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February 29, 2016

Mayor Albert Howard
City of Angoon
PO Box 189
Angoon, AK 99820

Dear Mayor Howard:

Thank you for the time you and Friends of Admiralty (Friends) have invested in collecting samples in Hawk Inlet. The Department of Health and Social Services (DHSS) and Department of Environmental Conservation (DEC) appreciate "citizen science" we can use to augment the information we receive from agency work and permittees. We share your interests in the health of Hawk Inlet and concerns about the safety of local foods: Protecting human health is a key part of our missions.

Below, DHSS and DEC address the four questions you posed in your December 2015 letter. We also offer to visit Angoon to discuss your concerns, the technical contents of this letter, and what additional sampling and analyses might be warranted or desired.

Question 1

Do the levels of metals reported in subsistence species in Hawk Inlet warrant any concern for the health of the eco-system?

The data collected by several agencies and contractors, which include many years of water quality, sediment and marine tissue data, indicate the ecosystem in Hawk Inlet is healthy.

The only authorized discharger into Hawk Inlet currently is Greens Creek Mine operated by Hecla Greens Creek Mining Company, LLC. The discharge is authorized under an Alaska Pollutant Discharge Elimination System (APDES) permit. The APDES permit (No. AK0043206) sets the allowable discharge contaminant limits and establishes rigorous monitoring requirements designed to assure protection of the uses of Hawk Inlet, which include subsistence use. The monitoring program includes sampling of the water column, sediment, and selected marine life within Hawk Inlet.

DEC has required monitoring in Hawk Inlet for many years. This monitoring program pre-dates the Greens Creek Mine and will continue for years after the mine ceases operation and is reclaimed. All of the information we have seen so far leads us to the conclusion that the overall health of the ecosystem in Hawk Inlet has been protected from harmful discharges from the Greens Creek Mine.

Sediment sampling in two areas in Hawk Inlet, near the head of Hawk Inlet and near a historic ore spill at the Greens Creek Mine ore loading facility indicate elevated metals concentrations in these areas. These samples are compared to applicable Alaska Water Quality Standards (WQS) for toxic and other deleterious organic and inorganic substances for the protection of designated uses for water supply, water recreation, and growth and propagation of fish, shellfish, other aquatic life, and wildlife. Alaska WQS include *narrative* criteria related to sediment quality. The National Oceanic and Atmospheric Administration (NOAA) SQuiRT screening levels were selected as an appropriate *numeric* sediment quality target that meets WQS and supports Hawk Inlet designated uses. The NOAA SQuiRT screening levels were selected because they represent sediment quality concentrations below which minimal effects on aquatic life are expected.

The elevated levels appear to be limited to these two specific areas. In response to these elevated levels, the Environmental Protection Agency (EPA) and DEC are working on a comprehensive review of all of Hawk Inlet to determine if there might be other areas of elevated metals and what the source of the metals might be. This review is designed to allow development of a Total Maximum Daily Load (TMDL) for Hawk Inlet. A TMDL is effectively a "pollutant budget" or recommendation for allowable addition of pollutants to areas that have been found to have elevated levels of pollutants, like metals.

The Hawk Inlet TMDL will prove instrumental in assessing the information that you and Friends have provided to DEC. Fortunately, the work on the TMDL was already well-underway when we received the additional information you provided. This TMDL — which is being developed by an experienced, independent contractor — analyzes all of the available environmental information for Hawk Inlet. Based on this analysis, the health of the Inlet will be further assessed and recommendations made to ensure Hawk Inlet and its users are protected. Everyone, including tribes, state and federal agencies, conservation groups, Hecla Mining, and the public, will have the opportunity to review and weigh in on the draft TMDL before it is finalized. The purpose of this review is to make certain that we have all available information about Hawk Inlet, including natural sources of metals.

Preparing the draft TMDL involved extensive data analyses to identify potential sources of pollution to Hawk Inlet and to evaluate the data trends throughout the inlet. These analyses confirmed that there are no water impairments (levels above water quality criteria) in the inlet associated with cadmium, copper, lead, mercury, or zinc. Water quality criteria are designed so that meeting the water quality criteria in the water column should avoid causing impacts to aquatic life and subsistence users from the discharges of treated wastewater from the mine.

We also require biomonitoring of the sedentary species near the mine's outfall to confirm this, as described above. The monitoring of marine life (biomonitoring) intentionally selects bottom-dwelling organisms because they are abundant, they are a key lower part of the food chain and they are constantly exposed to the water that is studied. Data analyses of fish and shellfish tissue have shown some elevated metals concentrations (above EPA 2000 and 2001 recreational and subsistence cadmium and mercury recommended values). However, the recent concentrations of metals in the tissue samples are similar to pre-mining conditions in Hawk Inlet. This indicates that the elevated tissue levels may be due to naturally high background metals, which often occur in highly mineralized areas such as Hawk Inlet. Additional monitoring is recommended to determine if there is a tissue impairment (levels above EPA-recommended tissue screening values and criterion).

Other species, like seals, that spend a significant amount of time in other areas with high metals levels could pick up metals from prey in those areas. Because the lower trophic species around the mine outfall are not showing higher metals, it would appear they are not likely be a major source of the high metal concentrations that might be found in higher trophic species such as seals.

We will reexamine our conclusion about the health of the Hawk Inlet ecosystem as we review data submitted by tribes, state and federal agencies, conservation groups, and the public, and complete the TMDL. In the future, additional data may need to be collected to help us better understand the ecosystem in Hawk Inlet.

Local knowledge and experience is beneficial to the work in finalizing the TMDL document. The sample data you have sent us will be used to help develop the final TMDL document. As work on the TMDL progresses, DEC will request and evaluate the data collected for the sample study summarized in the reports provided by Friends in order to integrate this information into the final TMDL report. Again, we very much appreciate the data that you and Friends have provided.

Question 2

Should we or other citizens have any concern over harvesting or purchasing, consuming and sharing these traditional foods items from Hawk Inlet?

The Environmental Public Health Program (EPHP) within DHSS has performed an initial assessment of the monitoring data provided by Friends. EPHP estimated community exposures to contaminants from traditional foods based on contaminant levels reported by Friends (Tables 1 and 8) and traditional foods community harvest data for Angoon from the Alaska Department of Fish and Game (ADF&G). These exposures were compared to standards and guidelines developed by national and federal agencies. In doing so, EPHP considered the nutritional, cultural, physical, spiritual, and religious benefits of traditional foods. Following are EPHP's recommendations and conclusions:

Recommendations on Shellfish and Seaweed Consumption

Using the most recent annual harvest data from ADF&G, for both shellfish and seaweed, EPHP obtained proxy consumption rates that estimate how much people eat. Table 3 shows 2012 harvest data from the ADF&G Community Subsistence Information System.

For each species, ADF&G provided the 50th (median), 95th, and 100th (maximum) percentile consumption rates of subsistence foods in Angoon. These rates, typically available as pounds per person per year, reflect usable harvest weight – what residents would actually consume, not including weight of shells and other discarded parts.

Calculating acceptable food intake based on contaminant content

Noncancer risk

To calculate *noncancer* risks associated with contaminants in the shellfish and seaweed, EPHP used the 95th percentile data that would include heavy consumers of traditional foods, accounting for higher exposures to contaminants from these foods. When 95th percentile values were not available, EPHP used the 100th percentile (maximum) values for species harvest rates.

EPHP found that the levels of arsenic, cadmium, chromium, copper, manganese, mercury, nickel, selenium, silver, and zinc reported for the tested seaweed, shrimp, hermit crab, butter clams, cockles, and mussels do not pose a noncancer health concern when these foods are consumed at the estimated 95th percentile of Angoon harvest data rate. Contaminant exposures were well below federal standards for noncancer health effects associated with the ingestion of these metals (Table 5).

To evaluate the potential exposure to lead from traditional foods, we calculated lead exposure doses using the EPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children (Version 1.1, Build 11, EPA, 2010). The model calculates long-term lead exposure for children aged 6 months to 7 years, but does not account for potential daily or seasonal variations in exposure. Because fetuses and young children are the most sensitive populations to exposures from toxins in the environment, exposure calculations were done only for this age group. This model suggests that if children were to eat traditional foods at the Angoon 95th percentile harvest rates, there would be less than a 0.25% chance that exposed children under seven (<7) years of age would exceed the CDC blood lead reference level of 5 μg/dL even if they consumed at the 95th percentile for their age (Table 7). This level is set by the Centers for Disease Control and Prevention as a reference level for child lead exposure. While there is no level for exposure to lead that has been shown to be safe, and because younger children are not at an appreciable lead exposure risk, these calculations indicate that older children and adults are not at an unusual lead exposure risk.

Cancer risk

To calculate *cancer* risks, EPHP used the median harvest data as these more accurately reflect an exposure time of 65 years (90th percentile residence time in Angoon, ADF&G). Cancer risk calculations assume that both current contaminant concentrations in food and food consumption rates remain constant, on average, for lifetime residence in Angoon.

EPHP found that exposure to inorganic arsenic, the only cancer-causing contaminant by ingestion from the tested shellfish and seaweed tissue, is associated with a cumulative possible excess cancer risk ranging from 0 to 5 additional cases above background for every 10,000,000 persons consuming crabs and ranging from 0 to 1 in every 100,000 consuming clams for a 65-year period of exposure, depending on the food species consumed (Table 6). Stated another way, the chance of *not* getting cancer from consuming high amounts of these species every year for 65 years is between 99.99995 and 99.999%. These risks are considered low to very low and fall within the EPA's range of acceptable excess lifetime cancer risk.

Finally, data for shellfish and finfish available from DEC and included in DEC's TMDL document[1] do not indicate higher health risks than presented above.

Recommendations on Seal Consumption

The analyses of tissues from a single seal, although useful, provide limited information to allow for any firm recommendations about potential health effects that could result from the consumption of seal meat and organs harvested in the vicinity of Hawk Point. Therefore, EPHP used a semi-quantitative analysis that draws on data published in the peer-reviewed literature and the State of Alaska's Fish Consumption Guidelines.[2]

[1] ADEC TMDL for Hawk Inlet

[2] http://dhss.alaska.gov/dph/Epi/eph/Pages/fish/default.aspx#guidelines

Influence of Seal Age on Contaminants Concentration

It is well-established that some heavy metals (such as mercury) and persistent organic pollutants, because of their high potential for bioaccumulation, are found at higher concentrations in older animals than younger animals of the same species. Male harbor seals live an average of 20 years of age compared to the female of the species (25—30 years) and generally measure 1.4—1.9 meters (4.6—6.2 feet) in length.[3] This species' long life span could cause contaminants concentrations in its tissues to be highly variable, depending on age of the seal. Hunters who harvested the seal discussed in this report noted taking an "older adult male" (length, 2.28 meters or 7.48 feet) and its age should be considered in the following assessment.

Mercury and Selenium Concentrations

Because the harbor seal harvested by one of the community members was an older male, the concentration of contaminants in its tissues should be larger than in younger specimens. This could in part explain why liver concentrations of total mercury and selenium measured in this specimen were higher than levels reported in the literature, none of which were measured in seals older than 11 years of age in Alaska Water. This included seals from Prince William Sound (0.51—77.5 ppm mercury per wet weight of tissue) and Kodiak (0.61—106 ppm mercury per wet weight of tissue).[4] Young male and female harbors seals five years or younger (≤5 years) of age in this study mostly had liver mercury concentrations <10 ppm wet weight and heart muscle mercury concentrations <1 ppm wet weight, much lower than those reported for the older male harvested from Hawk Point (Table 8).

Moreover, total mercury concentration in seal tissues is not always an adequate indicator of toxicity in humans consuming them. Mercury absorption in the body following ingestion of contaminated tissues is highly dependent on the mercury species. Mercury absorption into the body after ingestion has been estimated at 95% for methylmercury (MeHg), 7—15% for inorganic forms, and much less than 1% for elemental mercury. There is evidence that only 3—12% of the total mercury found in the liver of marine mammals is present as MeHg, while the remaining fraction is characterized by less bioavailable inorganic forms of the metal.[5] Whenever possible, determining the specific mercury content of the seal tissue is important to properly assess the risk to human health. Furthermore, there is considerable evidence that selenium compounds in fish consumed by marine mammals function to limit the health risks associated with mercury in these fish when consumed. These protective elements and benefits in the marine mammal diet are difficult to quantify, but should be considered when examining the potential risks of consuming marine mammal tissue.

Based on data for tissues harvested from the seal and reported by Friends and colleagues, and using the State of Alaska's Fish Consumption Guidelines[6], EPHP recommends the following:

1. **Blubber/Fat**: While blubber metal concentrations do not indicate any appreciable health risk, fat tissue tends to be a reservoir for persistent organic pollutants that bioaccumulate (build up) with age in mammals. EPHP is not able to fully assess the safety of consuming blubber from this seal at this point, but it generally recommends that Alaskans limit the consumption of seal blubber to that from younger seals, which generally have lower contaminant levels than older seals.

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[3] http://marinebio.org/species.asp?id=158
[4] Marino et al. 2011. Environ Res. 111(8):1107-15.
[5] Wagemann et al. 1998. The Science of the Total Environment, 218 19-31
[6] http://dhss.alaska.gov/dph/Epi/eph/Pages/fish/default.aspx#guidelines

2. **Liver**: Liver: Considering the high concentration of total mercury (Hg) in this seal liver, children, and women who are pregnant or plan to become pregnant should not consume liver from older adult seals. EPHP does not yet have sufficient information to provide specific consumption recommendations on liver from older adult seals for those who are not women of child bearing age and children. Therefore, men and women not of child bearing age or not planning to become pregnant should either not consume liver from older adult seals or limit their consumption of liver from older adult seals to very small amounts. This is because this particular liver is high not only in mercury, but in several other heavy metals as well.
3. **Kidney**: Evidence shows that approximately 10% of mercury in kidney is in MeHg form,[7] a highly absorbable form of mercury. Therefore, children and women who are pregnant or plan to become pregnant are advised to consume not more than one 6-ounce serving (the size of a regular tuna can) of seal kidney per week. Men and women not of child bearing age or not planning to become pregnant do not have any restrictions on consuming this tissue.
4. **Muscle**: Most of the mercury in muscle tissue is in MeHg form. Therefore, children and women who are pregnant or plan to become pregnant are advised to consume no more than four ounces per week (the size of a deck of cards) of seal muscle. Men and women not of child bearing age or not planning to become pregnant do not have any restrictions on consuming this tissue.

Other Metals

Mercury in seal tissue appears to be the risk driver for tissue consumption and risk from other metals in this tissue would be addressed by following the above recommendations for seal tissue consumption based on mercury.

Conclusion

Tissue analyses were available from only one seal and an unknown sample size and harvest location of shellfish and seaweed. Therefore, we cannot extrapolate to other foods that might be harvested from Hawk Point or Hawk Inlet and the recommendations here are limited to the currently available data. Additional contaminants data on traditional foods from Hawk Inlet are necessary to make better informed consumption recommendations.

It is reasonable to assume that, because the seal specimen was an older adult seal as identified by the hunters, the level of contamination of its tissues is expected to be higher than it would be in a younger seal. A more extensive sampling of seal from more locations and a wider age range than currently available is necessary for both a better representation of the seal population of this area and a more accurate assessment of the potential health benefits and risks associated with seal tissue consumption. However, other studies on harbor seals in Alaska and elsewhere (Marino *et al.*, 2011[8]; Brookens, 2006[9]; Akmajian *et al.*, 2014[10]) suggest that various seal tissues (including liver) could be consumed albeit with much less restriction than for this old seal. Restriction parameters depend on, among other factors, the seal age and the consuming population (*e.g.*, pregnant women and children *vs*. men).

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[7] Alaska Section of Epidemiology, 2004. Epidemiology Bulletin, 8(8)
[8] Marino et al. 2011. Environ Res. 111(8):1107-15.
[9] Brookens, 2006. Trace Element Concentrations in the Pacific harbor seal, Phoca vitulina richardii in central and northern California. Master Thesis. http://capstone.csumb.edu/world/2006/brooken.pdf
[10] Akmajian et al., 2014. Northwestern Naturalist. 95:83–91.

Traditional food consumption recommendations often cannot adequately address the *benefits* of consuming these foods. This is because more information is available on the contaminant health risks rather than on the risk-benefit balance when contaminants are present in traditional foods. This introduces uncertainties into the recommendation process for many of these contaminants and likely results in a precautionary process that might unnecessarily limit the consumption of traditional foods.

EPHP has been working to assemble and convene a panel of traditional, environmental, medical, and public health experts to explore the development of marine mammal consumption guidelines for Alaskans who consume these mammals. When this panel is convened, it will aim to explore both the benefits and risks associated with consuming marine mammals harvested in Alaska waters.

Data provided by Friends on shellfish and seaweed from Hawk Inlet indicate no appreciable public health risk from harvesting or purchasing, consuming and sharing these traditional foods items from Hawk Inlet assuming both 2012 Angoon subsistence use rates and contaminant levels in the tested species are representative of other organisms within the same species in Hawk Inlet. The seal data indicate potential risks from consuming some tissue and EPHP makes relevant recommendations earlier in this document. Data from this one seal warrant further testing of seals in Hawk Inlet and elsewhere in Southeast Alaska, but area residents should not be deterred from harvesting and consuming their traditional foods including seal, shellfish, fish, and seaweed. Traditional foods are beneficial from many perspectives that are not limited to nutrition. These benefits are also cultural, physical, spiritual, and religious.

Knowing how much mercury is safe to eat can be estimated by how much mercury is in the food. However, other simple and more direct tests can tell if someone is getting too much mercury. The EPHP manages a Hair Mercury Biomonitoring program that aims to determine mercury load in an individual. This test is available free of charge to Angoon residents and other Alaskans interested in learning how much mercury they are getting from their food and other sources. We encourage everyone in Angoon and surrounding areas to donate hair samples for analysis; these tests are available upon request.

Question 3

Is it possible to determine the source of the elevated metals?

In order to determine if metals in fish tissue are elevated, current levels must be compared relative to a set standard or background level. The Friends reports generally compared tissue concentration results with statewide, national or international screening levels to determine if Hawk Inlet species samples were elevated. However, trace metals and mercury data can vary in a population of fish and shellfish and be dependent on many site-specific factors. One such important factor is the geologic deposits in the natural environment.

The DEC data used in the Friends reports represent the mean values or averages from across the state from different ecosystems. When comparing the Friends study data to these statewide reference values it is important to note there can be quite a large variance (minimum to maximum) of the metal concentration in a population of fish or shellfish. For example if you look at halibut data from the DEC webpage (n=2490) the range in concentration of trace metals, some of which are bioaccumulated in the muscle tissue of the fish, is quite great extending from non-detect to the maximum reported (e.g., Mercury ranges from non-detect to a maximum of 2.0 mg/kg; Arsenic ranges from non-detect to a maximum 17 mg/kg and Cadmium ranges from non-detect to a maximum of 0.14 mg/kg).

In evaluating whether the Hawk Inlet concentrations are above natural background levels, it would be better to compare these data to the data the DEC Fish tissue monitoring program (FTMP) has on contaminants in fish and shellfish from the area surrounding the northwest corner of Admiralty Island. The graphs attached at the end of this letter (Appendix) compare these data to data from samples collected and analyzed by the Friends. Some concentrations appear to be elevated in comparison to the reference DEC values while others appear to be lower or roughly equivalent. However, since the number of samples is limited, more samples need to be evaluated to characterize the range of variation in the population of the fish or marine animals residing in the area.

We have identified a number of sources that could contribute metals to the Inlet. The Greens Creek Mine is a possible source. There has also been historical mining in the Inlet that could be contributing metals. These mines were operated and closed long before environmental protection laws like the Clean Water Act were in effect. Additional sources of metals to the Inlet include natural drainages (rivers and streams) that empty into the Inlet. Since Hawk Inlet is in a highly mineralized area, these natural drainages can have metal levels that are higher than what we would expect to see in non-mineralized areas. Each of these sources will be discussed in detail in the TMDL document.

Question 4

If these foods are found to be unsafe to consume, what steps will the state take to protect consumers as well as mitigate the hazard?

The fish tissue data collected by DEC and from other studies are used to determine if there are any areas, species of fish, or specific contaminants that warrant more in-depth sampling and evaluation and also provide Alaska residents with information to make an informed dietary decision based on risks and benefits of eating Alaska Fish. Since food is a complex mixture of nutrients (protein, vitamins, minerals, fats, energy), as well as contaminants, the concentration of a contaminant in a food is just one factor that is evaluated in determining the consumption recommendations. Other considerations include the cultural, physical, spiritual, and religious benefits of traditional foods. The state evaluates fish consumption guidelines based on the risk of exposure to a contaminant from eating fish or shellfish with the nutritional health benefits and makes a recommendation to optimize Alaskan resident's health. Fish and shellfish are a good source of lean protein, vitamins, minerals (selenium), polyunsaturated fatty acids (Omega 3 fatty acids); and are low in sugars/carbohydrates and saturated fats. A Scientific Advisory Committee for fish consumption, comprised of members from state and federal agencies and Alaska Native Tribal Health Consortium evaluates the data and makes recommendations to the DHSS EPHP. An independent group of outside expert scientists in the field of public health review and comment on the guidelines prior to release to the public. The fish consumption recommendations are posted on the EPHP's webpage and presented to the general public and to communities by health providers.

DEC manages a rigorous permitting system for the discharge of wastewater in Alaska. DEC is required to ensure that all discharges of wastewater are protective of human health and the natural environment. This includes protecting the water use of available subsistence foods for harvesting. The Greens Creek Mine has a permit to discharge wastewater into Hawk Inlet. If DEC discovers — through review of permit-required reporting, the TMDL review or some other means — that the environment in Hawk Inlet has not been protected, it is incumbent on the department to evaluate the cause(s), possibly re-evaluate the permit conditions and possibly establish a TMDL that limits the chemical loading of contaminants into the waterbody to ensure that the uses of the waterbody are protected.

Within the Greens Creek Mine loading dock area, monitoring natural recovery processes from the ore spill is recommended. Monitored natural recovery is a remedy that uses ongoing, natural processes to contain, destroy, or reduce the contaminant toxicity or contaminants available to be absorbed by living organisms in the sediments. Monitored natural recovery is often the remedy of choice when removing the contaminant would be more disruptive to the environment; for example, the physical action of removing the contaminants could release contaminants into the water column. Continuing monitoring efforts in Hawk Inlet are recommended to determine whether natural recovery is occurring in the loading dock area, and metals concentrations are continuing to decrease over time. Monitoring will allow ADEC to track changes in the water and sediment, and determine whether acceptable progress is being made. If natural recovery does not result in decreased metal concentrations and meeting the TMDL targets, then capping or other options such as targeted removal will be investigated. In addition, continued management of Greens Creek Mine shipping and docking operations to prevent future spills, restrictions on future development activity, and recording the contamination left in place in the property deed ensure that marine sediments are not disturbed. The TMDL report will evaluate and provide recommendation for monitoring of water, sediment, and tissue (shellfish and worm) samples within Hawk Inlet to provide necessary data that will be used to determine whether water quality continues to meet state standards, and whether there are impacts to the water uses, including subsistence.

Please feel free to contact the Department of Health and Social Services Environmental Public Health Program (Ali Hamade at 907-269-8086) if you have further questions regarding traditional food safety and human health. Please contact the Department of Environmental Conservation Division of Water (Allan Nakanishi at 907-269-4028) with further questions about the source of the metals, safety to the eco-system, and what the State may do to mitigate hazards if they are found.

Sincerely,

Michelle Hale
Director, Division of Water, DEC

Jay C. Butler, M.D.
Chief Medical Officer, Department of Health and Social Services
Director, Division of Public Health

CC:
Larry Hartig, DEC, Commissioner
Valerie Davidson, DHSS, Commissioner
Sam Cotten, DFG, Commissioner
Ed Fogels, DNR, Deputy Commissioner

Robert Blankenburg, DEC, Division of Environmental Health, Director (acting)
Joseph McLaughlin, DHSS, Division of Public Health, Chief Epidemiologist
Dave Rogers, DFG, Division of Habitat, Director
Jackie Timothy, DFG, Division of Habitat, Southeast Regional Supervisor

Table 1: Metals Concentrations (mg/kg wet weight) in Shellfish and Seaweed (Friends, 2015).

Element	Clams	Cockles	Mussels	Crab	Shrimp	Seaweed*
Total Arsenic	7	3.33	2.67	4	7	3
Cadmium	0.29	0.23	1.04	1.07	0.13	0.19
Chromium	1	0.9	1.23	0.6	0.5	0.28
Copper	4.42	3.04	8.36	10.4	11.9	0.83
Lead	0.4	0.93	0.87	0.8	0.4	0.4
Manganese	1.36	2.23	3.05	1.52	2.65	6.28
Mercury	0.009	0.01	0.01	0.029	0.032	0.005
Nickel	0.7	0.77	1.2	0.5	0.3	0.55
Selenium	1	2.33	1.67	2	1	1
Silver	2.68	0.22	0.06	0.3	0.47	0.06
Zinc	16.4	14.9	20.73	32.4	15	3.88

- mg/kg = milligrams per kilogram

- Seaweed contaminant concentrations from *Porphyra* and *Fucus* spp were averaged assuming mixed consumption of these species.

Table 2. Inorganic Arsenic Concentrations (mg/kg wet weight) in Shellfish and Seaweed (Friends, 2015).

Element	Clams	Cockles	Mussels	Crab	Shrimp	Seaweed*
Arsenic	0.07	0.033	0.027	0.04	0.07	0.03

- Inorganic arsenic was considered to be 1% of total

- Seaweed contaminant concentrations from *Porphyra* and *Fucus* spp were averaged assuming mixed consumption of these species.

Table 3. Equation to Assess Exposure from Ingestion of Shellfish and Seaweed.

Exposure Pathway: Ingestion of Shellfish and Seaweed **Equation*: Dose (mg/kg/day) = (C x IR x AF) / BW** Source: ATSDR, 2005				
Parameter	**Parameter Definition**	**Units**	**Value**	**Reference/ Reason**
C	Contaminant Concentration	mg contaminant/kg shellfish or seaweed (mg/kg)	Table 1	Friends, 2015
IR	Intake Rate of clams or seaweed	kg shellfish or seaweed/day (kg/day)	Clams, 0.0096 Cockles, 0.0077 Mussels, 0.0023 Crab, 0.0127 Shrimp, 0.0031 Seaweed (average of Porphyra and Fucus spp), 0.0065	ADF&G, 2012$^{\alpha}$
AF	Bioavailability Factor**	Unitless	1	Dose is compared to CV. No additional bioavailability considerations
BW	Body Weight	kg	Adult = 80 Child (1-6 yrs) = 16	Adult and Child, ATSDR, 2014

mg/kg/day = milligrams per kilogram body weight per day, kg = kilogram

*For children, the dose, D, was multiplied by a body weight multiplier, $Multiplier_{BW}$:

$Multiplier_{BW}$ (unitless) = Child Body Weight (kg)/ Adult Body Weight (kg) (EPA, 2000); Results for children were generally not different between children and adults except for lead. Therefore the only child outcomes presented are those for lead (Table 7).

**The bioavailability factor represents, as a percent, the total amount of a substance ingested, inhaled, or contacted that actually enters the bloodstream and is available to possibly harm a person. Typically, the bioavailability factor is assumed to be 1 (100%) for screening purposes. That is, all of a substance to which a person is exposed is assumed to be absorbed.

α = Proxy consumption rates (or how much people eat) for shellfish and seaweed from yearly harvest data available from the ADF&G Community Subsistence Information System. EPHP used the most recent data collected by ADF&G for the year 2012.

Table 4. Gastrointestinal (Gut) Absorption Factors Used in Calculations

Analyte	Absorption Factor	Source[11]
Arsenic	0.95	EPA, 2004
Cadmium	0.025	EPA, 2004
Chromium	0.025	EPA, 2004
Copper	0.71	Turnlund, 1998
Lead	**	EPA, 2010
Manganese	0.04	EPA, 2004
Mercury	0.95	EPA, 2004
Nickel	0.04	EPA, 2004
Selenium	0.8	EPA, 2004
Silver	0.04	EPA, 2004
Zinc	1	EPA, 2004

**For lead, EPHP used the default absorption factors for each media in the EPA Integrated Exposure Uptake Biokinetic (IEUBK) model.

[11] - EPA, 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)
- EPA, 2010. Integrated Exposure Uptake Biokinetic Model for Lead in Children
- Turnlund, 1998. Copper absorption, excretion, and retention by young men consuming low dietary copper determined by using the stable isotope ^{65}Cu. The American Journal of Clinical Nutrition. 67:1219–25.

Table 5. Calculated Adult Noncancer Exposure Doses and Risks for Metal Contaminants

	Dose (mg/kg/d)						Comparison Value (Noncancer) (mg/kg/d)	CV Source	Hazard Quotient$^{\beta}$	Contaminant of Concern (COC)
	Clams	Cockles	Mussels	Crab	Shrimp	Seaweed				
Arsenic#	1.2E-05	3.1E-06	7.4E-07	6.1E-06	2.6E-06	2.3E-06	0.0003	ATSDR chronic MRL	<1 for all species	No
Cadmium	1.2E-06	5.5E-07	7.6E-07	4.3E-06	1.3E-07	3.9E-07	0.0001	ATSDR chronic MRL	<1 for all species	No
Chromium†	4.3E-06	2.2E-06	9.0E-07	2.4E-06	4.9E-07	5.6E-07	1.5	EPA RfD	<1 for all species	No
Copper	5.4E-04	2.1E-04	1.7E-04	1.2E-03	3.3E-04	4.8E-05	0.12	NAS IOM $^{\alpha}$	<1 for all species	No
Lead	*	*	*	*	*	*	*	N/A	<1 for all species	No
Manganese	9.4E-06	8.6E-06	3.6E-06	9.7E-06	4.1E-06	2.0E-05	0.15	NAS IOM $^{\alpha}$	<1 for all species	No
Mercury	1.5E-06	9.2E-07	2.8E-07	4.4E-06	1.2E-06	3.8E-07	0.00056	ATSDR chronic MRL	<1 for all species	No
Nickel	4.8E-06	3.0E-06	1.4E-06	3.2E-06	4.7E-07	1.8E-06	0.016	NAS IOM $^{\alpha}$	<1 for all species	No
Selenium	1.4E-04	1.8E-04	3.9E-05	2.6E-04	3.1E-05	6.5E-05	0.0075	NAS IOM $^{\alpha}$	<1 for all species	No
Silver	1.8E-05	8.5E-07	7.0E-08	1.9E-06	7.3E-07	1.9E-07	0.005	EPA RfD	<1 for all species	No
Zinc	2.8E-03	1.4E-03	6.0E-04	5.2E-03	5.8E-04	3.1E-04	0.59	NAS IOM $^{\alpha}$	<1 for all species	No

* see Table 7

$^{\alpha}$ = Tolerable Upper Intake Limit

1% Inorganic arsenic content

$^{\beta}$ =A hazard quotient <1 indicates that no appreciable health risk is anticipated from this exposure. A hazard quotient >1 suggests that there might be an elevated health risk, although no adverse health effects may occur.

† EPHP assumed all chromium in shellfish and seaweed at Hawk Point to be trivalent chromium, because hexavalent chromium rapidly reduces to trivalent chromium once in contact with clam tissue or plant tissue, as hexavalent chromium is highly reactive and will generally be reduced in the presence of organic matter and cellular molecules (Debetto et al., 1988; Petrilli and De Flora, 1988). The National Academy of Sciences Institute of Medicine also states that hexavalent chromium is generally not found in food (NAS, 2001).

- Body weight, BW for adult = 80 kg; MRL = Minimal Risk Levels for chronic oral intake; EPA RfD = Environmental Protection Agency Reference Dose; Hazard quotient = site mean dose/comparison value. NAS IOM=National Academy of Sciences Institute of Medicine.

- Dose is based on proxy consumption rates (or how much people eat) for shellfish and seaweed from yearly harvest data available from the ADF&G Community Subsistence Information System. EPHP used the most recent data collected by ADF&G for the year 2012 (Table 3). 95th percentile harvest data (based on households consuming more than 95% of the rest of the community) were used for noncancer calculations.

Table 6. Calculated Cancer Risks for Arsenic from Shellfish and Seaweed

Source	Dose (mg/kg/d)	Slope Factor	Estimated Excess Cancer Risk
Clams	7.9E-06	1.5	9.8E-06
Cockles	3.1E-06	1.5	3.8E-06
Mussels	7.4E-07	1.5	9.2E-07
Crab	3.9E-07	1.5	4.9E-07
Shrimp	2.6E-06	1.5	3.2E-06
Seaweed	2.3E-06	1.5	2.9E-06

Cancer risks were calculated using the following equations:

Calculated possible cancer risk (individual contaminant) = AF x Chronic Daily Dose × CSF

Where,
- AF = Absorption Factor, or how much contaminant is absorbed by the body (0.95 for arsenic)
- Chronic Daily Dose = Amount of contaminant ingested daily on a chronic basis per kilogram body weight. Median harvest rate estimates were used for cancer calculations.
- CSF = Cancer Slope Factor

Exposure duration of 65 years was used for the time span of ingestion of these foods.

Dose is based on proxy consumption rates (or how much people eat) for shellfish and seaweed from yearly harvest data available from the ADF&G Community Subsistence Information System. EPHP used the most recent data collected by ADF&G for the year 2012 (Table 3). 50th percentile harvest data (based on households consuming more than 50% of the rest of the community) were used for cancer calculations.

Table 7. Lead Results from IEUBK Model*

Species	Lead concentration (mg/kg)	% Above 5 µg/dL
Cockles	0.93	0.247
Clams	0.4	0.009
Mussels	0.87	0.188
Crab	0.8	0.133
Shrimp	0.4	0.009
Seaweed	0.4	0.009
Average of all Seafood	0.6	0.042

* Default values for EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model parameters were used in the calculations except that the lead levels in both water and soil were set to zero. We assumed that shellfish comprised 15% of all seafood consumed for the model's diet parameter.

EPHP calculated potential lead exposure by using EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model (EPA, 2010). There is no CV for lead. The CDC uses a reference value of 5 µg/dL for children under 6 years of age and EPHP uses this same level for all children under 18. In the past, the level of concern was 10 µg/dL of lead in blood. The new lower value means that more children will likely be identified as having lead exposure that warrant action allowing parents, doctors, public health officials, and communities to act earlier to reduce the child's future exposure to lead.

Table 8: Metals Concentrations (mg/kg wet weight) in Seal (Friends, 2015).

Element	Seal Tissue			
	Fat	Muscle	Liver	Kidney
Arsenic	1*	1*	1*	1*
Cadmium	0.04*	0.04*	4.31	12.3
Chromium	1.5	0.1*	0.1*	0.2
Copper	9.29	2.08	19.2	7.99
Lead	0.9	0.4*	0.4*	0.5
Manganese	0.6	0.16	3.39	0.83
Mercury	0.057	2.18	222	6.3
Nickel	0.7	0.2*	0.2*	0.2*
Selenium	1*	1*	82	3
Silver	0.06*	0.06*	0.45	0.06*
Zinc	8.4	21.1	58.9	38.6

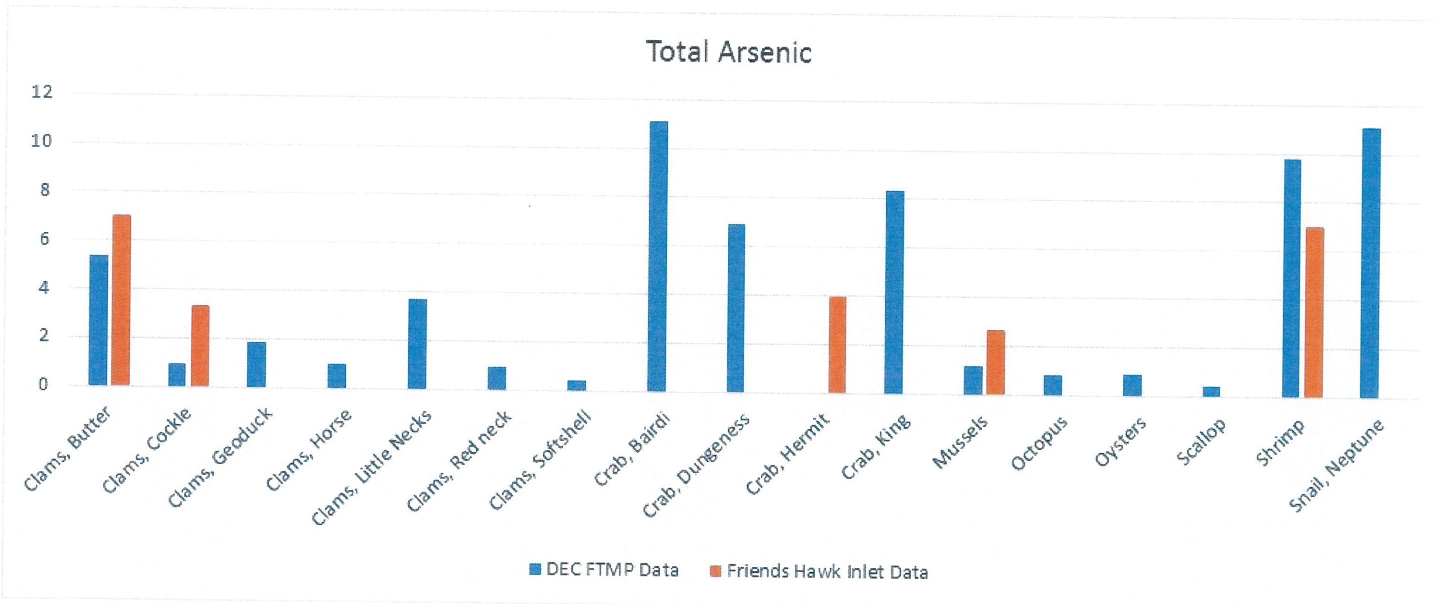
mg/kg = milligrams per kilogram

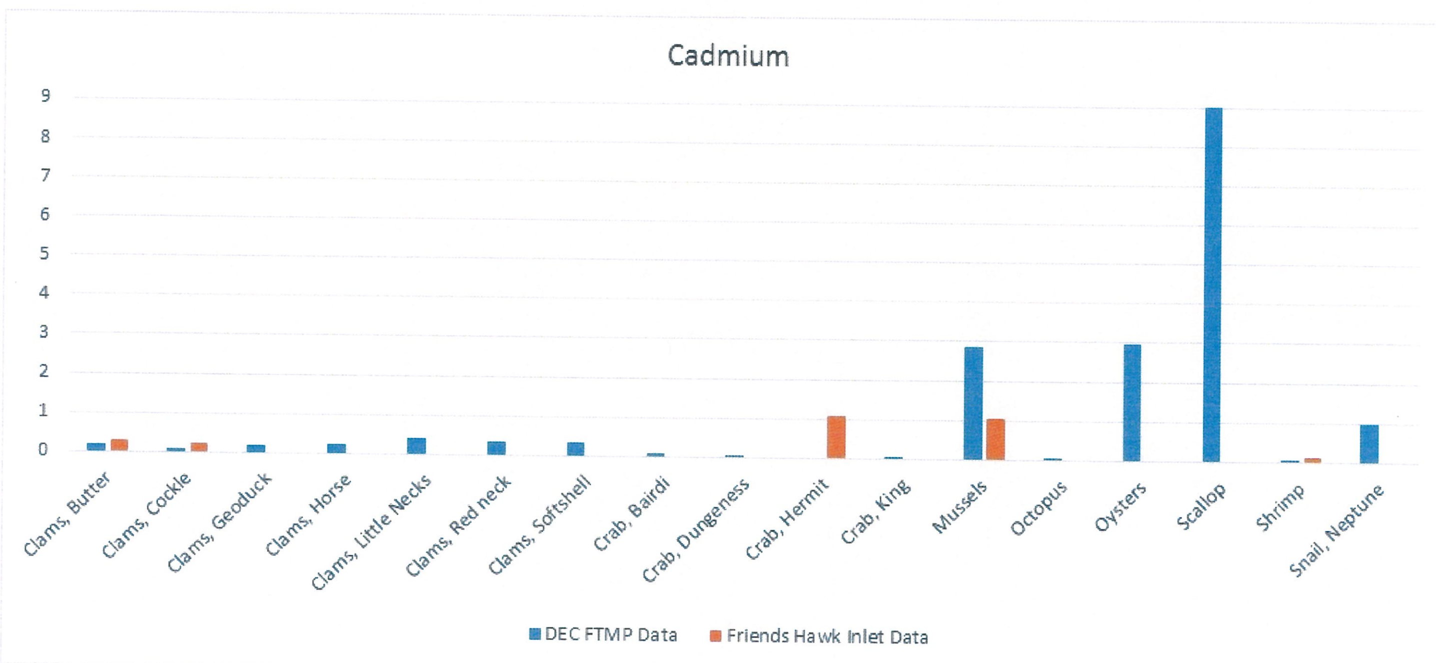
*LOQ, Limit of Quantification or the lowest concentration that the testing lab could detect. Therefore, the actual concentration is between zero and this number.

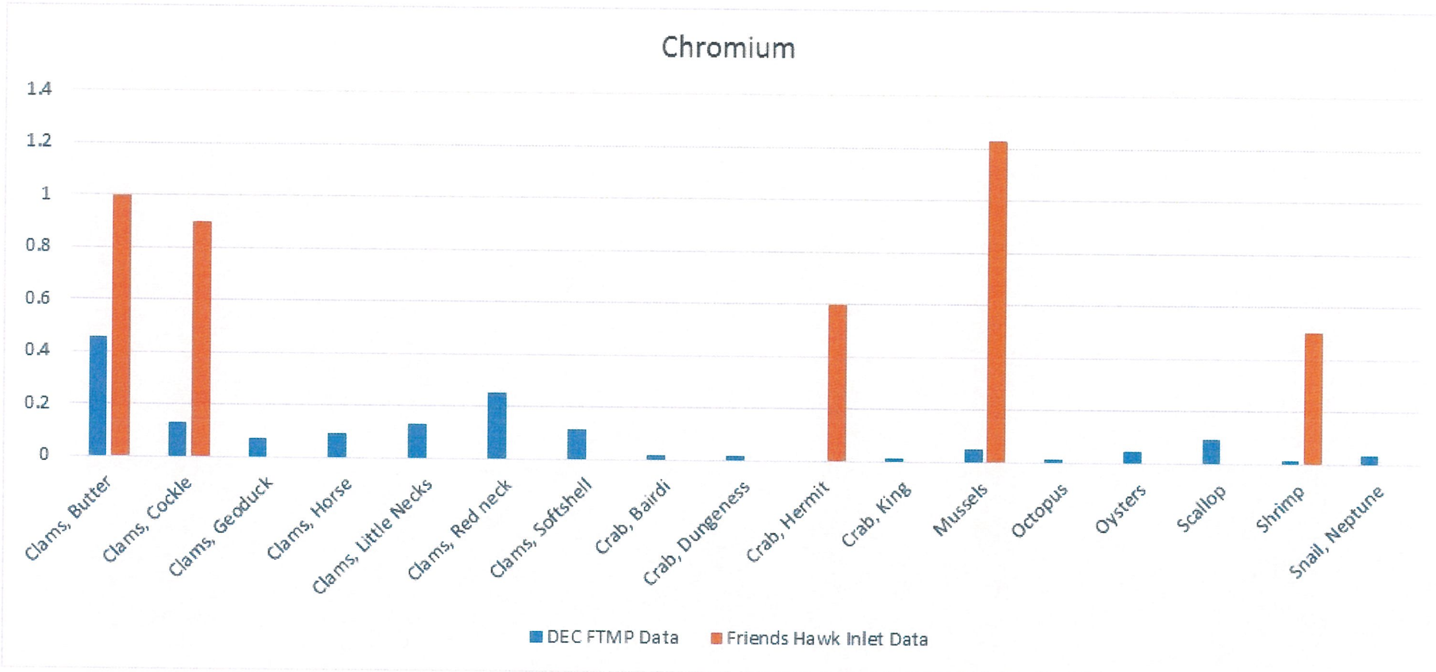
Appendix

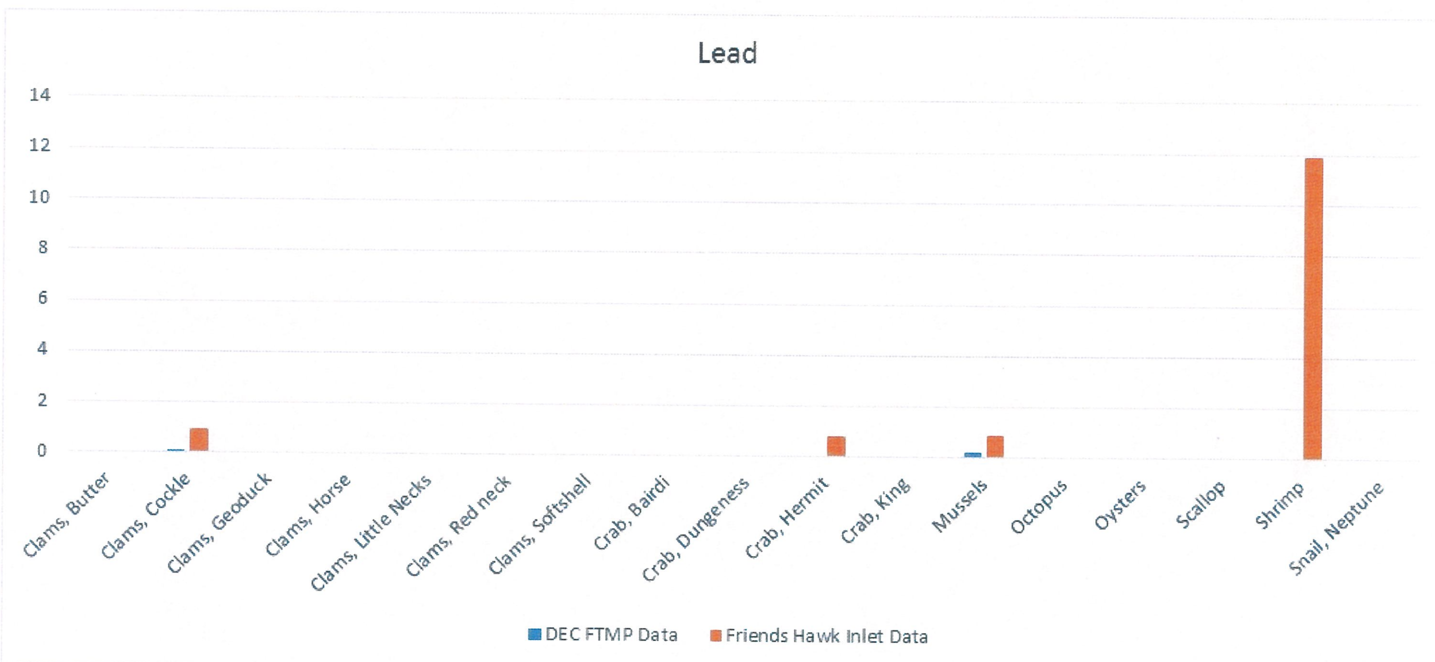
DEC Fish Tissue Monitoring Program Data (FTMP) and Friends Hawk Inlet Report Data Comparison

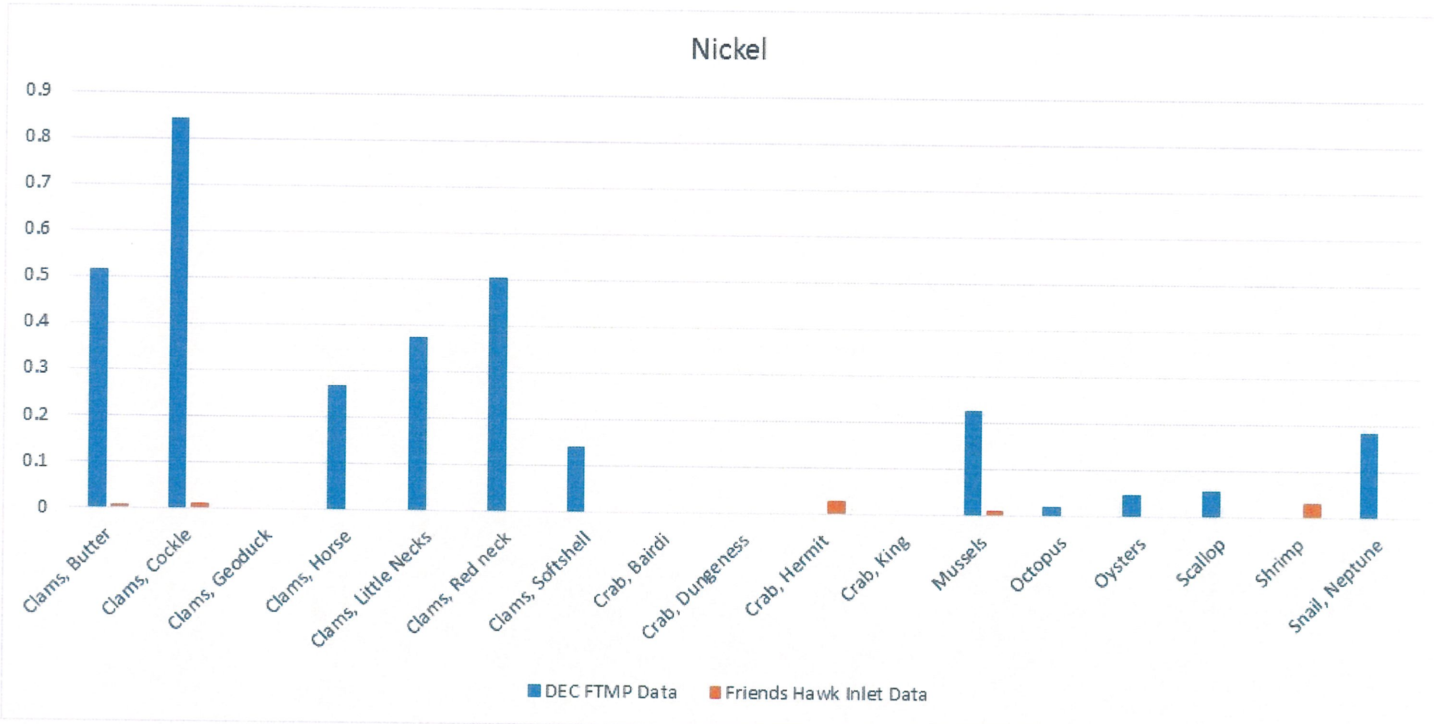
<u>Legend</u>
Concentration of trace metals presented as mg/kg wet weight
Blue Bars = DEC Fish Tissue Monitoring Program (FTMP) Data
Orange Bars = Friends Hawk Inlet Report - Edible Marine Species Data.

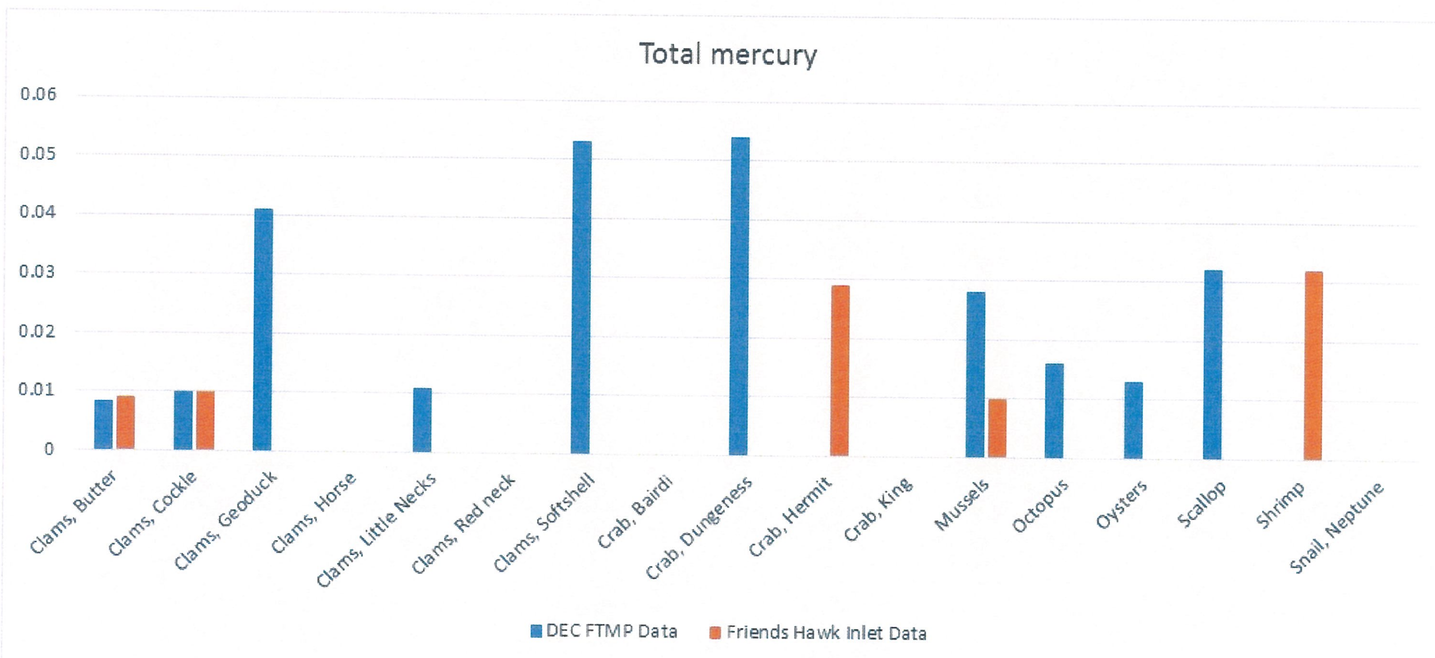





Chromium
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Clams, Butter
Clams, Cockle
Clams, Geoduck
Clams, Horse
Clams, Little Necks
Clams, Red neck
Clams, Softshell
Crab, Bairdi
Crab, Dungeness
Crab, Hermit
Crab, King
Mussels
Octopus
Oysters
Scallop
Shrimp
Snail, Neptune
DEC FTMP Data
Friends Hawk Inlet Data


Lead
14
12
10
8
6
4
2
0
Clams, Butter
Clams, Cockle
Clams, Geoduck
Clams, Horse
Clams, Little Necks
Clams, Red neck
Clams, Softshell
Crab, Bairdi
Crab, Dungeness
Crab, Hermit
Crab, King
Mussels
Octopus
Oysters
Scallop
Shrimp
Snail, Neptune
DEC FTMP Data
Friends Hawk Inlet Data


Nickel
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Clams, Butter
Clams, Cockle
Clams, Geoduck
Clams, Horse
Clams, Little Necks
Clams, Red neck
Clams, Softshell
Crab, Bairdi
Crab, Dungeness
Crab, Hermit
Crab, King
Mussels
Octopus
Oysters
Scallop
Shrimp
Snail, Neptune
DEC FTMP Data
Friends Hawk Inlet Data


Total mercury
0.06
0.05
0.04
0.03
0.02
0.01
0
Clams, Butter
Clams, Cockle
Clams, Geoduck
Clams, Horse
Clams, Little Necks
Clams, Red neck
Clams, Softshell
Crab, Bairdi
Crab, Dungeness
Crab, Hermit
Crab, King
Mussels
Octopus
Oysters
Scallop
Shrimp
Snail, Neptune
DEC FTMP Data
Friends Hawk Inlet Data