy after commercial fishing. On average, the City of Unalaska generates 9,000 kW of power, and roughly 2,000 kW of that power goes to households, with the remainder going to various shipping companies (James Fitch, pers. comm.).

Power provided by the municipal electrical utility costs 51 cents per kilowatt hour (kWh). For the customers eligible for the Alaska Energy Authority's Power Cost Equalization subsidy, the cost is reduced to roughly 27 cents per kWh (James Fitch, pers. Comm.). Residents of the City of Unalaska received

$1,065,287 of the subsidies in 2012 (AEA, 2013). The cost is still greater than the state average of 18.71 cents per kWh, and significantly higher than the national average of 12.51 cents per kWh (http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a). Unalaska's high cost of energy is attributed to both the rising cost of fuel and the cost of transportation (James Fitch, pers. comm.).

Three passes near Unalaska, including Unalga Pass, located between Unalaska and Unalga Islands approximately 20 km (13 mi) from the City of Unalaska over land, and Baby and Akutan Passes, located on the opposite side of the 7 km (4 mi) wide Unalga Island, have tidal power generation potentials of 75,000 kW, 26,000 kW, and 114,000 kW, respectively (http://www.google.com/earth/index.html, http://www.tidalstreampower.gatech.edu/Final_Report_tidal_v2.pdf). The partial exploitation of the nearest, at Unalga Pass, would be sufficient to cover the power needs of the entire community of Unalaska, including the fish processors operating within the city. In conjunction with a switch from home heating oil to electric heating, the dependence of the community on transported fossil fuels would be greatly reduced.

Tidal potential in Unalaska was not studied by ORPC due to the perceived low current velocities in the area. With APIA, ORPC has also been investigating other kinds of renewable energy in the Aleutian Islands, including wave energy. ORPC is also looking at developing tidal power as an energy source in other areas of Alaska, including the south end of Prince of Wales Island (Doug Johnson, pers. comm.).

VII. Cobscook Bay: A Comparative Case Study

Cobscook Bay, part of the Bay of Fundy located near Eastport, Maine, was the site of the first grid-connected tidal power operation in North America when one of ORPC's TidGen systems was installed in the summer of 2012. It currently generates enough energy to power 25 to 30 homes, and over the next three years, the project will expand to generate a total of 5 mW, enough to power up to 1,200 residences or businesses (Table 1) (http://science.energy.gov/sbir/highlights/2013/sbir-2013-01-e/).

The Cobscook Bay project received $10 million in funding from the U.S. Department of Energy for research and installation costs. Since 2007, the project has brought more than $21 million in revenue to

Maine's economy, including $5 million spent locally on several contractors and goods and services. Over 100 jobs are attributed to the project (http://science.energy.gov/sbir/highlights/2013/sbir-2013-01-e/).

In addition to the preliminary studies conducted during the development of the project, ORPC is facilitating ongoing monitoring of impacts to the local environment. They are assessing the physical environment, the benthic habitat, marine mammals, fish, and birds through several monitoring plans. So far, results indicate that the TidGen system in Cobscook Bay does not have any significant adverse effects on the environment. However, data collection was difficult due to the highly dynamic environment of the bay and other circumstances. Benthic disturbance and biofouling were minimal. Observations of marine mammals indicate that there were no population or behavioral changes during construction, operation, and maintenance, and there is no evidence of any marine mammal strikes. Seabird populations and behaviors were not significantly affected. (http://www.orpc.co/permitting_doc/environmentalreport_Mar2013.pdf)

Site	Kinetic Power Density (W/m^2)	Area (km^2)
Cobscook Bay, ME	574	<1
False Pass, AK	1619	5
Unalga Pass, AK	3751	25

Table 1. Tidal power potentials of three locations (http://www.tidalstreampower.gatech.edu/Final_Report_tidal_v2.pdf).

VII. Economics of Tidal Power

The greatest costs associated with tidal power are the initial startup costs, including the research and permitting process, and the acquisition and installation of the equipment required. In the case of Unalaska, additional funds would also be required for purchasing and installing power transmission cables to get the power from Unalga Pass to Unalaska. However, all of these costs are one-time occurrences, which would likely be incurred by one or more organizations, and slowly paid off by the consumers. The cost of power for the consumer after the switch to tidal power would be lower than the current cost, by a variable amount, depending on the cost of diesel at the time.

The project at Cobscook Bay, Maine cost approximately $15 million by the time the first turbine was installed in the water (http://www.foxnews.com/us/2012/09/14/1st-tidal-power-delivered-to-us-power-grid-off-

maine/). According to Bruce Wright, of the Aleutian Pribilof Islands Association, the tidal power project at False Pass will cost on the order of $10 million (pers. comm.). As the technology develops, and the interactions between the turbines and animal species are better understood, the initial investment of turbine installation and research required should continue to decrease.

Outside of the cost and complexity of turbine installation for a project at Unalga Pass, the provision of power to Unalaska would be complicated by the need to transmit it over approximately 20 km (13 mi) of Unalaska Island (http://www.google.com/earth/index.html). The relatively large distance between the pass and the city would increase costs significantly. The cost of installation for a 69 kV overhead power transmission cable is approximately $285,000 per mile, leading to a total cost of over $3.7 million just for transportation of power (Public Service Commission of Wisconsin, 2011). This cost could potentially be higher, because of the cost of transportation of supplies to Unalaska and the additional costs related to the absence of roads, but at this time additional information is not available.

	Annual Energy Production (kWh)	Energy Price (per kWh)	Price with Power Cost Equalization (per kWh)
False Pass[1] (FY 2012)	531,143	.42	.15
Unalaska[1] (FY 2012)	44,932,348	.51	.27
Alaska[2] (2011)	6,320,000,000	.1608	N/A
United States[2] (2011)	3,749,846,000,000	.09895	N/A

Table 2. Current energy costs and consumption of False Pass and Unalaska, compared to Alaska and nationwide averages.
[1] http://www.akenergyauthority.org/PDF%20files/pcereports%5CFY12
[2]http://www.eia.gov/electricity/annual/customersales-map3.cfm

However, this cost, similar to the cost of procuring and installing the turbines, is a one-time expenditure. Other cities in Alaska that rely on renewable power resources, such as Juneau, have similar systems with significant distances between the power generation site and the city. The Snettisham hydroelectric power plant, which provides the majority of power for the City and Borough of Juneau, is located 28 miles away from the city, power is transported by 44 miles of overhead and undersea power transmission cables that run through multiple avalanche chutes and under the Taku River (http://www.aelp.com/history/ electric.htm).

The tidal power provided in Cobscook Bay costs customers $0.215 per kWh (https://bangordailynews.com/2013/08/13/news/down-east/tidal-power-project-headed-for-next-stage/). If a similar price could be achieved in Unalaska, it would provide enormous cost savings to commercial entities that are not eligible for Power Cost Equalization. During times of peak power usage by the four fish processors, they would save an estimated $81,881 per day by using such tidal power (assuming similar generation costs, neglecting line loss, as those reported by the Alaska Energy Authority (http://www.akenergyauthority.org/PDF%20files/pcereports/fy12statisticalrptcomt.pdf)). While residential customers covered by PCE might not see a significant short-term change, tidal power could keep down costs in the long term (Table 2). State oil production has been declining, and is expected to continue to do so. With it, the oil tax revenues that fund the state government, including the Power Cost Equalization Program, are declining (http://www.alaskanomics.com/ 2013/04/states-new-oil-production-forecast-model-less-rosy-too-early-to-tell-if-it-is-more-accurate.html).

As with other tidal power installations, one near Unalaska would require a mechanism to stabilize the power output and provide power during slack tides. As with the project at False Pass, additional research would need to be done into the benefits of various technologies. The production of extra ice for use by fish processors during slack tides could be one component of a more comprehensive solution, but it alone would not satisfy the needs of residential customers and other businesses. Such a solution should be developed in cooperation with the fish processors to better satisfy the power needs of the whole community.

VIII. Cultural Preservation

The rising cost of living in the Aleutians, driven by fuel prices and the dependence on diesel for energy generation, is one of many factors contributing to the decline off the Aleut culture. These factors cause small communities in rural Alaska to shrink and decay, and the cultural heritage diminishes as well. In a survey of people moving from rural Alaska, 65% of respondents replied that “nothing could make me return/village is dying,” (http://www.arlis.org/docs/vol1/B/237133779.pdf). Maintaining the traditional way of

life in small villages is a necessary component of preserving Alaska Native cultural heritage, which includes subsistence, a strong sense of community, and ties to both family and one's village.

One method of improving the quality of life in rural areas and lowering the cost of living is transitioning from diesel-generated power to cheaper, sustainable tidal power. This effort would result in a long-term decrease in energy costs to residences and businesses and prevent high living costs from driving residents away from village life. In addition, the construction required to install tidal generators and the associated infrastructure would bring skilled workers to the area, benefitting the local economy through increased demand for goods and services. Jobs maintaining the turbines and doing other work associated with the support of a tidal power system would help to replace the jobs lost from the transition to tidal power.

Tidal power has the potential to help preserve Native traditions and heritage by decreasing further emigration from villages due to extremely high living costs. As such, both non-profit and for-profit Native organizations, including APIA and the Aleut Corporation, should have a strong incentive to support and fund the development of tidal power in the region. APIA's mission states that it exists as a non-profit corporation "to provide self-sufficiency and independence of the Unangan/Unangas by advocacy, training, technical assistance and economic enhancement; to assist in meeting the health, safety and well-being needs of each Unangan/Unangas community..." (http://www.apiai.com/about.asp?page=about). APIA has previously demonstrated its commitment to develop tidal power, as well as other renewable power opportunities in the Aleutian region, by funding a study of the potential for tidal power generation at False Pass, along with research into other possible energy sources, including solar, geothermal and wave energy technologies (Bruce Wright, pers. comm.). The use of tidal power, or other renewable energy sources, is consistent with traditional Aleut values, which include holding respect for the natural world (http://www.firstalaskans.org/index.cfm?section=Census-Information-Center&page=Regional-Fact-Sheets&viewpost=2&ContentId=602). Decreasing the cost of electricity and therefore the overall cost of living in the Aleutians is a demonstrable economic enhancement and also contributes to meeting the well-being needs of the Unangan peoples.

Turbine operation and resultant power distribution at the False Pass project would likely be a cooperative effort by ORPC, APIA, and the False Pass Electric Utility, although details of ownership and each entity's role in operation of the turbine has not yet been finalized (Bruce Wright, pers. comm.). A project at Unalga Pass, powering Unalaska, could be either wholly owned by the Unalaska Power Utility, with the TidGen system purchased from ORPC, or jointly owned by ORPC, Unalaska Power Utility, APIA, Ounalashka Corporation (the local for-profit Native corporation for Unalaska), Aleut Corporation (the for-profit Native corporation of the Aleutian region), a separate organization, or any combination of the above. Participation by Aleut Corporation would be a direct benefit to the Unangan peoples, of both Unalaska and other parts of Alaska, as the profit from selling power to the businesses and homes of Unalaska would be passed on to the shareholders of the corporation, the Aleut people. Involvement by Ounalashka Corporation would also benefit the indigenous peoples of Unalaska, but not of other communities in the Aleutians or other regions of Alaska. Ounalashka Corporation's mission states that it exists "[t]o continue as a prosperous corporation through excellence in education and management, to benefit Shareholders thereby strengthening Unangan culture, and to become the premier village corporation," a mission that aligns with the goals of a tidal power project (http://www.ounalashka.com/about/). Ownership of the turbine by the Unalaska Power Utility would likely result in the lowest cost to the consumers, as the city generating a profit from the sale of power to individuals within Unalaska is unlikely. However, in the instance of the power utility owning and operating the turbines, the Aleut peoples wouldn't receive monetary benefits from the energy sales through shareholder dividends. Any single entity or combination of entities owning and operating tidal power generation turbines in the Aleutians would be a benefit to the peoples there, through a significant reduction in energy costs and also potentially through dividends to Alaska Native shareholders.

IX. Conclusion

The use of tidal power and other renewable energy sources is essential in reducing of further damage to the environment as a whole, and the oceans specifically. The Aleutian Islands are well suited for the

development of tidal power due to the high current velocities in passes near communities that are currently utilizing unsustainable power generation sources. False Pass, a location previously established as a potential site for tidal power, should be used as a pilot project to test the feasibility and identify other areas in which tidal power could be developed, including other communities in the Aleutians such as Unalaska.

The benefits of tidal power far outweigh the nominal risks of ecosystem damage and the high costs of initial analysis and installation. However, to ensure the preservation of the Aleutian region's unique ecosystem and the culture that depends on it, monitoring of the impacts of turbines on marine mammals, various species of fish, and benthic habitats is necessary. In addition to reducing CO_2 emissions, from burning and transporting fossil fuels and lowering the potential for harmful spills, the development of alternative energy sources in the Aleutians would benefit its residents by reducing the high cost of living. This growing problem threatens the traditional way of life for Alaska Natives in small villages, therefore, transitioning to more sustainable and economically viable energy sources is a demonstrable benefit to the individuals of the Aleutians and the preservation of their cultural heritage. Further research should be conducted into specific locations within the Aleutians, including Unalga Pass, to determine feasibility of tidal power opportunities that have the potential to provide sustainable, cost-effective power for this region.

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