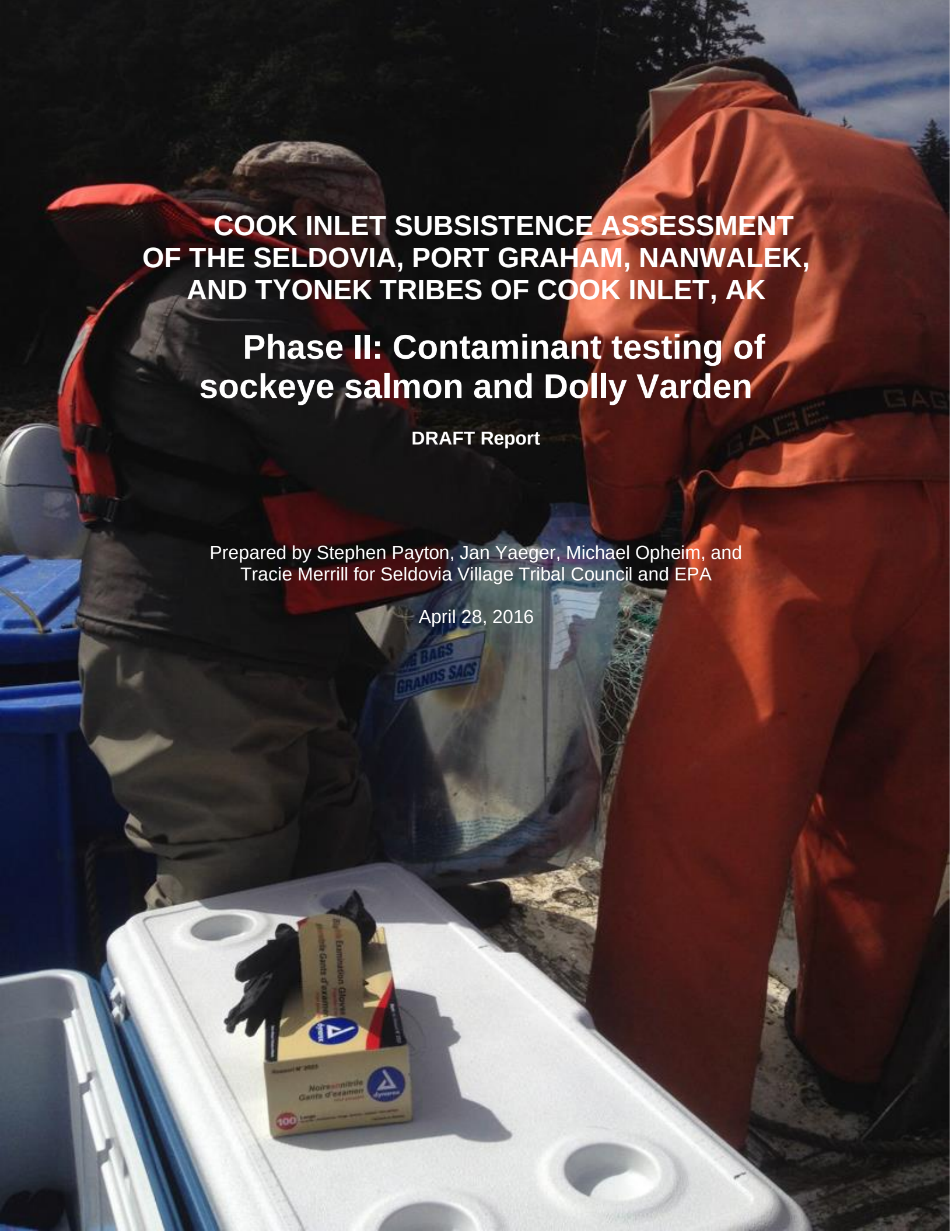

COOK INLET SUBSISTENCE ASSESSMENT OF THE SELDOVIA, PORT GRAHAM, NANWALEK, AND TYONEK TRIBES OF COOK INLET, AK

Phase II: Contaminant testing of sockeye salmon and Dolly Varden

DRAFT Report

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List of Acronyms

ADD	Average Daily Dose
ADEC	Alaska Department of Environmental Conservation
As	Arsenic
AT	Averaging Time
ATSDR	Agency for Toxic Substances and Disease Registry
BW	Body Weight
°C	Celsius
C	Chemical Concentration
Cd	Cadmium
CIRCAC	Cook Inlet Regional Citizens Advisory Council
cm	Centimeter
CRRC	Chugach Regional Resource Commission
Cu	Copper
DDT	Dichlorodiphenyltrichloroethane
ED	Exposure Duration
EHL	Environmental Health Laboratory
EPA	U.S. Environmental Protection Agency
°F	Fahrenheit
FDA	U.S. Food and Drug Administration
FTMP	Fish Tissue Monitoring Program
g	Gram
GPS	Global Positioning System
HCH	Hexachord-Cyclohexane
Hg	Mercury
IGAP	Indian General Assistance Program
IPHC	International Pacific Halibut Commission
IR/CR	Ingestion Rate/ Consumption Rate
IRA	Indian Reorganization Act
IRIS	Integrated Risk Information System
kg	Kilogram
km	Kilometer
mg	Milligram
mg/kg/day	Milligrams Per Kilogram Per Day
mm	Millimeter
MMS	Mineral Management Service
ng	Nanogram
NOAA	National Oceanic and Atmospheric Association
NPRB	North Pacific Research Board
NS&T	National Status and Trend Program
NWFSC	Northwest Fisheries Science Center
PAH	Polycyclic Aromatic Hydrocarbon
Pb	Lead
PBDE	Polybrominated Diphenyl Ethers
PCB	Polychlorinated Biphenyl

pg	Picogram
POP	Persistent Organic Pesticide
QAPP	Quality Assurance Project Plan
RfD	Reference Dose
RL	Reporting Limit
Se	Selenium
SOP	Standard Operating Procedure
SVT	Seldovia Village Tribe
µg	Microgram

Abstract

In 2015, Seldovia Village Tribe (SVT) staff, along with personnel contracted from the Cook Inlet communities of Seldovia, Port Graham, Nanwalek, and Tyonek, collected a total of 36 sockeye salmon whole-body tissue samples and 35 Dolly Varden whole-body tissue samples from local fishing areas around the four communities. Tissue samples were analyzed for total mercury, selenium, copper, lead, cadmium, PCB congeners, PBDEs, and organochlorine pesticides through partnership with the Alaska Department of Environmental Conservation (ADEC)'s Fish Tissue Monitoring Program. Average contaminant levels in samples collected as part of this project showed no metals exceeding FDA action levels or EPA chronic consumption thresholds, although two Dolly Varden samples from Seldovia did exceed reporting limits for lead. None of the samples had levels of PCB congeners, PBDEs, or organochlorine pesticides that exceeded EPA or FDA limits. Dolly Varden fillets sampled from Nanwalek, Port Graham, and Tyonek had higher average levels of metals than sockeye fillets, with the exception of Seldovia sockeye. Whole-body samples of sockeye had higher levels of metals on average compared to whole-body Dolly Varden.

Acknowledgements

Seldovia Village Tribe sincerely thanks the Environmental Protection Agency (EPA) for funding this project under an Indian General Assistance Program (IGAP) Unmet Needs grant, and the Alaska Department of Environmental Conservation (ADEC) for funding shipping and testing of samples at their Environmental Health Laboratory in Anchorage, Alaska, and at AXYS Analytical Services in Sidney, British Columbia. We also thank the tribes who participated in this project; the tribal environmental staffs of Port Graham, Nanwalek, and Tyonek; and the people who obtained fish samples in the communities of Seldovia, Port Graham, Nanwalek, and Tyonek. Without all this support, the work could not have been completed.

Introduction

Salmon are a food resource critical to the cultural, spiritual, economic, and physical well-being of the members of Cook Inlet-area tribes. Cook Inlet stretches 180 miles (290 km) from the Gulf of Alaska to Anchorage in south-central Alaska. This large tidal estuary covers about 100,000 km² of southern Alaska, and lies east of the Aleutian Range and south of the Alaska Range. At least 200 rivers and streams important to anadromous fishes empty into Cook Inlet. For thousands of years, Native Alaskans have relied on the rich diversity and abundance of animals and plants in the Cook Inlet basin.

Seldovia Village Tribe is one of 229 federally-recognized tribes and Native villages in Alaska. The name “Seldovia” is derived from "*zaliv seldevoy*," a Russian term meaning "herring bay.” Seldovia is located close to Port Graham and Nanwalek, on the south shore of Kachemak Bay on the Kenai Peninsula. Seldovia is a community of approximately 420 people, of which 28.8% are American Indian and/or Alaska Native (US Census 2010). Historically, the Seldovia area was a meeting and trading place for the Kodiak Koniaqs, the Aleuts from the Aleutians, the Chugach people from Prince William Sound, and the Dena’ina people of Cook Inlet. They traveled over land and across the sea to make their home near Kachemak Bay. Speaking Sugpiaq, Aleut, and Dena’ina, they traded goods, ideas, and regional traditions. This confluence of cultures gave rise to a tradition of subsistence from the sea and land that continues to this day. Mining, fox farming, logging, and fishing were major industries conducted in Seldovia between the 1800s and mid-1900s. Salmon has played a vital role in the survival of the Seldovia people for many generations. There is a tradition of caring for neighbors, family and friends by providing them with fish. When the salmon are running, fish may be eaten three times a day, and in between meals tribal members are busy catching more fish.

Port Graham, home to a sovereign, federally-recognized tribe, is a rural, predominately Native village. Located 225 miles southwest of Anchorage, the village lies close to the southern tip of the Kenai Peninsula. The population is approximately 177, of which 90.4% are American Indian and/or Alaska Native (US Census 2010). Most of these Sugpiat, or “real people”, of the Chugach region trace their roots and heritage to Prince William Sound and the Gulf of Alaska. Like many rural villages in Alaska, Port Graham is heavily dependent on traditional ways of life. A vast knowledge of natural resources and the environment has been passed from generation to generation and is a major component of the Native culture. Traditional ways of life are ingrained in their very existence; their lives and culture literally depend on the health of traditional resources.

Nanwalek, formerly known as English Bay, is a small, Native village close to the southern tip of the Kenai Peninsula, about 28 miles southwest of Homer, ten miles southwest of Seldovia and four miles east of Port Graham. Nanwalek is governed by the federally-recognized Nanwalek IRA Council. The word “Nanwalek” means “place with a lagoon”. Approximately 254 people live in Nanwalek, of which 89.4% are American Indian and/or Alaska Native (US Census 2010). The beautiful village sits in an area surrounded by Mount St. John and Mount Bede, and overlooks the lower Cook Inlet. There is a reef that people can walk out on during low tide. This bountiful environment offers the people who live there an unending source of food. Almost everything from the ocean is edible. The people of Nanwalek harvest wild foods such as seaweed, five species of salmon, butter clams, cockles, lady slippers, bidarkis (chitons), snails, China caps, mussels, steamer clams, sea cucumber, tomcod, octopus, halibut, seal, sea lion, bass, cod, fish eggs, and waterfowl. The Native people of this

village have used these food sources for centuries, and they still depend heavily on them. Ancestors lived off the land and passed their knowledge of how to prepare and preserve foods down through generations. Nanwalek is fortunate to have the traditions of food and culture, and to have people that keep this knowledge alive today. The people of Nanwalek, as in many other communities that live and depend on the ocean for food, find it very important to keep the ocean, air, and land as clean as possible.

Tyonek lies on a bluff on the northwest shore of Cook Inlet, 43 miles southwest of Anchorage. Approximately 171 people reside there, of which 94.7% are American Indian and/or Alaska Native (2010 US Census). The Native Village of Tyonek is a federally-recognized tribe located in the community. Tyonek's traditional name is "Tubughnenq'", and the people of Tyonek, known as "Tebughna", or "the beach people", have lived there for at least a thousand years. A subsistence lifestyle is practiced in Tyonek. Subsistence activities provide salmon, moose, beluga whale, and waterfowl. Their tribe has taught for generations to respect and protect their lands and resources, because the land and animals are the ones that feed and help them survive. Tyonek is a fishing community. Net fishing in Cook Inlet has been the way of life for thousands of years. Salmon is an important ingredient in their community potlatches, holiday feasts, and activities. Salmon is the first solid food for their babies, and parents let them gnaw on smoked fish (*biliek*) when they start teething or just as something to chew on. Fish is always kept in their freezers for wintertime when the times become difficult.

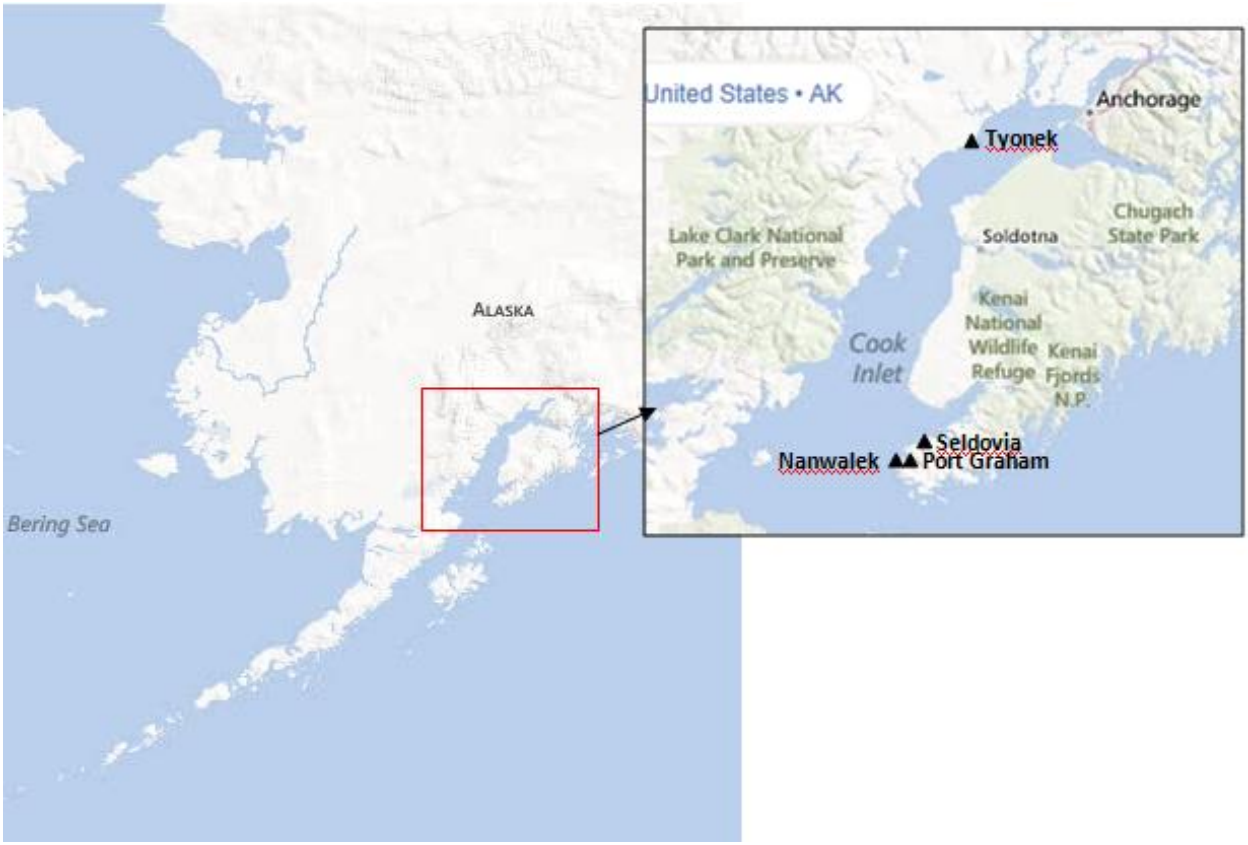


Figure 1. Map of Cook Inlet

Development and oil and gas activities occurring in upper Cook Inlet have raised great concerns over contaminants in traditional foods harvested within Cook Inlet, and the risk these contaminants pose to human health. Tyonek, the most northerly community in this study, is located within ten miles of the nearest oil and gas operations. The other three communities are much more distant: Seldovia is approximately 117 miles away, while Port Graham and Nanwalek are about 128 miles away (US EPA 2000, 2003, as cited in ATSDR 2009).

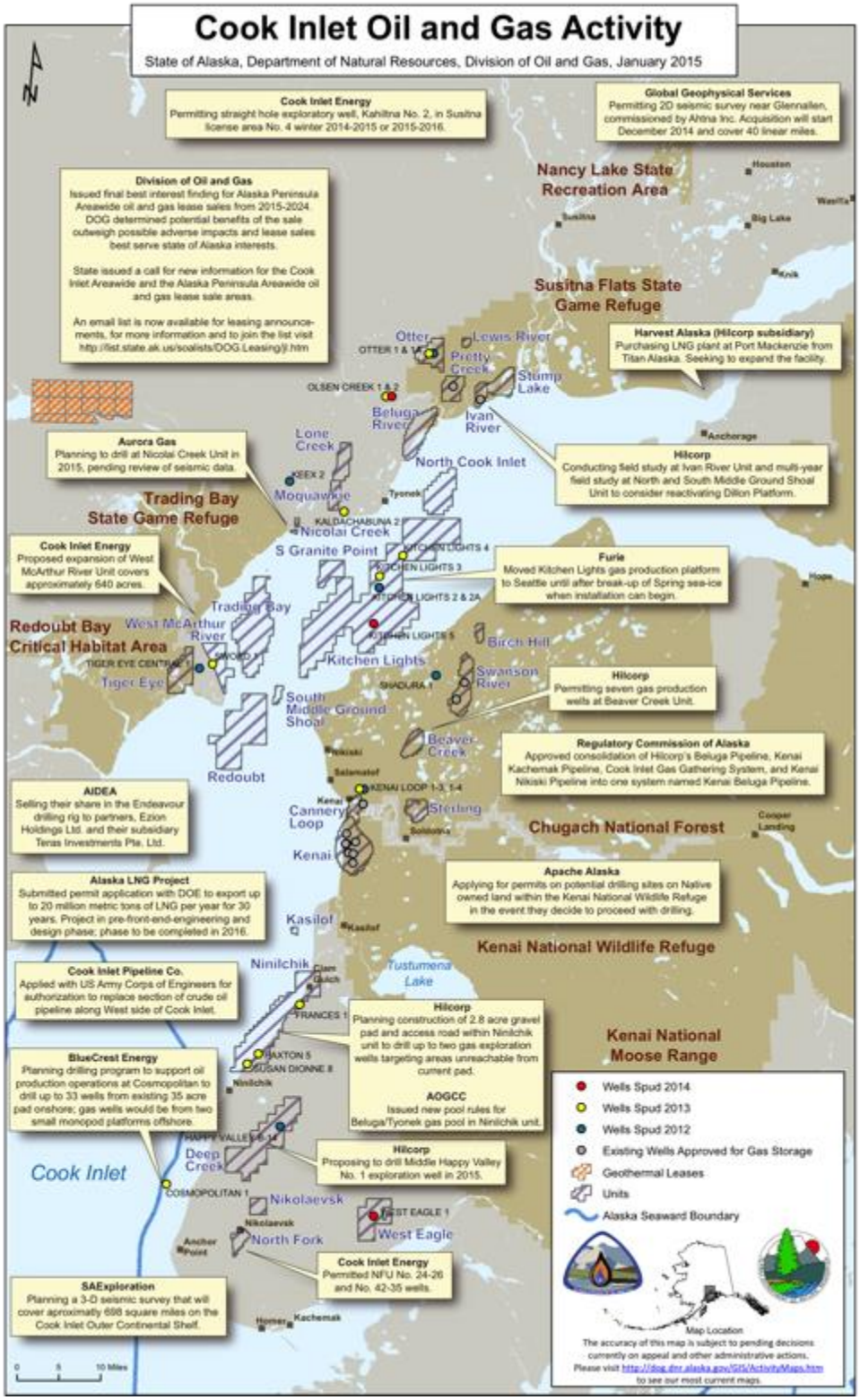


Figure 2. *Map of oil and gas activity in Cook Inlet*

Some of the Cook Inlet oil platforms have the capacity to separate and treat production fluids (oil, gas, and water) and wastewater at the platforms and directly discharge the production water into Cook Inlet. Production fluids from the remaining platforms are piped to one of three on-shore facilities (Granite Point, Trading Bay, or East Foreland) for separation and treatment, and then discharged to Cook Inlet (either directly from the on-shore facilities or piped back to a platform for discharge) (US EPA 1996 as cited in ATSDR 2009). Treated wastewaters and drilling mud are the main sources through which contaminants generated from these operations enter Cook Inlet (ATSDR 2009). Some of these contaminants include oil, grease, mercury, cadmium, barium sulfite, and chemical additives such as flocculants, oxygen scavengers, biocides, cleansers, and scale corrosion inhibitors. It is estimated that 253 tons of oil are discharged into Cook Inlet from treated wastewaters each year (MMS 2003, as cited in ATSDR 2009). Additionally, persistent organic pollutants (POPs) such as pesticides, industrial chemicals, and unintended industrial by-products have been found across the globe and can travel great distances from their source of origin. They are known to have a wide variety of harmful impacts to the environment, wildlife, and human health. Limited sampling of Alaskan fishes for POPs has not found levels of concern, but questions about the safety of eating fish from the North Pacific still arise. Although contaminant levels in anadromous fish cannot necessarily be correlated with local sources of contaminants, anyone who eats fish is still potentially impacted by contaminants present in the fish, regardless of the source. Due to these concerns, SVT, as well as other Cook Inlet-area tribes, participated in two contaminant testing studies of traditional foods prior to this project:

1) Assessment of contaminant body burdens and histopathology of fish and shellfish species frequently used for subsistence food by Alaskan Native communities (North Pacific Research Board - Project-1019; July 1, 2010 - February 28, 2013*)*. This project was a collaborative effort of the Chugach Regional Resources Commission (CRRC), the Alutiiq Pride Shellfish Hatchery, the NOAA National Status and Trend (NS&T) Program, and the Northwest Fishery Science Center (NWFSC). This study examined sockeye and chum salmon, littleneck clams and cockles. These species were selected because they are widely used as subsistence foods by Chugach-area Alaska Natives. Samples were collected by members of the Nanwalek, Port Graham and Seldovia communities from their traditional subsistence harvest areas, with training and assistance from NOAA scientists. Metals tested for included silver, arsenic, cadmium, chromium, copper, iron, lead, mercury, manganese, nickel, selenium and zinc. Organic contaminants tested for included chlordanes, DDT, dieldrin, chlorobenzenes, chlorpyrifos, hexachlorohexanes, endosulfans, PCBs and mirex.

2) Evaluation of seafood and plant data collected from Cook Inlet near the native villages of Port Graham, Nanwalek, Seldovia, and Tyonek, Alaska - Agency for Toxic Substances and Disease Registry (ATSDR)-2009. In 1997, EPA collected and analyzed metal and POP concentrations in whole fish, mussels and clams,

other invertebrates (i.e. snails, chitons, and octopi) and plants from Cook Inlet. In a separate 2002 study, ADEC collected 65 fish from lower Cook Inlet between June and August 2002. Species sampled included Pacific cod, chinook salmon, pink salmon, chum salmon, sockeye salmon, coho salmon, pollock, and halibut. Forty-seven fish were analyzed for heavy metals, using roasts from the halibut and skinless fillets from other species.

There have also been other contaminant studies done on fish and shellfish in Cook Inlet that tribes have not actively been involved in. For example, the Alaska Department of Environmental Conservation (ADEC) developed a Fish Tissue Monitoring Program in 2001 to analyze a wide variety of chemical contaminants (methylmercury, total mercury, nickel, chromium, arsenic, selenium, copper, lead, cadmium, dioxins, furans, organochlorine pesticides, PCB congeners and brominated fire retardants) in fish from Alaska. This program involves a large collaborative effort by biologists from the Alaska Department of Fish and Game, the U.S. National Oceanic and Atmospheric Agency (NOAA), the International Pacific Halibut Commission (IPHC) and fishermen. Samples from a variety of fish species, including salmon, are collected from marine waters, rivers, and lakes throughout the state.

Support Data for Fish Collected for Organics Analysis in the Fish Tissue Testing Program, 2001-2012

	Aleutians	Bering Sea	Bristol Bay	Cook Inlet	GOA	PWS	SE	FW-Arc	FW-Int	FW-SC	FW-SW
Pacific Halibut	17				19	4	21				
Pacific Cod	20										
Sablefish					19		20				
Walleye Pollock		4	12								
Dusky Rockfish	15										
Capelin		1									
Eulachon				7							
Pacific Herring		1		10							
Sand Lance		1									
Salmon Shark					1	7					
Sleeper Shark				1							
Chinook Salmon		7	7	6			8		35	6	
Sockeye Salmon			6		27		18			6	16
Coho Salmon						11	107			18	
Chum Salmon		6	15			2	26		3		6
Pink Salmon						10	14			10	
Arctic Char										1	
Dolly Varden										1	
Lake Trout											11
Humpback Whitefish											2
Sheefish								8			
Northern Pike											10

GOA: Gulf of Alaska
PWS: Prince William Sound
SE: Southeast Alaska
FW-Arc: Freshwater, Arctic
FW-Int: Freshwater, Interior (Yukon Drainages)
FW-SC: Freshwater, Southcentral Alaska, including Kodiak Island
FW-SW: Freshwater, Southwest Alaska, including Bristol Bay and Kuskokwim drainages

Non-detetects in the Organic Results Tables are treated as 1/2 the detection limit when calculating compound concentrations
Chlordanes are cis-, trans-, and oxychlordane, and cis- and trans-nonachlor
DDT is 2,4-DDD, 4,4-DDD, 2,4-DDE, 4,4-DDE, 2,4-DDT, and 4,4-DDT,
Lindane-HCH is Alpha, beta, delta, and gamma (lindane) Hexachlorocyclohexane
Toxaphene is an undefined mix of similar compounds

Alaska Department of Environmental Conservation
Fish Tissue Testing Program

Figure 3. Number of samples per species collected in Alaskan waters through *Fish Tissue Monitoring* Program (2011-2012)

Table 1. ADEC Fish Tissue Monitoring Program data for Cook Inlet 1996-2013

Heavy Metals:		Organics:	
Species/Taxa	Years of Data	Species/Taxa	Years of Data
Clams	1996-2001		
Sleeper Shark	2013	Sleeper Shark	2013
Pacific Cod	2001-2009	Pacific Cod	2010
Dolly Varden	2008		
Eulachon	2009	Eulachon	2010
Grayling	2008		
Halibut	2002-2007		
Pacific Herring	2008-2010	Pacific Herring	2008
Lingcod	2002 and 2010		
Walleye Pollock	2002 and 2009		
Rockfish	2007		
Chinook Salmon	2001 and 2006	Chinook Salmon	2002
Chum Salmon	2002		
Pink Salmon	2002		
Sockeye Salmon	2002-2003		
Coho Salmon	2002-2006		
Spiny Dogfish	2001-2002		
Rainbow Trout	2009		

Another example is the Cook Inlet Regional Citizens Advisory Council (CIRCAC) Environmental Monitoring Program, which began a series of preliminary studies in 1993 to examine impacts of oil and gas operations on Cook Inlet. Studies done in 1993 and 1996 sampled mussels and deposit-feeding clams from eight locations (seven in Cook Inlet and one in Shelikof Strait) for total polycyclic aromatic hydrocarbons (PAHs). (ATSDR 2009). In 2000, another CIRCAC study measured PAH concentrations in three razor clams, two mussels, and three deposit-feeding clams from the east side of upper Cook Inlet; four soft-shell clams, one razor clam, and two deposit-feeding clams from the middle of upper Cook Inlet; and five deposit-feeding clams, one mussel, two razor clams, and one soft-shell clam from the west side of upper Cook Inlet (ATSDR 2009).

In part to help identify species prioritized by Cook Inlet-area tribal members for contaminant testing, between 2011 and 2012, Seldovia Village Tribe (SVT) staff undertook an assessment of Cook Inlet-area tribal members' subsistence consumption levels (primarily focusing on fish and shellfish consumption). SVT produced a report of findings in 2013. This work was funded through the Environmental Protection Agency (EPA)'s Indian General Assistance Program (IGAP) and done in collaboration with three other Cook Inlet-area tribes (Port Graham, Nanwalek, and Tyonek). Based on quantity and frequency of consumption, coho salmon, halibut, chinook salmon, sockeye salmon, and pink salmon were identified in the assessment as priority fish species.

Methods

1. Project initiation:

After SVT completed the survey of Cook Inlet-area tribal members' subsistence consumption in 2013, SVT staff contacted ADEC with inquiries about their Fish Tissue Monitoring Program: what contaminants they test for, what fish species they test, sampling protocols, and costs of laboratory analyses. This project was initiated on the basis of these discussions and the subsistence survey results. SVT formed a partnership with ADEC's Fish Tissue Monitoring Program in 2015 to test for contaminants in sockeye salmon and Dolly Varden collected from Cook Inlet. SVT received funding through an EPA IGAP Unmet Needs grant to train tissue sample collectors from Port Graham, Nanwalek, and Tyonek; provide sampling supplies/equipment; and collect samples from these three communities as well as Seldovia. After being awarded funding, SVT staff initiated teleconference calls with Port Graham, Nanwalek, and Tyonek tribal environmental staff to discuss the project. All three tribes agreed to partner with SVT in the project.

2. Species selection:

Sockeye salmon was chosen for contaminant testing because it is a high-priority subsistence resource for Cook Inlet-area tribal members (approximately 75% of adult tribal members surveyed in SVT's survey eat sockeye), because ADEC had very limited contaminant data on this species, and because ADEC was willing to test samples of this species for contaminants through their Fish Tissue Monitoring Program at no cost to SVT. Dolly Varden was chosen because it can be a resident species in south-central Alaska lakes and streams and therefore may provide more information about local contaminants. Additionally, although not a top subsistence resource in terms of fish species consumed by tribal members, Dolly Varden are eaten by about 40% of adult Cook Inlet-area tribal members who were surveyed in SVT's subsistence consumption assessment. ADEC also had very limited contaminant data on this species. Before including Dolly Varden, SVT consulted with ADEC and with tribal staff from Port Graham, Nanwalek, and Tyonek to ensure there was consensus on this species being chosen over other possibilities. ADEC was willing to test samples of this species through their fish tissue monitoring program at no expense to SVT.

3. Determination of what contaminants to test for:

The cost to perform the set of contaminant tests used in this study is roughly $3,000 per sample. Collaboration with the FTMP was critical to the success of this project, as funding from the EPA IGAP grant was not sufficient to cover the range of tests and number of samples necessary for the project. Fortunately, the ADEC FTMP was able to offer testing of samples at no cost to SVT. Because fish

samples were analyzed through the FTMP, the determination of what contaminants to test for was pre-determined from the beginning of the project and followed the State of Alaska's established protocols of the program. The contaminants tested for in this program are: total mercury, selenium, copper, lead, cadmium, arsenic, dioxins, furans, organochlorine pesticides, PCB congeners and brominated fire retardants (PBDEs). These environmental contaminants are evaluated because they 1) resist chemical degradation, 2) travel great distances from their source of production, and 3) are known to bioaccumulate in the food chain, all of which increase the risk they pose to human health.

4. Sample sizes and standard deviation:

The study design called for nine whole-body sockeye salmon and ten whole-body Dolly Varden to be collected from each of the four communities. Nine whole-body sockeye salmon were collected from fishing areas near all four communities, for a total of 36 sockeye salmon samples. Ten whole-body Dolly Varden were collected from fishing areas near Seldovia and Nanwalek. Sample collectors from Tyonek were only able to catch four Dolly Varden despite trying a variety of fishing methods, and Port Graham provided one extra Dolly Varden, for a total of 35. In total, 71 whole-fish samples were collected in this project.

The number of fish samples was largely determined by the capacity of ADEC's Environmental Health Laboratory in Anchorage, as determined by budget and staff limitations, laboratory resources, and storage space. Other considerations were: the number of samples that could be easily collected by samplers in the timeframe needed and by the number of samplers; not diverting too much fish or time from subsistence harvests of samplers and the communities; and the number of samples that could easily fit into available storage space (i.e. freezer space) within communities.

For metals analysis, sockeye salmon and Dolly Varden were sampled individually, both fillets and whole-body fish. For the project, this yielded a total of 72 metals results (eighteen per village) for sockeye, and 70 metals results for Dolly Varden (twenty each for Seldovia and Nanwalek, 22 for Port Graham and eight for Tyonek). Organics were sampled only from whole-body composites of multiple fish. Sockeye from each village were put into three groups of three fish apiece, and each group was then homogenized into a single sample, for a total of three organics results per village and twelve samples total for the project. Dolly Varden whole-body samples from each village were combined into a single composite sample, yielding one sample per village for organics and four samples for a project total. (Please see the "methods" section for more information.) Therefore, for metal contaminants analyzed, each fish represents two results (one fillet, one whole-body), whereas for each organic contaminant analyzed, a single contaminant value (i.e. a mean value) came from multiple fish homogenized into a single composite sample. Because whole-body fish vary in size, and different numbers submitted

were homogenized together into the composite samples, specimens did not contribute equally in terms of volume/weight to each composite sample.

5. Supplies purchased/used/made:

48-quart coolers
Identification/sample labels (to be included in fish bags)
Shipping labels
Fish tissue sampling sheets (provided by ADEC) – copied onto Rite in the Rain paper
Two-gallon Ziploc bags (for sockeye salmon samples)
One-gallon Ziploc bags (for Dolly Varden samples)
One-quart Ziploc bags (for labels)
Laminated copies of standard operating procedures (SOPs)
Laminated copies of Quality Assurance Project Plan (QAPP)
Nitrile exam gloves
GPS units
Pencils
Permanent markers
Bags of ice
Ice packs
First aid kits
Packaging tape
Clipboards
Cable ties
AA batteries for GPS units
GPS manual
Thermometers

6. QAPP, sampling protocols, and technical forms:

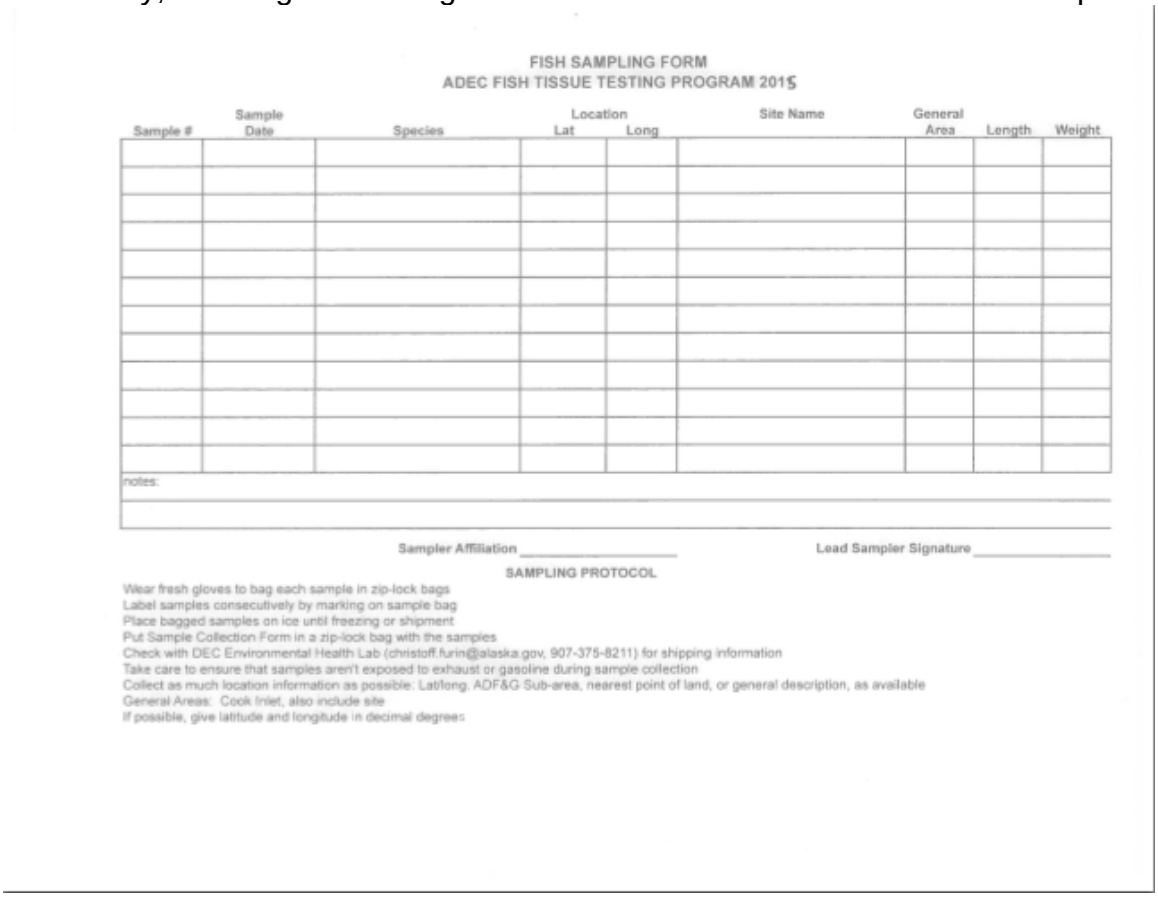
SVT staff wrote and submitted a Quality Assurance Project Plan to EPA (approved by Katherine Brown and Don Matheny from EPA in May 2015) for collection, storage, and shipping of fish samples to ADEC for analysis. The QAPP included information on when the samples would be collected; sampling location selection criteria; a list of sampling equipment/gear; sample selection methods; procedures for collection, storage, and transferring of samples for laboratory analysis; chain of custody forms; laboratory analysis procedures; laboratory quality assurance documents; and data quality procedures.

After securing project funding and partnerships, SVT staff created job descriptions contracts to hire two sampling personnel from each community (Seldovia, Port Graham, Nanwalek, and Tyonek) to collect fish samples. Tribal staff from each community circulated the job posting and assisted with contracting procedures. At least one sampler from each community was required to have access to a boat and fishing gear (such as a net and/or rod and reel).

Sampling protocols were created for both sockeye salmon (see Appendix A) and Dolly Varden (see Appendix B) and provided to sampling personnel. An inventory checklist was also created and included in the cooler of sampling supplies sent to each community (see Appendix C). Whenever sampling personnel collected a fish sample, they filled out fish tissue sampling sheets provided by ADEC. Information for multiple samples could be recorded on the same sheet. These sheets acted as chain of custody forms, and provided the following information to ADEC:

1) Sample number
2) Sample date
3) Species
4) Location of sampling event (latitude and longitude)
5) Site name
6) General area
7) Sampler name/signature and affiliation

Once samples were received and processed at ADEC's Environmental Health Laboratory, fish length and weight were recorded on the forms for each sample.



FISH SAMPLING FORM
ADEC FISH TISSUE TESTING PROGRAM 2015

Sample #	Sample Date	Species	Location Lat	Location Long	Site Name	General Area	Length	Weight

notes:

Sampler Affiliation _____ Lead Sampler Signature _____

SAMPLING PROTOCOL

Wear fresh gloves to bag each sample in zip-lock bags
Label samples consecutively by marking on sample bag
Place bagged samples on ice until freezing or shipment
Put Sample Collection Form in a zip-lock bag with the samples
Check with DEC Environmental Health Lab (christoff.furin@alaska.gov, 907-375-8211) for shipping information
Take care to ensure that samples aren't exposed to exhaust or gasoline during sample collection
Collect as much location information as possible: Lat/long, ADF&G Sub-area, nearest point of land, or general description, as available
General Areas: Cook Inlet, also include site
If possible, give latitude and longitude in decimal degrees

Figure 4. Fish sampling form - ADEC Fish Tissue Sampling Program

Each sample was identified with a label printed on Rite in the Rain paper. These labels were placed with the fish samples as samples were individually bagged. They provided the following information:

1) Sample number
2) Sample date
3) Species
4) Latitude and Longitude
5) Site name
6) Sample collector's name

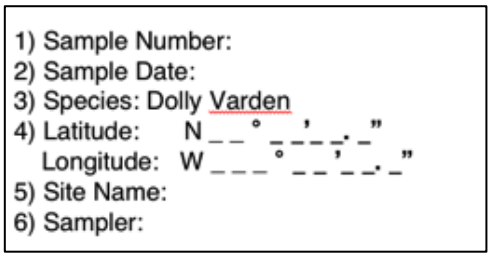


Figure 5: Sample label made by SVT staff

7. Training of samplers:

SVT staff visited Port Graham June 8th, 2015, and Nanwalek on June 15th, 2015, to meet with the tribal environmental staff and the contracted fish sample collectors from those communities. SVT staff discussed all sampling procedures, equipment, forms, and GPS units prior to any sample collection taking place. Sockeye salmon samples were then collected in the presence, and with the assistance, of SVT staff, using set nets put out a few hours earlier. On June 25th, 2015, SVT staff accompanied the two fish samplers hired in Seldovia and followed the same process. On July 9th and 10th, 2015, SVT staff traveled to Tyonek and provided instruction to their tribal environmental staff and the two contracted samplers, but did not collect any samples with them due to the tides not being conducive to fishing. Prior to the face-to-face trainings, SVT staff sent electronic copies of the project QAPP and SOPs to the tribal environmental staff in Port Graham, Nanwalek, and Tyonek to share with the sampling personnel. There were also several telephone calls with the tribal environmental staff in those communities to discuss travel logistics, expectations and responsibilities of the sampling personnel, and sampling procedures.

8. Fish sampling locations:

For both sockeye salmon and Dolly Varden, fishing sites were within ten miles of each village. Based on survey information collected in 2011-2012, it was known that the vast majority of community members living in Seldovia, Tyonek, Port Graham, and Nanwalek fish within 25 miles of their respective villages. Sampling locations were chosen based on local knowledge of where the target fish species

are found and are typically harvested. Proximity or distance away from potential point sources of contaminants in Cook Inlet was not a factor in sampling site selection. GPS coordinates of sample collection points were collected and recorded on sample identification labels, and on a fish sampling form provided by ADEC. Although both Dolly Varden and sockeye salmon samples were often caught in saltwater bays near each community, they were usually not collected at the same fishing sites.

9. Sample selection and collection:

Two sampling personnel in each community were instructed to obtain a total of nine sockeye salmon samples and ten Dolly Varden samples. Sample collection took place as part of the sampling personnel's normal subsistence fishing activities. Prior to collection events, two coolers and sampling supplies were provided to sampling personnel in each community and the personnel were trained on collection procedures. Bags of ice were initially sent over when samplers were trained and kept in freezers until needed. Coolers were placed in locations (both on and off the boat(s)) away from engine exhaust. When they were ready to collect samples, the samplers filled the coolers with ice and placed a thermometer inside the cooler to monitor temperature. Upon being caught, fish used as samples were immediately retrieved from fishing gear and placed into large Ziploc bags (two-gallon bags for sockeye salmon and one-gallon bags for Dolly Varden). Each sample was bagged individually. Samplers were instructed that all fish used as samples had to be in good condition (either alive at time of collection or very freshly dead) with no tears, bite marks, or rips. Fish used as samples, and the bags they were placed into, had to be clean and kept free from sources of contamination (not touching the bottom of a boat, not in contact with gasoline, petroleum, grease, etc.). To avoid introducing any contamination, samplers wore nitrile gloves, changing into a fresh pair for each individual fish.

After fish samples were bagged, the fish sampling form and an identification label were filled out for the sample, and the label was placed into a one-quart Ziploc bag. That Ziploc bag was then sealed and placed inside a larger Ziploc bag containing the fish sample, which was sealed in turn. Permanent marker was used to write the same information on the outside of each large Ziploc bag as on the individual identification label. The bagged fish sample was then immediately placed on ice in the cooler. Once fishing was complete, samples were immediately transferred out of the cooler into a freezer for storage.

Samplers from Seldovia at work

Once a decision was made to use an individual fish as a sample, protocols did not differ between sockeye salmon and Dolly Varden. However, selection criteria

for which individuals to collect as samples did slightly differ between the species.

a. Specific Methods for Sockeye Salmon

Sockeye salmon were caught using set nets. An eighteen-inch measure was drawn, using permanent marker, on the lid of the sample-storage coolers. Only sockeye salmon eighteen inches or longer were used as samples. Samplers set the nets a few hours prior to attempting to collect samples. Many samplers checked their nets a few times a day. All sockeye salmon used as samples were in the nets less than 24 hours.

b. Specific Methods for Dolly Varden

Dolly Varden were caught using nets and/or rod and reel (this varied by community and by sampling personnel). Sampling personnel were instructed to only use fish that were between 100 mm/3.94" and 400 mm/15.75" in size as samples. If possible, sampling personnel were requested to get five Dolly Varden within the lower end of this size range (100 mm/3.94" to 150 mm/5.91") and five individuals in the higher end of this size range (150 mm/5.91" to 400 mm/15.75"), so that contaminant levels could be compared between different life stages.

It is important to note that although sampling SOPs were originally made by SVT staff and provided to samplers, when collection of samples actually took place, there was some deviation from protocols. For instance, for many of the communities involved in this project, there was great diversity in the number of collection events that actually took place to obtain the required number of samples. For some communities, nine sockeye salmon samples were obtained during a single collection event. In other communities, it took two to three fishing collection events to get the number of salmon needed. The same held true for the collection of Dolly Varden samples. Some communities were able to get ten samples within one day. In others, it took two to three attempts to acquire the number of needed samples. In Tyonek, despite repeated tries, sampling personnel could not catch ten Dolly Varden to sample.

It was also thought that hatchery reared salmon could easily be visually distinguished from wild stock. When it was determined this was not the case, but that they could be differentiated through analysis of their otoliths (since local hatchery-reared salmon have thermally-marked ear bones), samplers were not asked to try to differentiate between wild and hatchery-reared salmon when selecting fish to sample. Finally, although samplers were instructed to collect Dolly Varden within two specified size ranges, both ADEC and SVT recognized that it might be quite difficult to get equal numbers of Dolly Varden in each of the two ranges for comparison purposes, and so decided to accept any Dolly Varden samples so long as they fell within the overall size range requested.

10. Storage of fish:

Upon returning from collecting samples, sampling personnel immediately moved the individually-bagged fish from coolers into freezers, usually kept in the sampling personnel's homes or in tribal office buildings. The thermometer provided was put in the freezer with the samples to ensure the temperature inside remained adequate for quality assurance purposes (-20°C/-4°F). In many cases, upon first returning with samples, the freezer temperature control was set at -20°C/-4°F. The labeled samples remained in the freezers until they were shipped out.

11. Shipping of fish samples:

After consulting with ADEC, it was deemed appropriate to send samples to the ADEC Environmental Health Laboratory from each community as a single shipment to save expense and improve efficiency. Sampling personnel in each community were responsible for shipping samples, with the exception of Seldovia, where SVT staff did this. Ease of collecting samples, availability of sampling personnel, access to fishing gear and/or boats, and plane schedules varied by community, and each factor influenced how long it took for all samples to be collected and ultimately shipped to ADEC. Sampling personnel were not paid until all their samples were successfully received by ADEC and confirmed as meeting quality assurance standards. If ADEC determined that any samples were not acceptable, the sampling personnel were immediately contacted by SVT and asked to acquire more samples until the required numbers were met. With the exception of Tyonek, all samples were shipped to ADEC in late June through mid-July 2015. Shipping labels were provided to sampling personnel in each community and ADEC staff were immediately notified by both SVT staff and sampling personnel when samples were shipped. Because sampling personnel from Tyonek were still trying to collect ten Dolly Varden, samples from Tyonek were sent in October of 2015.

When samples were ready to be shipped, samples were removed from freezers and put into the coolers provided by SVT. A thermometer and at least two ice packs, provided by SVT and ADEC, were included in each cooler along with fish samples. A completed fish sampling form was included on top in each cooler. Sampling personnel were also instructed to verify that the fish sampling forms were completely filled out and that each sample was labeled, as well as to write "keep frozen" in large print with permanent marker on the outside of each cooler. The coolers were shipped to the Office of the State Veterinarian in Anchorage. From Seldovia, Port Graham, and Nanwalek, samples were shipped via Smokey Bay Air or Homer Air to Homer, then on Ravn Airlines to Anchorage, where they were picked up at the airport by ADEC staff. Tyonek sampling personnel used Spernak Airways to ship their samples directly to Anchorage. Shipping costs were billed to accounts that ADEC had set up with each air carrier. When possible, shipping logistics were arranged so that samples could be received by

ADEC on the same day they were shipped from the communities. When this was not possible, the samples were kept in a freezer at the airline overnight and received by ADEC the day after shipping.

12. Laboratory procedures and processing:

Samples were analyzed for metals at the State of Alaska (ADEC)'s Environmental Health Laboratory (ADEC EHL) in Anchorage, Alaska. A subset of samples was sent to AXYS Analytical Services in Sydney, B.C., by ADEC staff for testing of organic contaminants (209 PCB congeners, 29 organochlorine pesticides, and 46 PBDE congeners) (see Appendix D).

The metals tested for were total arsenic, cadmium, lead, selenium, copper, and total mercury. When samples were received at the ADEC EHL, a laboratory technician evaluated the fish to ensure that they were properly labeled and packaged, were in good condition, and arrived with sufficient ice to keep them at near-freezing or colder temperature. If a sample was received that was not in satisfactory condition (e.g. received without ice, decomposed, or otherwise physically damaged enough to compromise the integrity of the sample), the lab technician made a record to note the disposal of the sample and contacted SVT staff to obtain additional replacement fish samples through coordination with partner villages. Collection information was entered into a database, and each sample was given a unique laboratory identification number. The sample was then placed in a freezer with a temperature set within a range of -15ºC/5ºF to -20ºC/-4ºF.

When it was time to collect samples, each fish was placed on a clean cutting board. The laboratory technician recorded physical data for each fish (fork length, weight, and sex) and collected an otolith for age determination. One fillet was removed and skinned. A subsample (approximately 20 g for sockeye or 5 g for Dolly Varden) was taken from the fillet for metals analysis. The whole fish carcass, including the remainder of the fillet, was then homogenized in a commercial meat grinder. Subsamples of each homogenized carcass were taken for metals and organics analysis. Between samples, all equipment was rinsed with 1% nitric acid, acetone, cyclohexane, methylene chloride and then water purified by reverse osmosis, and allowed to air dry (C. Furin, ADEC, personal communication, February 8, 2017).

For sockeye salmon, the nine organics subsamples from each village were put into groups of three, and then a single homogenized sample was created from each group, for a total of three samples per village and twelve sockeye samples for the study as a whole. For Dolly Varden, all of the raw whole-body organics subsamples from each village were homogenized together into one composite sample (four composite samples total for the project) (C. Furin, ADEC, personal communication, February 8, 2017). All fillet and whole samples were raw. The specific steps of homogenization of whole-body fish are as follows (as stated in ADEC's Fish Tissue Processing SOPs):

9.5 Homogenization of Whole Body Fish (if requested).

9.5.1 This section is only followed if whole body analysis is requested by the Project Manager.

9.5.2 After removing the otoliths and preparing the fillet homogenate, grind the remainder of the fish. Whole samples should be homogenized immediately since grinding and homogenization of biological tissue is easier when the tissue is partially frozen. Excess fillet tissue, if available, should be added to the whole fish before homogenization.

9.5.3 Grind the whole sample in a commercial tissue grinder or mince it by hand using the fillet knife. Large samples should be run through the grinder at least three times. A Teflon spatula or tamper tool should be used to ensure that all tissue is continually being run through the grinder blades.

9.5.4 If only small amounts of tissue are available, do not use the grinder. Using the grinder results in loss of mass. The sample should be trimmed to remove possible contaminants and then minced with the fillet knife. The resulting tissue should be roughly comparable to the grinder homogenate.

9.5.5 Homogenates should be divided amongst labeled 4 oz jars depending on needs for analysis. They are frozen and stored at -20°C. Each homogenate portion should be roughly three ounces. The jar should not be completely filled. Analytical decisions are made by the Project Manager.

Figure 6. *ADEC w*hole-body fish homogenization procedures

Each homogenate was divided into four portions: one for trace metals, one for all other contaminants, one for reference, and one for potential use as a blind duplicate. Each sample portion was placed in an approved (certified pre-cleaned) glass sample container (I-Chem jar), labeled with the sample number, and frozen at -15ºC/5ºF to -20ºC/-4ºF. Maximum holding time for frozen samples was one year. The sample portions sent to the contract lab were held at the ADEC EHL until there was a minimum of fifteen samples to send. Their freezer is armed with a temperature alarm, and internal temperatures in the freezer were continuously monitored.

Two grinder rinsate samples were prepared by washing the grinder following standard procedures, and then rinsing de-ionized water over the grinding surfaces and into amber glass bottles. The rinsate samples were kept refrigerated and included with the tissue samples in the analysis. An ADEC lab blank was also included with the tissue samples.

Quality control measures for the metals and total mercury analyses at the ADEC EHL include the analysis of a duplicate for each batch of ten or fewer samples. For each duplicate, a second tissue sample is removed from one of the jars and analyzed. A random number table is used to determine which of the samples in the group to use. The results of the duplicate are compared to the paired sample as a standard quality control measure. The same is done with the

organic analyses, with the exception that a batch at AXYS may contain up to fifteen samples. Additionally, every year five blind field duplicates are collected by the ADEC FTMP. Each blind duplicate is a second set of jars of homogenized tissue from a selected sample. The blind duplicates are given separate lab numbers and are treated as original samples for analytical purposes. They are analyzed at the ADEC EHL for metals and at AXYS for organics, and the data reported to the Fish Tissue Monitoring Program. Fish Tissue Monitoring staff then compare the analytical results of the blind duplicate with the original sample for analytical consistency.

An aliquot of selected homogenized samples is sent to a contract lab using chain-of-custody procedures for additional chemical analysis, although the homogenization/processing for all samples takes place at the ADEC EHL. The Environmental Health Laboratory ships frozen samples via overnight delivery to the contract lab (AXYS). The contract lab is notified via fax or e-mail of the impending delivery, along with the tracking numbers. The shipment includes a chain-of-custody document (see Appendix E) and a description of the samples shipped, including identification numbers. If the contract lab does not receive the sample within 24 hours of shipment from the ADEC EHL, they contact the quality assurance officer of the ADEC EHL and report the delay. The ADEC EHL also contacts the contract lab to confirm receipt of the sample shipment. In the case of delayed receipt, the ADEC EHL quality assurance officer determines whether the delay has impacted the integrity of the samples or the quality of the analytical data. If there is any question, the samples are not analyzed and new samples are sent. All incidences are recorded on the chain-of-custody paperwork (see Appendix E).

The contract lab keeps all samples frozen until processed for analysis. All sample material remaining after subsamples are removed for extraction is refrozen. The contract lab holds all excess sample material and extracts for one year after the results have been delivered. At that time the contract lab contacts appropriate ADEC EHL or ADEC personnel to determine whether the samples and extracts are to be discarded or returned to the State. Samples and extracts are stored at the contract lab at -20˚C/-4˚F and in the dark at all times.

Holding time for frozen organic samples is one year; the extract holding limit is two years. For metals, the holding time is not well defined but is generally six months. The contract lab (AXYS) analyzes the samples for selected PCBs and pesticides following EPA-approved methods. Percent lipid is determined gravimetrically, and PBDEs are analyzed using a modified EPA method (EPA 1614A).

EPA methods for lab analyses are as follows:

1. Percent Lipid

The determination of lipid content in a sample extract is carried out by quantitatively measuring (by weight or by volume) an aliquot of an extract prepared for one of the organic analyses to be performed on the samples, typically either the PCB or dioxin/furan analysis. Each aliquot is placed into a pre-weighed foil weigh boat. The solvent is allowed to evaporate at room temperature prior to drying of the extract at 105°C/221ºF for 30 minutes. When cool, the weigh boat is re-weighed to determine the weight of lipid. The percent lipid in the sub-sample of extract is determined as the weight of the remaining material divided by the weight of the sample with solvent. The above lipid determination is performed in duplicate and the average percent lipid is reported. The percent recoveries of the labeled surrogate compounds in the remaining extract are corrected for amount of extract consumed in the lipid determination.

2. Trace Metals

Analyses for arsenic, cadmium, copper, lead, and selenium are performed using the following methods. The most recent revision of each method as listed in SW-846 was used:

Table 2: Trace metal methods

Analyte	Preparatory Method	Analytical Method
Total Arsenic	EPA Method 3050, 3051 or 3052	EPA Method 6020
Cadmium	EPA Method 3050, 3051 or 3052	EPA Method 6020
Copper	EPA Method 3050, 3051 or 3052	EPA Method 6020
Lead	EPA Method 3050, 3051 or 3052	EPA Method 6020
Selenium	EPA Method 3050, 3051 or 3052	EPA Method 6020

The preferred method for metals analysis for fish tissues and other environmental matrices is EPA Method 6020, Inductively Coupled Plasma - Mass Spectrometry, which ADEC's EHL utilizes. The use of ICP/MS technology enables the laboratory to measure the presence of metals in seafood at the lowest possible levels with greater efficiency and savings. The same measurement quality objectives for trace metals analysis are followed.

3. Total Mercury

Total mercury is determined by EPA Method 7473, Mercury in Solids and Solutions by Thermal Decomposition, Amalgamation, and Atomic Absorption Spectrometry.

4. Organochlorine Pesticides

29 organochlorine pesticides are determined by US EPA Method 1614A, Brominated Diphenyl Ethers in Water, Soil, Sediment, and Tissue.

5. PCB and PBDE Congeners

Analyses for 209 polychlorinated biphenyls (PCB) and 46 polybrominated diphenyl ethers (PBDE) congeners are determined by US EPA Method 1614A. The cleanup techniques described in the method are employed as necessary to eliminate interferences and to obtain the best possible reporting limits.

Results

The study found some level of metals, PCB congeners, PBDEs and organochlorine pesticides in all sockeye and Dolly Varden sampled. Contaminant levels varied between species, tissue type (fillet vs. whole-body), and study sites. Even Nanwalek and Port Graham, which are located only four miles apart, varied in contaminant levels. On average, Dolly Varden fillets had higher levels of metal contaminants than did sockeye fillets. Whole-body sockeye had higher average levels of metal contaminants than did Dolly Varden. However, both whole-body sockeye and sockeye fillets had higher average levels of mercury than did Dolly Varden. Lead was only found in one sockeye fillet sample, from Seldovia. Because all Dolly Varden in this study were caught in saltwater or in the lower reach of a stream, it must be assumed that all Dolly Varden sampled were anadromous. Therefore, we cannot make a comparison between contaminant levels of resident and anadromous Dolly Varden. Whole-body sockeye and Dolly Varden from Nanwalek had the highest levels of metal contaminants out of the four communities. Sockeye and Dolly Varden fillets from Tyonek had the highest average levels of metal contaminants out of the four communities. Nanwalek sockeye had the highest average amounts of more organic contaminants than any other village.

Fish Weights and Ages

Table 3 shows weight and length data for individual sockeye, as well as mean weight and length for each composite sample. The mean lengths and weights were similar for sockeye salmon from all four communities. The mean lengths for all composite sockeye samples were within five centimeters. The mean weights of composite sockeye salmon from all four communities were within 0.6 kg. Otoliths were extracted from all sockeye salmon samples to be reviewed for age and possible hatchery origin. Before samples were collected, an area aquaculture association expressed interest in reviewing otoliths for no charge, but has yet to do so. On average, male sockeye from Nanwalek, Port Graham, and Tyonek were larger in weight and length than female sockeye. Female sockeye from Seldovia were larger, on average, than male sockeye salmon.

Table 3: Weight and length of individual and composite sockeye salmon samples

Composite ID	Location	Species	Length (cm)	Weight (kg)	Sex	Mean Length (cm)	Mean weight (kg)
15NA-comp2	Nanwalek	Sockeye Salmon	59.7	2.494	M	57.47	2.38
	Nanwalek	Sockeye Salmon	56.6	2.336			
	Nanwalek	Sockeye Salmon	56.1	2.303			
15NA-comp3	Nanwalek	Sockeye Salmon	56.8	2.177		56.20	2.20
	Nanwalek	Sockeye Salmon	52	1.719			
	Nanwalek	Sockeye Salmon	59.8	2.692	M		
15NA-comp4	Nanwalek	Sockeye Salmon	61.6	2.672	M	59.50	2.58
	Nanwalek	Sockeye Salmon	53.4	2.068	F		
	Nanwalek	Sockeye Salmon	63.5	3	M		
15PG-comp1	Port Graham	Sockeye Salmon	56.5	1.932	F	57.87	2.27
	Port Graham	Sockeye Salmon	54.8	2.07	M		
	Port Graham	Sockeye Salmon	62.3	2.821			
15PG-comp2	Port Graham	Sockeye Salmon	56.7	2.046	F	59.00	2.51
	Port Graham	Sockeye Salmon	63.4	2.964	M		
	Port Graham	Sockeye Salmon	56.9	2.528	M		
15PG-comp3	Port Graham	Sockeye Salmon	61.6	2.977	M	58.13	2.29
	Port Graham	Sockeye Salmon	54.6	1.796	F		
	Port Graham	Sockeye Salmon	58.2	2.106	M		
15SE-comp1	Seldovia	Sockeye Salmon	59.4	2.546	M	54.43	2.01
	Seldovia	Sockeye Salmon	54.9	1.934	M		
	Seldovia	Sockeye Salmon	49	1.546	M		
15SE-comp2	Seldovia	Sockeye Salmon	58.7	2.292	M	56.83	2.22
	Seldovia	Sockeye Salmon	55.4	2.178	M		
	Seldovia	Sockeye Salmon	56.4	2.196	M		
15SE-comp3	Seldovia	Sockeye Salmon	57.8	2.421	F	56.73	2.37
	Seldovia	Sockeye Salmon	57.2	2.599	F		
	Seldovia	Sockeye Salmon	55.2	2.086	M		
15TY-comp1	Tyonek	Sockeye Salmon	54	1.915	F	54.90	2.04
	Tyonek	Sockeye Salmon	57.4	2.271	F		
	Tyonek	Sockeye Salmon	53.3	1.922	M		
15TY-comp2	Tyonek	Sockeye Salmon	54.8	2.558	M	56.00	2.36
	Tyonek	Sockeye Salmon	58	2.389	F		
	Tyonek	Sockeye Salmon	55.2	2.126	M		
15TY-comp3	Tyonek	Sockeye Salmon	57.7	2.177	M	55.00	2.00
	Tyonek	Sockeye Salmon	52.1	1.759	F		
	Tyonek	Sockeye Salmon	55.2	2.06	F		

Table 4 shows weight, length, and age data for individual Dolly Varden as well as mean weight, length and age for each composite sample. The mean lengths and weights for the four composite samples of Dolly Varden were similar with the exception of Seldovia. The mean ages of composite Dolly Varden samples from all four communities were similar. The majority of Dolly Varden samples were between seven and nine years of age. The oldest individual sampled came from Seldovia and was twenty years old. The youngest individuals sampled came from Seldovia and Port Graham and were five years old. There is no apparent

correlation of age with length and weight. The oldest Dolly Varden sampled was ten centimeters shorter and a fraction of the weight of a Dolly Varden half its age.

Table 4: Weight, length, and age of individual and composite Dolly Varden samples

Composite ID	Location	Species	Length (cm)	Weight (kg)	Sex	Age	Mean Length (cm)	Mean weight (kg)	Mean Age (Years)
15NA-COMP1	Nanwalek	Dolly Varden	23.75	0.149	F	9	30.585	0.3055	7.5
	Nanwalek	Dolly Varden	31.7	0.301	F	6			
	Nanwalek	Dolly Varden	26.8	0.209		7			
	Nanwalek	Dolly Varden	35.1	0.484		7			
	Nanwalek	Dolly Varden	32.2	0.373	F	6			
	Nanwalek	Dolly Varden	30.3	0.276		7			
	Nanwalek	Dolly Varden	32	0.344		7			
	Nanwalek	Dolly Varden	33.1	0.31	F	13			
	Nanwalek	Dolly Varden	36.2	0.471	F	6			
	Nanwalek	Dolly Varden	24.7	0.138	F	7			
15PG-COMP4	Port Graham	Dolly Varden	36.1	0.483		7	31.10909	0.335455	8
	Port Graham	Dolly Varden	34.9	0.388	M	9			
	Port Graham	Dolly Varden	32.7	0.387	F	7			
	Port Graham	Dolly Varden	27.3	0.275		7			
	Port Graham	Dolly Varden	31.5	0.324		9			
	Port Graham	Dolly Varden	29.8	0.295		5			
	Port Graham	Dolly Varden	31.6	0.364	F	7			
	Port Graham	Dolly Varden	32	0.379	F	8			
	Port Graham	Dolly Varden	28.3	0.223	F	7			
	Port Graham	Dolly Varden	27.4	0.243	F	10			
	Port Graham	Dolly Varden	30.6	0.329		12			
15SE-COMP4	Seldovia	Dolly Varden	33.6	0.332		11	18.91	0.0892	9.3
	Seldovia	Dolly Varden	14.5	0.04		9			
	Seldovia	Dolly Varden	20.6	0.089		20			
	Seldovia	Dolly Varden	20.2	0.099		9			
	Seldovia	Dolly Varden	15.8	0.049		7			
	Seldovia	Dolly Varden	16.8	0.053		5			
	Seldovia	Dolly Varden	16.6	0.047		7			
	Seldovia	Dolly Varden	15	0.037		9			
	Seldovia	Dolly Varden	19.5	0.083		7			
	Seldovia	Dolly Varden	16.5	0.063		9			
15TY-COMP4	Tyonek	Dolly Varden	34	0.362			29.75	0.287	9
	Tyonek	Dolly Varden	27.5	0.251		9			
	Tyonek	Dolly Varden	28.5	0.297		11			
	Tyonek	Dolly Varden	29	0.238		7			

Table 5: Mean values of metals in sockeye and Dolly Varden

Location	Species	n	Length	Age	Tissue	Hg	As	Cu	Pb	Se
NANWALEK	DOLLY VARDEN	10	30.6	7.5	Fillet	0.0316	1.0330	0.6967	ND	0.5822
					Whole	0.0273	0.9857	1.0026	ND	0.8766
PORT GRAHAM	DOLLY VARDEN	11	31.1	8.0	Fillet	0.0195	0.8366	0.7407	ND	0.5478
					Whole	0.0186	0.8829	0.9795	ND	0.8028
SELDOVIA	DOLLY VARDEN	10	18.9	9.3	Fillet	0.0332	0.4100	0.5319	ND	0.5098
					Whole	0.0301	0.4828	1.1764	0.03169*	0.7547
TYONEK	DOLLY VARDEN	4	29.8	9.0	Fillet	0.0267	1.2860	0.7875	ND	0.5438
					Whole	0.0244	1.3928	1.1925	ND	0.7868
NANWALEK	RED SALMON	9	57.7	NA	Fillet	0.0390	0.5094	0.6689	ND	0.5208
					Whole	0.0334	0.5858	6.1422	ND	1.0554
PORT GRAHAM	RED SALMON	9	58.3	NA	Fillet	0.0351	0.4493	0.5782	ND	0.5013
					Whole	0.0303	0.5426	5.2011	ND	1.0101
SELDOVIA	RED SALMON	9	56.0	NA	Fillet	0.0374	0.4002	0.6067	ND	0.4674
					Whole	0.0310	0.4929	7.2378	ND	1.1550
TYONEK	RED SALMON	9	55.3	NA	Fillet	0.0444	0.3711	0.7703	ND	0.5179
					Whole	0.0393	0.3486	5.0756	ND	0.8536

*The reporting limit (RL) for Pb is 0.05 mg/Kg. Two whole body dolly samples from Seldovia were at or above the RL, the other 8 were below the RL with the average reported in the table above. Results less than the RL but greater than the detection limit are considered an estimate.

Metals

1. Arsenic:

Naturally-occurring arsenic is found in volcanic ash and soils. Arsenic is also introduced into the environment through agricultural practices. It is used in pesticides, feed additives, and until 2004 the largest industrial use was in wood preservatives. There is currently no FDA action level or EPA chronic consumption threshold for total arsenic in seafood. The EPA set a standard for arsenic in drinking water at 0.010 mg/kg. Arsenic is linked to many kinds of cancer in humans, and has many non-cancerous effects including stomach pain, nausea, vomiting, diarrhea, blindness, and numbness in hands and feet.

The average amounts of arsenic in sockeye fillets from the four villages were: Seldovia: 0.4002 mg/kg; Nanwalek: 0.5094 mg/kg; Port Graham: 0.4493 mg/kg; and Tyonek: 0.3711 mg/kg. The average amounts of arsenic in whole-body sockeye salmon were Seldovia: 0.4929 mg/kg; Nanwalek: 0.5858 mg/kg; Port Graham: 0.5426 mg/kg; and Tyonek: 0.3486 mg/kg. The highest amount of arsenic found in sockeye salmon fillets was 0.744 mg/kg from Port Graham. Port Graham also had the highest amount of arsenic in a whole-body sample at 0.878 mg/kg. The lowest amount of arsenic found in a sockeye salmon fillet was 0.211 mg/kg from Tyonek. The lowest amount of arsenic found in a whole-body sockeye salmon sample was 0.24 mg/kg, also from Tyonek.

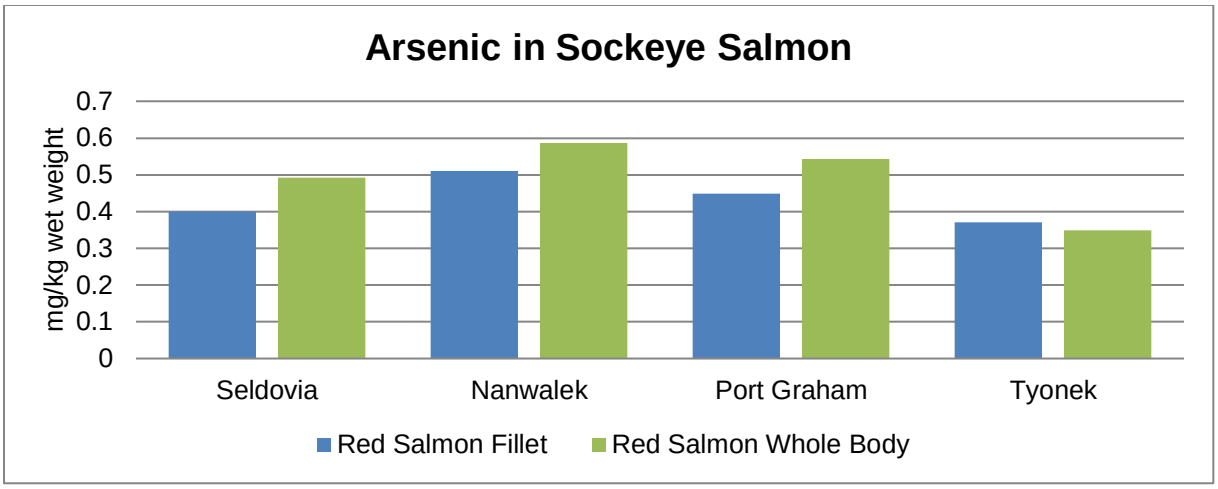


Figure 7: Mean arsenic levels in sockeye fillet and whole-body samples

The average amounts of arsenic found in Dolly Varden fillets for the four villages were: Seldovia: 0.41 mg/kg; Nanwalek: 1.033 mg/kg; Port Graham: 0.836636 mg/kg; and Tyonek: 1.286 mg/kg. The average amounts of arsenic found in whole-body Dolly Varden were: Seldovia: 0.4828 mg/kg; Nanwalek: 0.9857 mg/kg; Port Graham: 0.882909 mg/kg; and Tyonek: 1.39275 mg/kg.

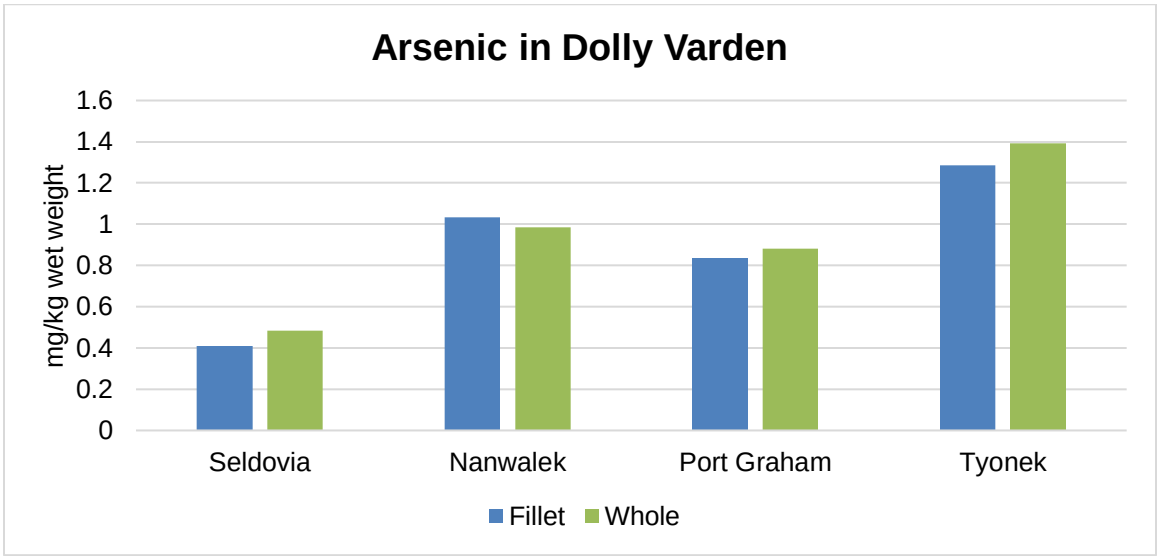


Figure 8: mean arsenic levels in Dolly Varden fillet and whole-body samples

The highest amount of arsenic found in a Dolly Varden fillet was from Tyonek with 2.37 mg/kg. The highest amount of arsenic found in a whole-body Dolly Varden was 2.43 mg/kg, also from Tyonek. The lowest amount of arsenic found in a Dolly Varden fillet was 0.227 mg/kg, from Seldovia. The lowest amount of arsenic found in a whole-body Dolly Varden was also from Seldovia, at 0.288 mg/kg.

2. Cadmium:

Cadmium occurs in small amounts in soils and is mined for use in batteries, electroplating, nuclear fission, and paints. Unlike other minerals and metals, aquatic animals have no use for cadmium. In high doses it can cause death, and chronic exposure can have negative effects on growth, reproduction, immune systems, and behavior. There is no FDA action level for cadmium, although there is an EPA chronic consumption level of 1.41 mg/kg for seafood. The method detection limit (MDL) for cadmium was 0.000961 mg/kg. The reporting limit (RL) is 0.05 mg/kg. Values between the MDL and RL are considered estimates because they are below the lowest calibration level equivalent (C. Furin, ADEC, personal communication, February 10, 2017).

The average amounts of cadmium in sockeye salmon fillets were: Seldovia: 0.002558 mg/kg; Nanwalek: undetectable; Port Graham: 0.002727 mg/kg; and Tyonek: 0.003889 mg/kg. The average amounts of cadmium in whole-body sockeye salmon were: Seldovia: 0.047589 mg/kg; Nanwalek: 0.044 mg/kg; Port Graham: 0.0477 mg/kg; and Tyonek: 0.039056 mg/kg.

The highest amount of cadmium found in a sockeye fillet sample was 0.00572 mg/kg, from Tyonek. The highest amount of cadmium found in a whole-body sockeye salmon sample, 0.12 mg/kg, was from Seldovia. This is the highest level of cadmium found in a whole sockeye sample in ADEC's Fish Tissue Monitoring Program. The lowest amount of cadmium from a sockeye salmon fillet was from Nanwalek, which had a level below the MDL. The lowest amount of cadmium found in a whole-body sockeye salmon sample was 0.0239 mg/kg, from Tyonek.

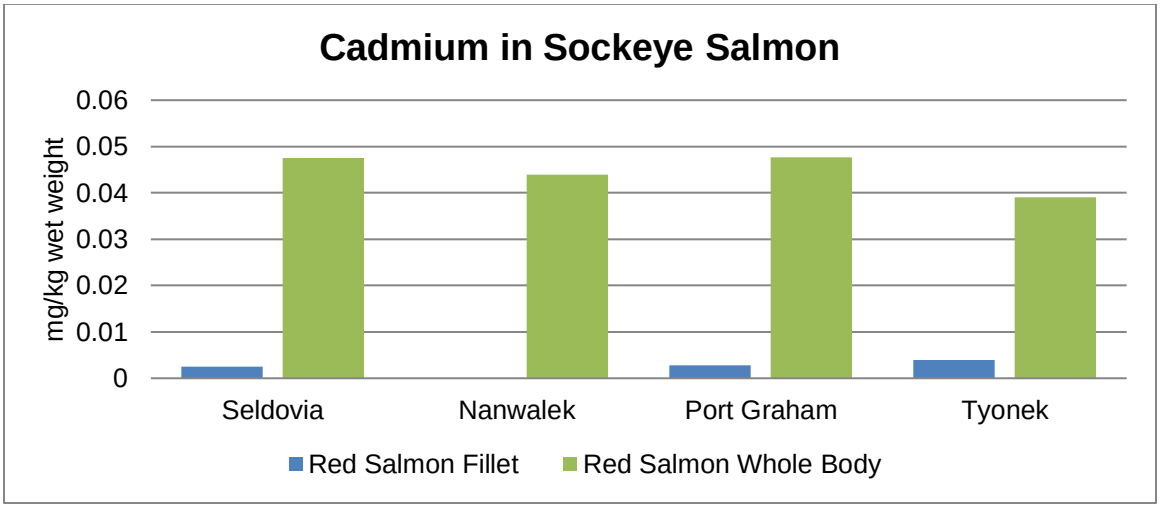


Figure 9: Mean cadmium levels in sockeye fillet and whole-body samples

Cadmium was undetectable in Dolly Varden fillets from the communities of Nanwalek and Tyonek. The average amounts of cadmium in Seldovia and Port Graham Dolly Varden fillets were 0.002536 mg/kg and 0.00175 mg/kg, respectively. The average amounts of cadmium found in whole-body Dolly Varden were: Seldovia: 0.013447 mg/kg; Nanwalek: 0.02737 mg/kg; Port Graham: 0.008629 mg/kg; and Tyonek: 0.006215 mg/kg.

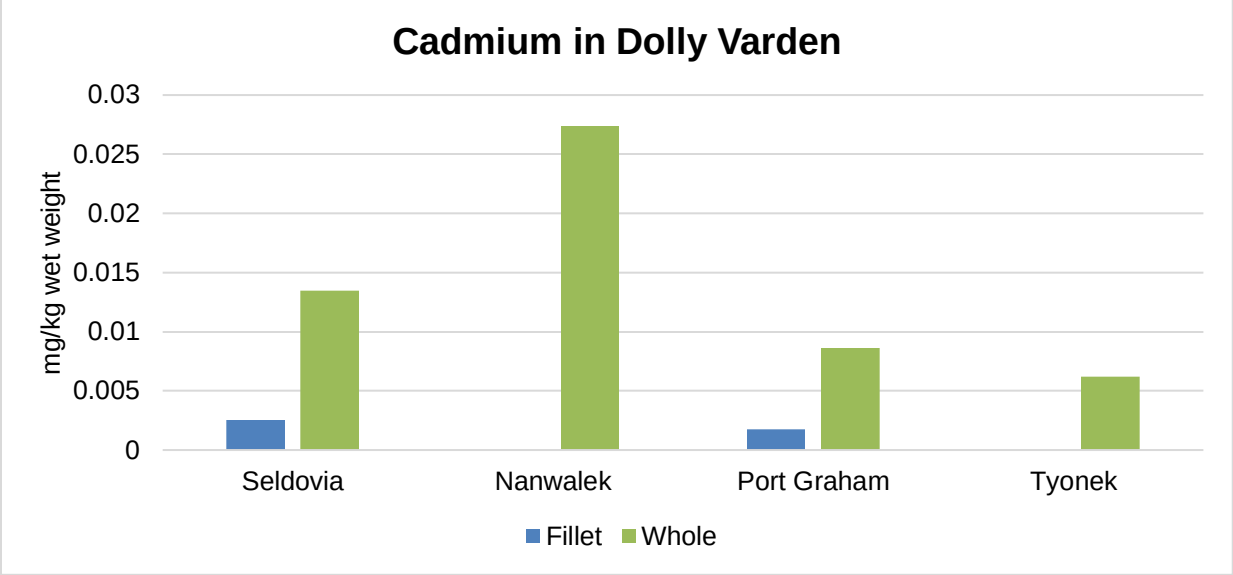


Figure 10: Mean cadmium levels in Dolly Varden fillet and whole-body samples

The highest amount of cadmium found in a Dolly Varden fillet was 0.00614 mg/kg from Seldovia. The highest amount of cadmium found in a whole-body Dolly Varden was 0.0434 mg/kg from Nanwalek. The lowest detectable amount of cadmium found in a Dolly Varden fillet was 0.00122 mg/kg from Seldovia. The lowest detectable amount of cadmium found in a whole-body Dolly Varden was 0.00263 mg/kg from Port Graham.

3. Copper:

Copper occurs in the environment naturally, and is washed out of soils into rivers and streams. Copper is also released into the environment through human actions. Marine paints used on boat hulls, buoys, and other objects under the water's surface are large contributors of copper to the marine environment. No FDA action level or EPA chronic consumption threshold could be found for copper in seafood; however, the EPA maximum contaminant level for copper in drinking water is 1.3 milligrams per liter. High amounts of copper in water are known to have negative effects on salmonids' ability to navigate.

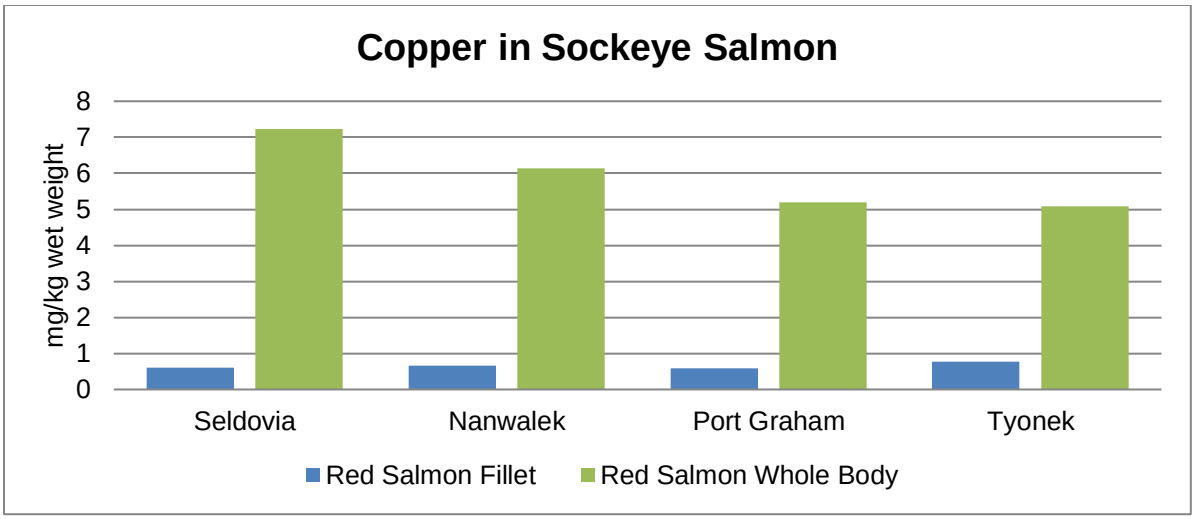


Figure 11: Mean copper levels in sockeye fillet and whole-body samples

The average amounts of copper in sockeye salmon fillets were: Seldovia: 0.6066 mg/kg; Nanwalek: 0.6689 mg/kg; Port Graham: 0.5782 mg/kg; and Tyonek: 0.7703 mg/kg. The average amounts of copper in whole-body sockeye salmon were: Seldovia: 7.237778 mg/kg; Nanwalek: 6.14222 mg/kg; Port Graham: 5.20111 mg/kg; and Tyonek: 5.075556 mg/kg

The community with the highest amount of copper in a sockeye salmon fillet sample was Nanwalek with 1.05 mg/kg. The community with the highest amount of copper found in a whole-body sockeye salmon sample was Seldovia with 25.5 mg/kg, which equaled a total of 64.9 milligrams of copper in this single fish. This is the highest amount of copper found in any whole-body sockeye salmon in ADEC's Fish Tissue Monitoring Program. The lowest amount of copper found in a sockeye salmon fillet sample was from Port Graham with 0.5782 mg/kg. The lowest amount of copper found in a whole-body sockeye salmon sample was from Tyonek with 5.07555 mg/kg.

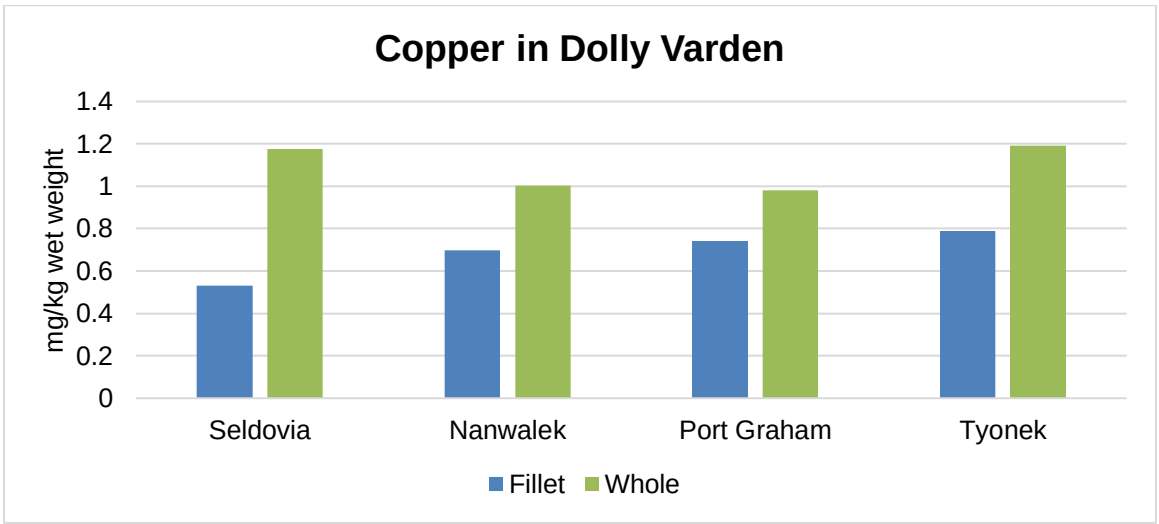


Figure 12: Mean copper levels in Dolly Varden fillet and whole-body samples

The average amounts of copper found in Dolly Varden fillets were: Seldovia: 0.5319 mg/kg; Nanwalek: 0.6967 mg/kg; Port Graham: 0.6967 mg/kg; and Tyonek: 0.7875 mg/kg. The average amounts of copper found in whole-body Dolly Varden were: Seldovia: 1.1764 mg/kg; Nanwalek: 1.0026 mg/kg; Port Graham: 1.0026 mg/kg; and Tyonek: 1.1925 mg/kg.

Nanwalek had the highest amount of copper found in both a whole-body Dolly Varden at 1.65 mg/kg and Dolly Varden fillet at 1.13 mg/kg. These are the highest amounts of copper found in any Dolly Varden fillet or whole-body sample in ADEC's Fish Tissue Monitoring Program. The lowest amount of copper found in a Dolly Varden fillet was 0.427 mg/kg from Seldovia. The lowest amount of copper found in a whole-body Dolly Varden was 0.655 mg/kg from Nanwalek.

4. Lead:

Lead is naturally found in the earth. It is released into the air, soil and water through mining, production, use, and disposal. Lead was used in gasoline and paint but has been banned in these products. It is still used in batteries, ammunition, weights and ceramic glazing. Although banned for waterfowl hunting since 1991, lead is still commonly used in shotgun ammunition for up-land hunting, as well as weights used for fishing. Although there is no safe amount of lead exposure, there is no FDA action level or EPA chronic consumption threshold for lead in seafood. The World Health Organization (2002) has a draft value of 200 µg/kg for lead in fish muscle tissue. The EPA states that lead exposure can cause behavior and learning problems, lower IQ, slowed growth, hearing problems and anemia in children. In adults it can have cardiovascular effects, decrease kidney function, and cause reproductive problems in both men and women.

The method detection limit (MDL) for lead was 0.00571 mg/kg (C. Furin, ADEC, personal communication, February 10, 2017). The reporting limit (RL) is 0.05 mg/kg.

Seldovia was the only community with a detectable amount of lead in a sockeye salmon fillet, in a single sample with 0.00859 mg/kg. The other three communities did not have any sockeye salmon fillet samples with a detectable amount. Tyonek was the only community that had detectable amounts of lead in whole-body sockeye salmon samples. Five of the nine whole-body samples from Tyonek had detectable amounts of lead. The highest amount of lead in a whole-body sockeye sample was 0.0163 mg/kg; the lowest amount was 0.00599 mg/kg. The average amount of lead in whole-body sockeye salmon samples from Tyonek was 0.008692 mg/kg.

Two whole-body Dolly Varden from Seldovia were at or above the reporting limit for lead of 0.05 mg/kg. The average amounts of lead in Dolly Varden fillets were undetectable for all four communities. Seldovia had the only detectable average

amount of lead in whole-body Dolly Varden samples with 0.03169 mg/kg. Only one out of four of Tyonek whole-body Dolly Varden had a detectable amount of lead.

Seldovia had the highest amount of lead found in both Dolly Varden fillet and whole-body Dolly Varden with 0.0279 mg/kg in fillets and 0.0748 mg/kg in whole-body samples. All four communities had one or more Dolly Varden fillets and whole-body Dolly Varden samples with lead levels below the MDL. The lowest detectable amount of lead in a Dolly Varden fillet was 0.00805 mg/kg from Port Graham. The lowest detectable amount of lead in a whole-body Dolly Varden was 0.0111 mg/kg from Port Graham.

5. Mercury:

Mercury is a rare metal that occurs naturally in the earth. It is often mined with other metals such as gold and copper. High amounts of mercury are released into the air by coal fired power plants, gold production, and non-ferrous metal production. After being released into the air, it settles on the ground or on water. When mercury settles in the water it creates methyl mercury, a highly-toxic form of mercury. Methyl mercury is ingested by fish and other marine animals and increases in concentration as it travels up the food chain. Mercury was commonly used in thermometers and even in ‘wobbling’ fishing lures. The mercury inside the lure rolled around, causing the lure to wobble and attract fish. It is still used in fluorescent light bulbs, industrial chemicals, and even make-up products such as eyeliner, skin creams, and lipsticks.

The State of Alaska has an acceptable daily intake of mercury set at 0.56 mg/kg. Currently the EPA has a chronic consumption threshold of 0.14 mg/kg for mercury, and in 2001 adopted a reference dose of 0.1 µg/kg body weight/day. The FDA has an action level of 1.0 mg/kg for mercury in seafood. The World Health Organization has a Provisional Tolerable Daily Intake of 0.5 µg/kg/day. Mercury is highly toxic and can cause brain, kidney, and lung damage. Symptoms of exposure to mercury include sensory impairment, lack of coordination, weakness and muscle atrophy, psychiatric problems and cognitive dysfunction.

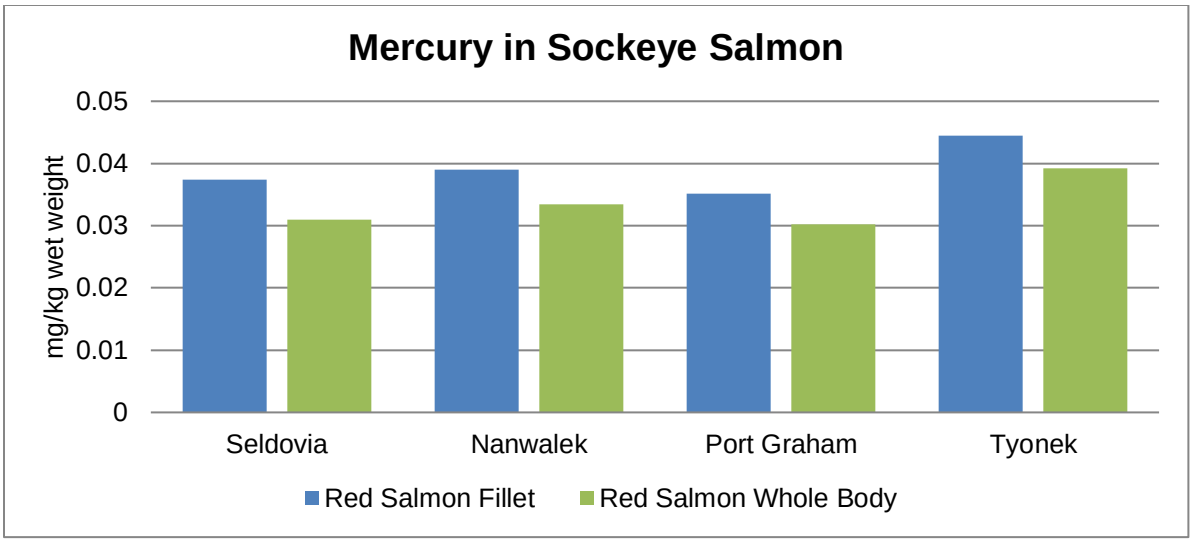


Figure 13: Mean mercury levels in sockeye fillet and whole-body samples

Mercury was found in all sockeye and Dolly Varden collected for this study. The average amounts of mercury in sockeye salmon fillets were: Seldovia: 0.037378 mg/kg; Nanwalek: 0.38956 mg/kg; Port Graham: 0.035144 mg/kg; and Tyonek: 0.4444 mg/kg. The average amounts of mercury in whole-body sockeye salmon were: Seldovia: 0.030978 mg/kg; Nanwalek: 0.033411 mg/kg; Port Graham: 0.030256 mg/kg; and Tyonek: 0.039267 mg/kg.

The highest amount of mercury detected in a sockeye salmon fillet was 0.0642 mg/kg from Seldovia. The highest amount of mercury detected in a whole-body sockeye salmon was 0.0552 mg/kg from Tyonek. This is the highest amount of mercury found in any whole-body sockeye salmon sample tested in ADEC's Fish Tissue Monitoring Program. The lowest amount of mercury detected in a sockeye salmon fillet was 0.239 mg/kg from Seldovia. The lowest amount of mercury detected in a whole-body sockeye was also from Seldovia, with 0.021 mg/kg.

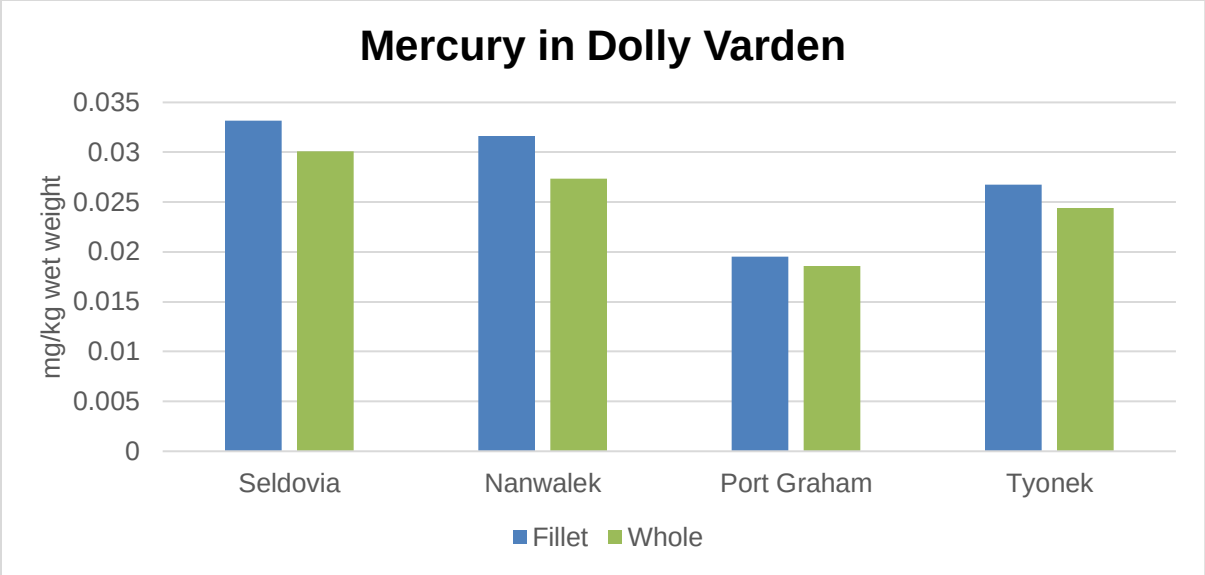


Figure 14: mean mercury levels in Dolly Varden fillet and whole-body samples

The average amounts of mercury found in Dolly Varden fillets were: Seldovia: 0.03319 mg/kg; Nanwalek: 0.03161 mg/kg; Port Graham: 0.03161 mg/kg; and Tyonek: 000.026725 mg/kg. The average amounts of mercury found in whole-body Dolly Varden were: Seldovia: 0.03007 mg/kg; Nanwalek: 0.02733 mg/kg; Port Graham: 0.018564 mg/kg; and Tyonek: 0.024425 mg/kg.

The highest amount of mercury found in a Dolly Varden fillet was 0.0886 mg/kg from Seldovia. The highest amount of mercury in a whole-body Dolly Varden sample was also from Seldovia, with 0.0837 mg/kg. The lowest amount of mercury found in a Dolly Varden fillet was 0.0084 mg/kg from Seldovia. The lowest amount of mercury in a whole-body Dolly Varden was 0.0079 mg/kg and also from Seldovia. These are the lowest amounts of mercury found in any Dolly Varden fillet or whole-body sample tested in ADEC's Fish Tissue Monitoring Program.

6. Selenium:

Selenium is also a naturally-occurring element. Selenium is released into the environment by natural weathering processes. Selenium is also released by human actions through coal-powered power plants, agriculture, and mining. Selenium is an essential nutrient, but becomes toxic in higher concentrations. Selenium bioaccumulates in marine animals. High amounts of selenium can cause reproductive impairments in fish and invertebrates, and have an adverse effect on juvenile growth and mortality. Selenium is toxic to waterfowl and other birds that eat contaminated aquatic organisms.

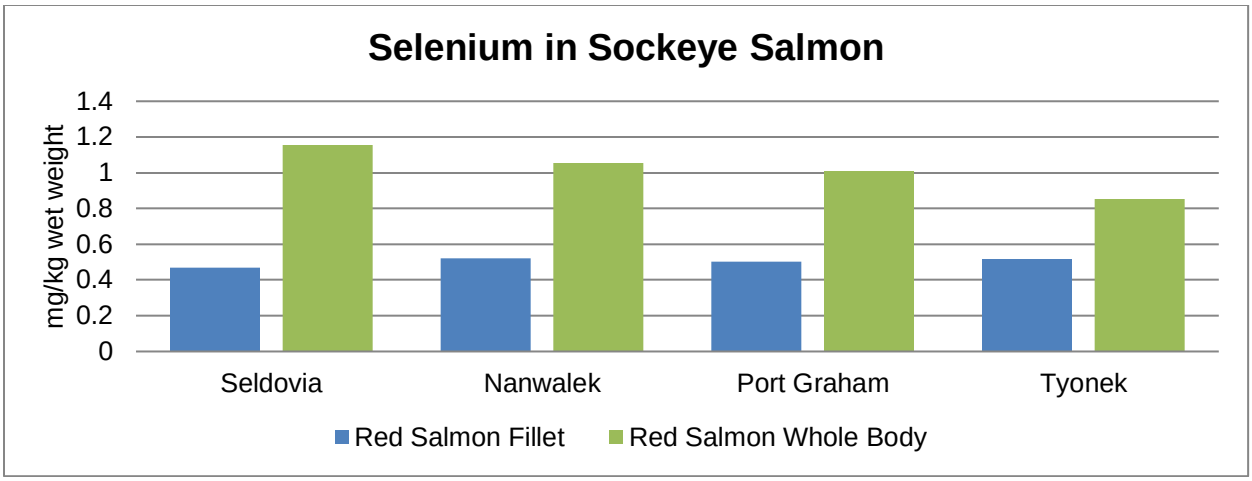


Figure 15: Mean selenium levels in sockeye fillet and whole-body samples

The average amounts of selenium in sockeye salmon fillets were: Seldovia: 0.467444 mg/kg; Nanwalek: 0.520278 mg/kg; Port Graham: 0.501333 mg/kg; and Tyonek: 0.517889 mg/kg. The average amounts of selenium in whole-body sockeye salmon were: Seldovia: 1.155 mg/kg; Nanwalek: 1.055444 mg/kg; Port Graham: 1.010111 mg/kg; and Tyonek: 0.853556 mg/kg.

The highest amount of selenium found in a sockeye salmon fillet was 0.554 mg/kg from Tyonek. The highest amount of selenium found in a whole-body sockeye salmon was 3.0 mg/kg from Seldovia. These are the highest amounts of selenium found in any whole-body or fillet sample tested in ADEC's Fish Tissue Monitoring Program. The lowest amount of selenium found in a sockeye salmon fillet was 0.398 mg/kg from Seldovia. The lowest amount of selenium found in a whole-body sockeye salmon was 0.447 mg/kg from Tyonek.

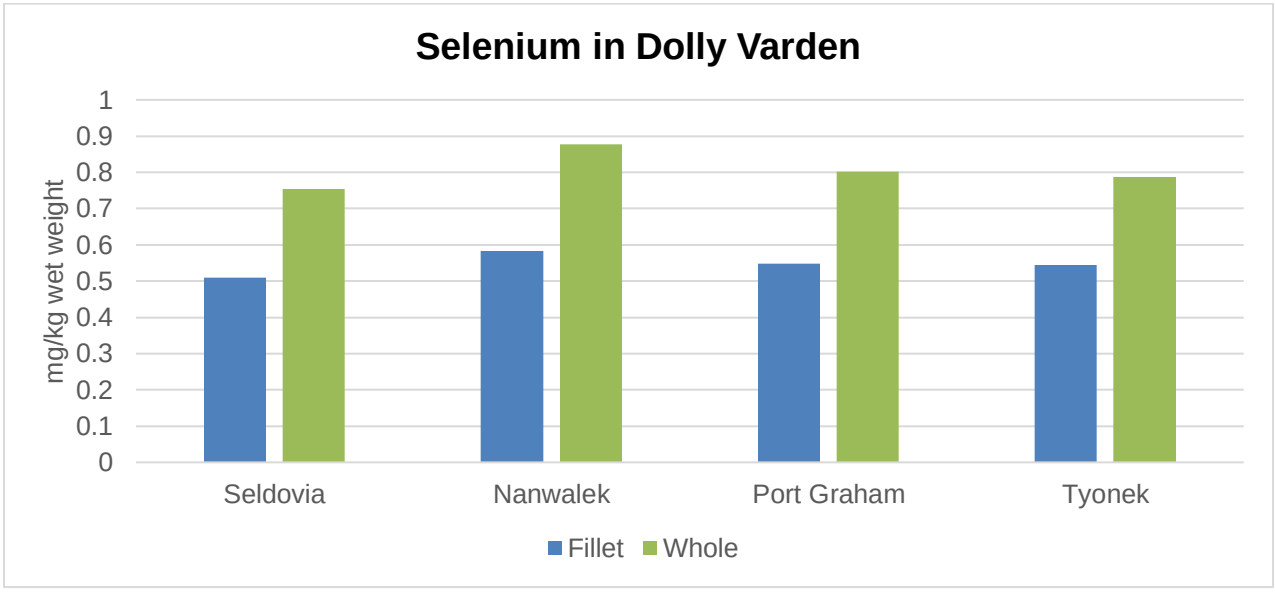


Figure 16: Mean selenium levels in Dolly Varden fillet and whole-body samples

The average amounts of selenium in Dolly Varden fillets were: Seldovia: 0.5098 mg/kg; Nanwalek: 0.5822 mg/kg; Port Graham: 0.547818 mg/kg; and Tyonek: 0.54375 mg/kg. The average amounts of selenium in whole-body Dolly Varden were: Seldovia: were 0.7547 mg/kg; Nanwalek: 0.8766 mg/kg; Port Graham: 0.802818 mg/kg; and Tyonek: 0.78675 mg/kg.

The highest amount of selenium found in a Dolly Varden fillet (0.832 mg/kg) was from Tyonek. This is the highest amount of selenium in any Dolly Varden fillet tested in ADEC's Fish Tissue Monitoring Program. The highest amount of selenium in a whole-body Dolly Varden sample (1.3 mg/kg) was also from Tyonek. The lowest amount of selenium found in a Dolly Varden fillet (0.359 mg/kg) and whole-body sample (0.476 mg/kg) were also from Tyonek.

Organohalogen Compounds

All of the organic compounds tested for are persistent organic pollutants (POPs). Several (PCBs, chlordane, DDT, hexachlorobenzene, mirex, dieldrin, toxaphene, aldrin, heptachlor and endrin) are part of the "Dirty Dozen": twelve POPs originally specified under the Stockholm Convention for reduction or elimination of production, use, and release. Many of these chemicals travel long distances from the area where they were originally released. Through the process of global distillation, these chemicals are particularly distributed to polar areas and show up in high numbers in the people and animals of these areas. Aldrin was also tested for but was not present in any samples from any of the four communities.

Table 6: Mean (SD) (ng/g wet weight) for composite whole-body samples submitted for select organohalogen contaminants

Location	Species	# Fish	% Lipid	Total PCBs	Total PBDEs	Sum Chlordanes	Sum DDT	Sum HCH	Hexachlorobenzene	Mirex	Sum Nonachlor	Dieldrin	Toxaphene
NANWALEK	DOLLY VARDEN	10	2.7	3.26	0.220	0.167	1.787	1.078	0.583	NA	0.398	NA	NA
PORT GRAHAM	DOLLY VARDEN	11	6.14	7.47	0.182	0.195	1.379	0.541	0.819	NA	0.326	0.171	NA
SELDOVIA	DOLLY VARDEN	10	2.63	11.3	0.145	1.10	0.693	0.066	0.474	NA	0.188	0.089	NA
TYONEK	DOLLY VARDEN	4	8.65	11.4	0.547	0.384	1.863	1.487	1.33	NA	0.731	0.249	NA
NANWALEK	RED SALMON	9*	7.05 (0.91)	10.3 (2.40)	0.147 (0.027)	1.057 (0.183)	11.04 (2.72)	1.536 (0.221)	1.62 (0.398)	0.07 (0.013)	1.621 (0.352)	0.377 (0.097)	21.4 (4.03)
PORT GRAHAM	RED SALMON	9*	6.12 (0.85)	6.89 (2.23)	0.152 (0.026)	0.838 (0.149)	6.83 (2.52)	0.770 (0.141)	1.27 (0.21)	0.075 (0.021)	1.135 (0.366)	0.327 (0.056)	14.33 (3.52)
SELDOVIA	RED SALMON	9*	6.49 (0.89)	5.81 (4.43)	0.141 (0.022)	1.02 (0.075)	8.61 (3.30)	1.047 (0.085)	1.40 (0.094)	0.918 1.44	1.240 (0.336)	0.383 (0.019)	15.33 (3.31)
TYONEK	RED SALMON	9*	5.73 (0.84)	5.81 (1.86)	0.152 (0.012)	1.398 (0.285)	10.82 (3.03)	0.597 (0.108)	1.70 (0.132)	0.090 (0.016)	1.582 (0.356)	0.440 (0.051)	17.98 (8.15)

*Three whole body composites of three fish each

1. Total PCBs:

Polychlorinated biphenyls (PCBs) are a group of man-made chemicals. There are a possible 209 PCB congeners, twelve of which are considered to have toxicological significance. PCBs were manufactured from 1929 until 1979, when their manufacture was banned. They were used in many industrial applications, including electrical and heat transfer equipment; pigments and dyes; and plasticizers in paints, plastics, and rubbers. Although they are no longer manufactured, PCBs are present in many products still in use today.

PCBs are still being released into the environment, including through improper and illegal disposal, and leaking or poorly-maintained PCB dump sites. Once in the environment, PCBs can persist for long periods of time and are easily transferred. PCBs have been found in snow and sea water in areas far from where they were released. Due to their ability to be easily transferred, they are found all over the world. PCBs bioaccumulate in fish and marine organisms, causing exposure to people who eat the contaminated organisms. The EPA has set a maximum contaminant level for PCBs in drinking water at 0.0005 mg/L (500 ppt), and the FDA tolerance level for fish is 2 mg/kg.

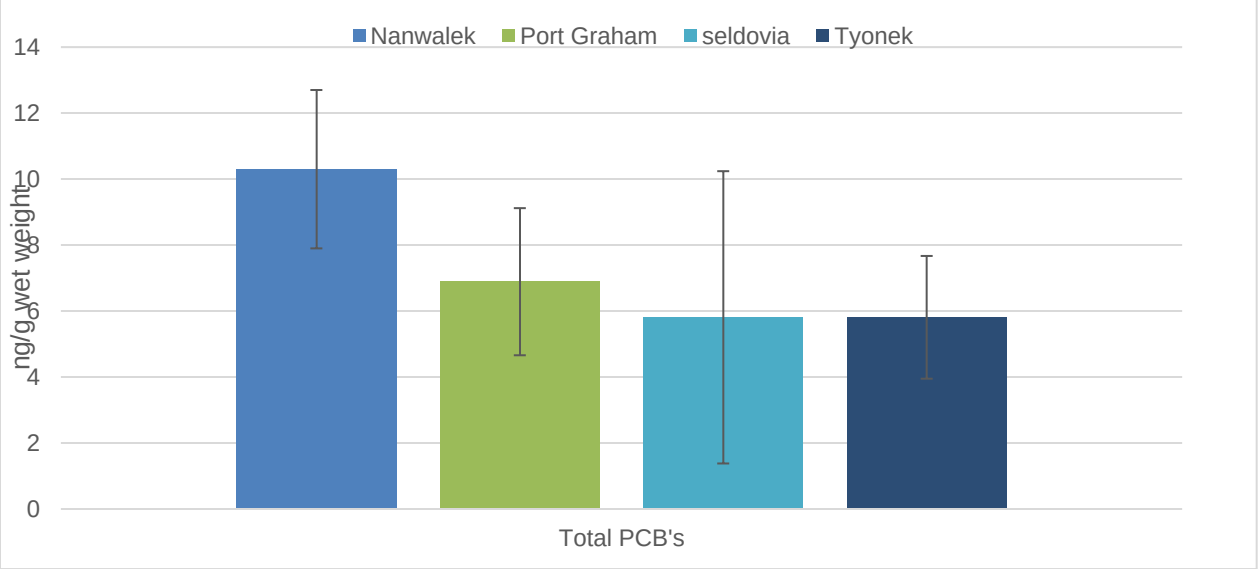


Figure 17: Total PCBs in whole-body sockeye salmon

The average amount of PCBs in whole-body sockeye salmon was: Seldovia: 5.81 ± 4.43 ng/g; Nanwalek: 10.3 ± 2.4 ng/g; Port Graham: 6.89 ± 2.23 ng/g; and Tyonek: 5.81 ± 1.86 ng/g. The community with the highest average of total PCBs in whole-body sockeye salmon was Nanwalek: 10.3 ± 2.4 ng/g. Seldovia and Tyonek both had an average of 5.81 ng/g of PCBs in composite sockeye samples. Seldovia had a standard deviation of 4.43 ng/g and Tyoneks was 1.86 ng/g. Tyonek had the highest total amount of PCBs in a composite sample of whole-body sockeye salmon, with 12,700 pg/g. Port Graham had the lowest total amount of PCBs in a composite sample of whole-body sockeye salmon, with 5290 pg/g.

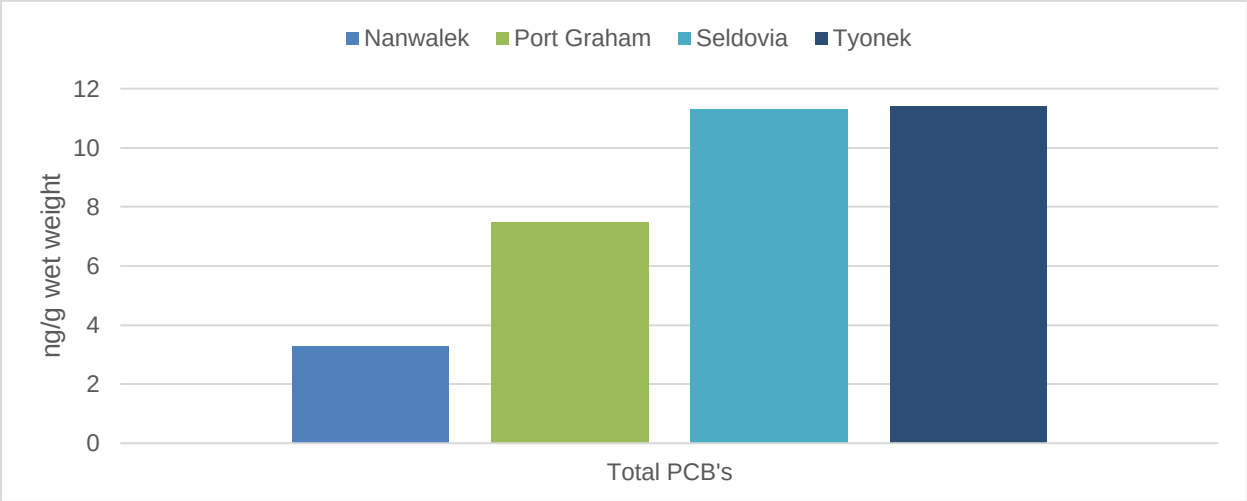


Figure 18: Total PCBs in whole-body Dolly Varden

The community with the highest average of total PCBs in a whole-body Dolly Varden composite sample was Tyonek with 11.4 ng/g. The community with the lowest average of total PCBs in a whole-body Dolly Varden composite sample was Nanwalek with 3.26 ng/g.

2. Total PBDEs:

Polybrominated diphenyl ethers (PBDEs) are man-made flame-retardant chemicals used in plastic and foam products. PBDEs are released into the environment during the production and use of such products. PBDE particles settle on the soil and in the water, where they stick to particles on the bottoms of rivers and lakes. Once in the water, PBDEs can be taken up by fish and bioaccumulate.

There is no definitive information on the health effects of PBDEs on humans, although they have shown to be carcinogenic to rats and mice. They can also cause neurobehavioral alterations and affect the immune system in animals. PBDEs are transferred through breast milk and have been shown to cause neurobehavioral effects in newborn animals. The EPA has listed certain PBDEs as possible human carcinogens.

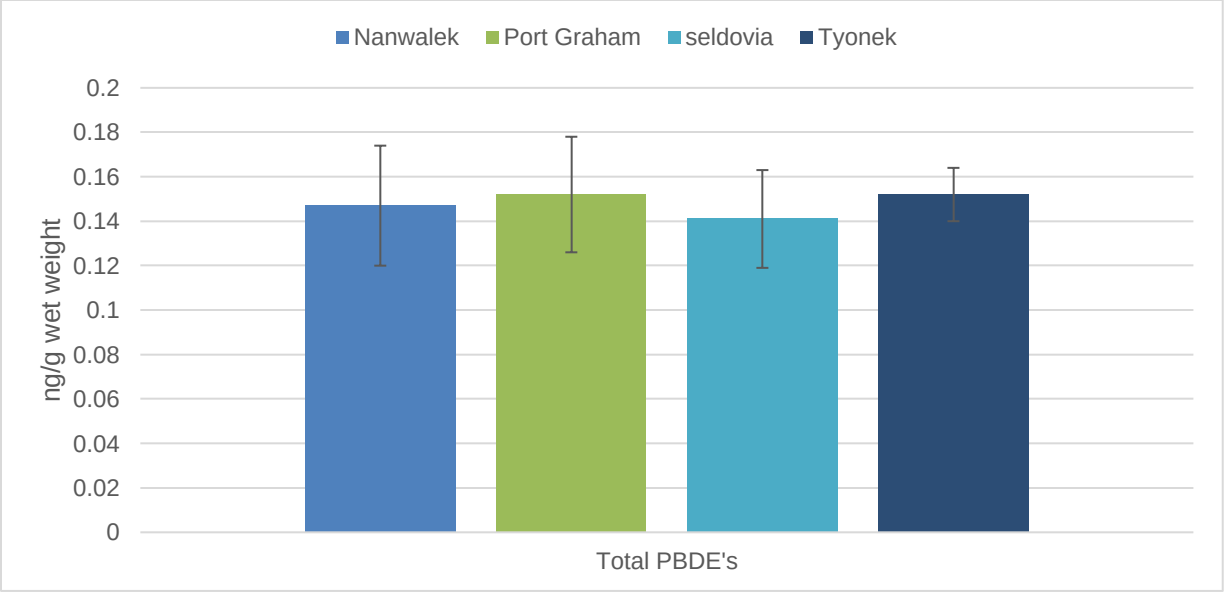


Figure 19: Total PBDEs in whole-body sockeye salmon

The average amount of PBDEs in whole body sockeye salmon was: Seldovia: 0.141 ± 0.022 ng/g; Nanwalek: 0.147 ± 0.027 ng/g; Port Graham: 0.152 ± 0.026 ng/g; and Tyonek: 0.152 ± 0.012 ng/g. Port Graham and Tyonek had the highest average levels of PBDEs in composite sockeye samples, at 0.152 ng/g. The community with the lowest average level of total PBDEs in whole-body sockeye salmon was Seldovia: 0.141 ± 0.022 ng/g. Port Graham had the highest total amount of PBDEs in a composite sample of whole-body sockeye salmon, with 177.848 pg/g. Nanwalek had the lowest total amount of PBDEs in a composite sample of whole-body sockeye salmon with 116.701 pg/g.

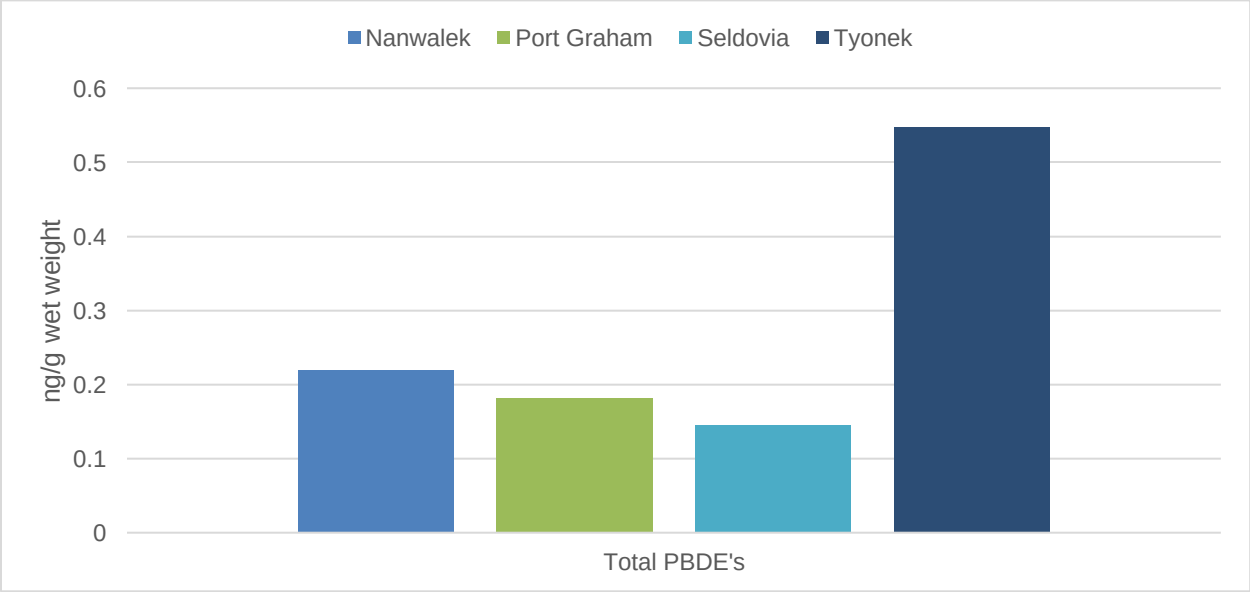


Figure 20: Total PBDEs in whole-body Dolly Varden

The community with the highest average of total PBDEs in whole-body Dolly Varden was Tyonek with 0.547 ng/g. The community with the lowest average amount of total PBDEs in whole-body Dolly Varden was Seldovia with 0.145 ng/g.

3. Sum Chlordane:

Chlordane is a man-made chemical that was used as a pesticide for termites and, before 1978, as an agricultural pesticide as well as on lawns and gardens. Used in the United States from 1948 until its ban in 1988, chlordane can persist for a very long time. Houses and soils treated with chlordane can still cause exposure. Chlordane persists in food to this day due to the amount of farmland treated with the chemical. It has a low potential to move in the soil but has been found in groundwater. Chlordane is categorized as a possible human carcinogen. It has been shown in multiple studies to cause liver cancer in mice and has been implicated in some cases of human cancer. Chlordane bioaccumulates and is highly toxic to fish. The FDA limit for chlordane in fish is 0.3 ppm.

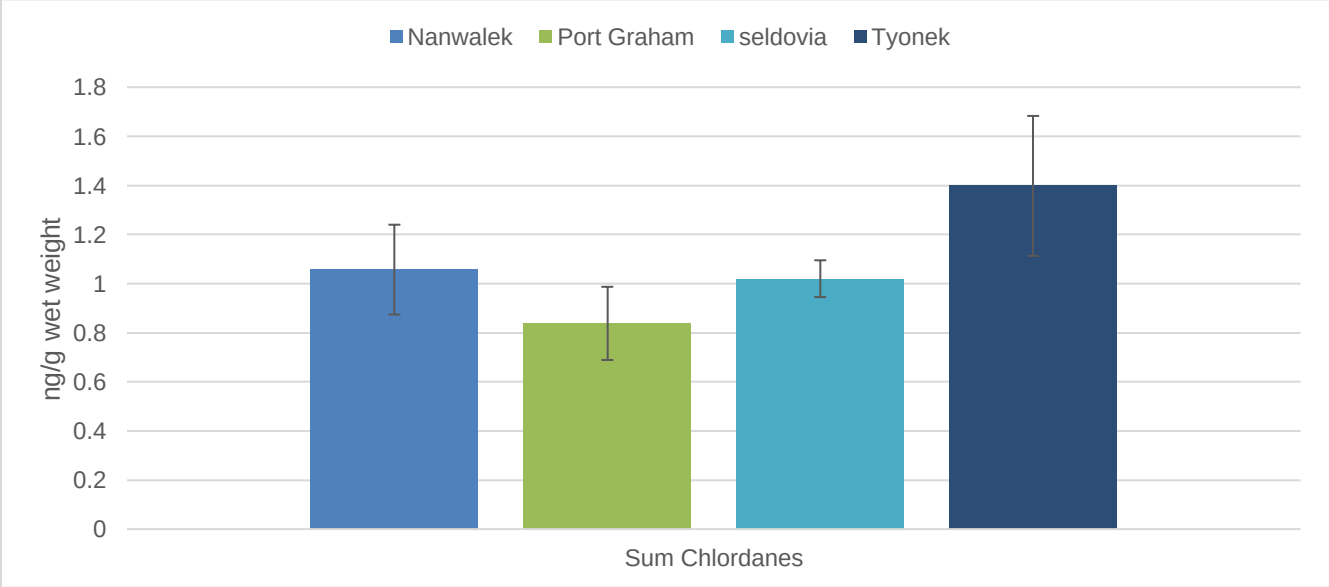


Figure 21: Sum chlordanes in whole-body sockeye salmon

The average amount of chlordane in whole-body sockeye salmon was: Seldovia: 1.02 ± 0.075 ng/g; Nanwalek: 1.057 ± 0.183 ng/g; Port Graham: 0.838 ± 0.149 ng/g; and Tyonek: 1.398 ± 0.285 ng/g. The community with the highest average amount of chlordane in whole-body sockeye salmon was Tyonek: 1.398 ± 0.285 ng/g. The community with the lowest average amount of chlordane in whole-body sockeye salmon was Port Graham: 0.838 ± 0.149 ng/g. Tyonek had the highest amount of chlordane in a composite whole-body sockeye salmon sample with 1.686 ng/g. Port Graham had the lowest amount of chlordane in a composite whole-body sockeye salmon sample with 0.675 ng/g.

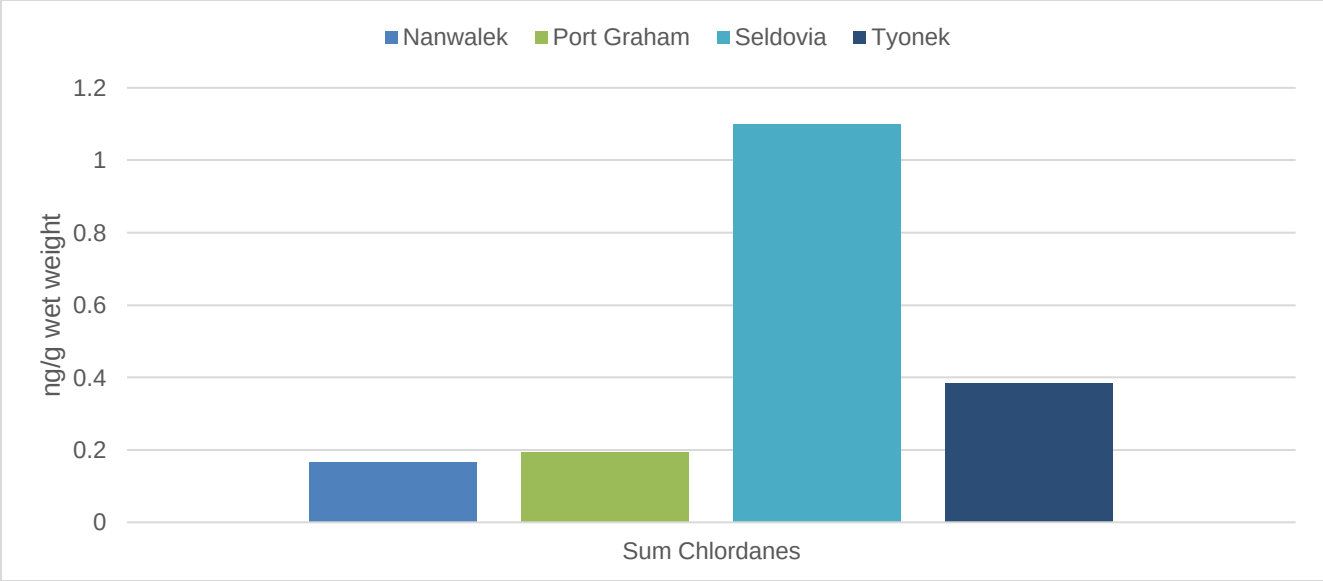


Figure 22: Sum chlordanes in whole-body Dolly Varden

The community with the highest amount of chlordane in a composite sample of whole-body Dolly Varden was Seldovia with 1.10 ng/g. The community with the lowest amount of chlordane in a composite sample of whole-body Dolly Varden was Nanwalek with 00.167 ng/g.

4. Sum DDT:

Dichloro-diphenyl-trichloroethane (DDT) is a man-made insecticide created in 1874. Used heavily in the United States until its ban in 1972, DDT can still be produced in the United States, but can only be sold to foreign countries. DDT was used as a pesticide for agriculture, lawn, garden, and military purposes, and was very effective in battling insect-borne diseases such as malaria and typhus. Its broad use led many pest insects to develop a resistance. DDT is persistent in the environment and biomagnifies in animals. DDT can be moderately acutely toxic to mammals, including humans. In laboratory tests, animals exposed developed hyperexcitability, tremors, incoordination, and convulsions. Those given fatal doses had developed liver lesions. People exposed while working with DDT reported a prickling sensation of the mouth, nausea, dizziness, confusion, headache, lethargy, incoordination, vomiting, fatigue and tremors. DDT has been shown to increase cancer risk in animal laboratory tests and has been classified as a possible human carcinogen. The FDA limit for DDT in fish is 5 ppm.

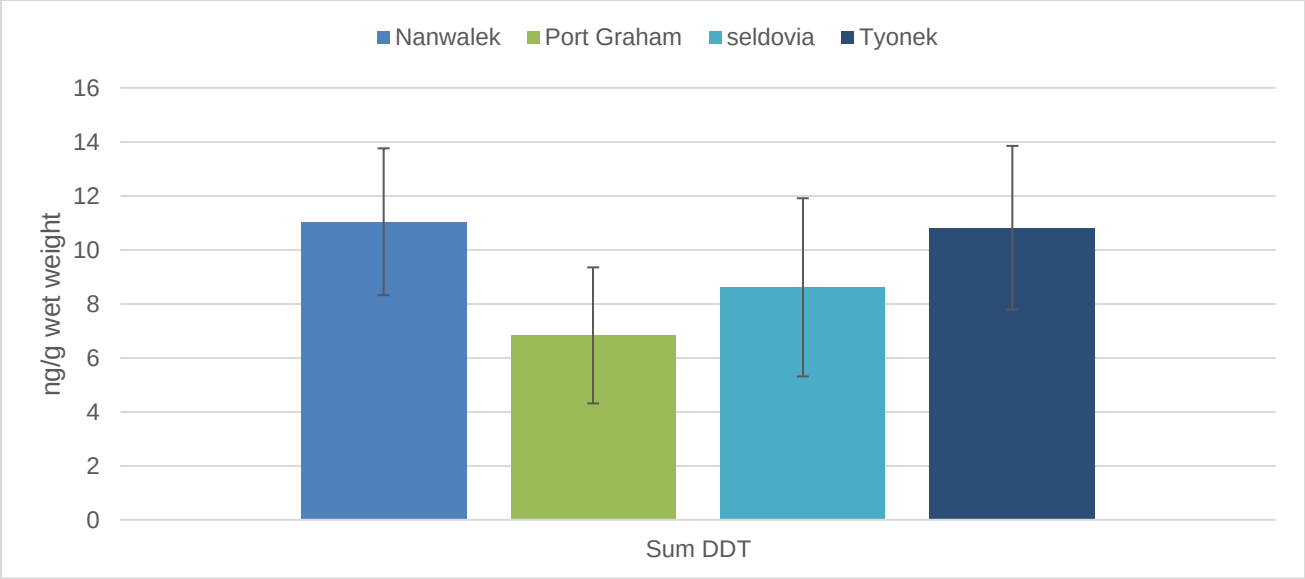


Figure 23: Sum DDT in whole-body sockeye salmon

The average amount of DDT in whole-body sockeye salmon was: Seldovia: 8.61 ± 3.30 ng/g; Nanwalek: 11.04 ± 2.72 ng/g; Port Graham: 6.83 ± 2.52 ng/g; and Tyonek: 10.82 ± 3.03 ng/g. The community with the highest average amount of DDT in whole-body sockeye salmon was Nanwalek: 11.04 ± 2.72 ng/g. The community with the lowest average amount of DDT in whole-body sockeye salmon was Port Graham: 6.83 ± 2.52 ng/g. Tyonek had the highest amount of DDT found in a composite whole-body sockeye salmon sample with 13.937 ng/g. Port Graham had the lowest amount of DDT found in a composite whole-body sockeye salmon sample with 5.154 ng/g.

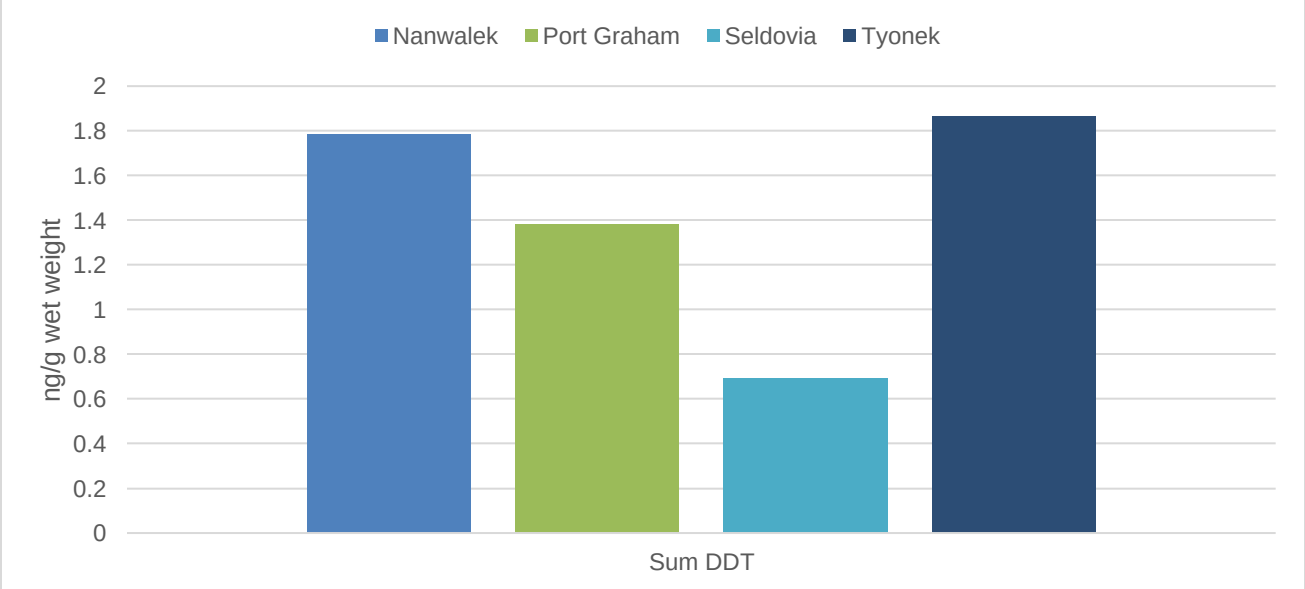


Figure 24: Sum DDT in whole-body Dolly Varden

The community with the highest amount of DDT in a composite whole-body Dolly Varden sample was Tyonek with 1.863 ng/g. The community with the lowest amount of DDT in a composite whole-body Dolly Varden sample was Seldovia with 0.693 ng/g.

5. Sum HCH:

Sum hexachlorocyclohexane (HCH) is the sum of four isomers of HCH: alpha-HCH, beta-HCH, delta-HCH, and gamma-HCH (AKA lindane). Lindane is a man-made chemical used as an agricultural pesticide, as well as in a pharmaceutical shampoo for the treatment of lice and scabies. Alpha-HCH and beta-HCH are by-products from the production of lindane. Alpha and beta-HCH don't have the insecticidal properties lindane has, and are much more toxic. During the 1940s and 1950s, alpha- and beta-HCH were dumped in open heaps for disposal, which led to soil and water contamination. Oral exposure to lindane in humans causes effects on the nervous system, cardiovascular system, and musculoskeletal system, as well as vomiting and nausea. Chronic exposure to lindane through inhalation has been associated with effects on the liver, blood, nervous, cardiovascular, and immune systems. The EPA recommends a drinking water limit for HCH of 0.0002mg/L.

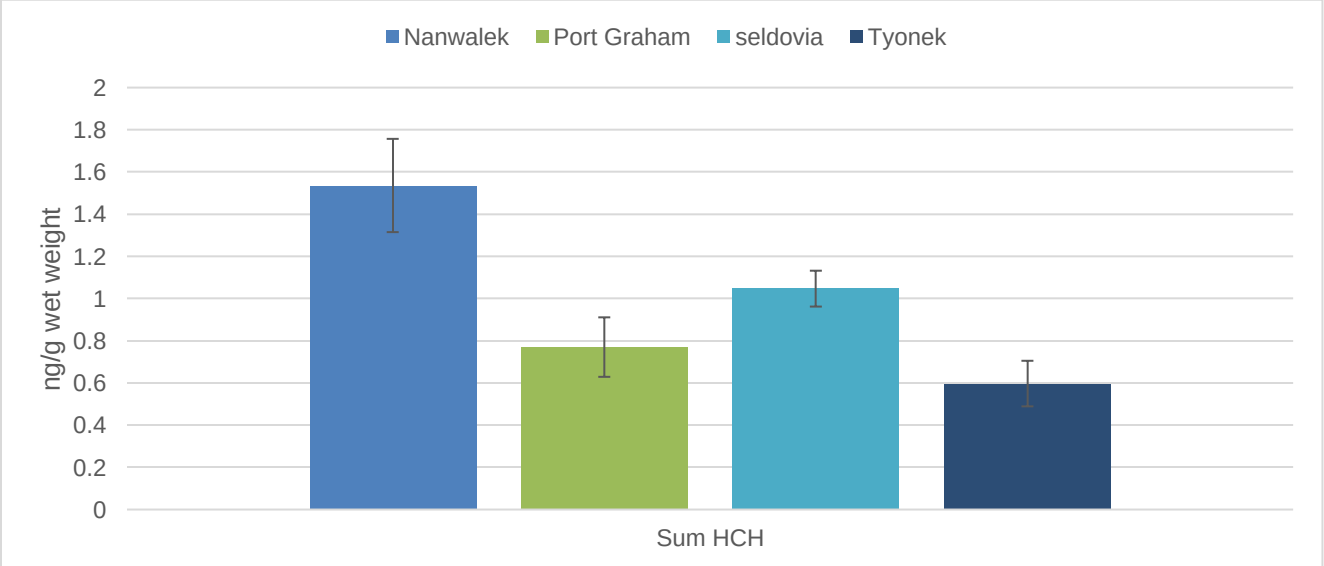


Figure 25: Sum HCH in whole-body sockeye salmon

The average amount of HCH in whole-body sockeye salmon was: Seldovia: 1.047 ± 0.085 ng/g; Nanwalek: 1.536 ± 0.221 ng/g; Port Graham: 0.770 ± 0.141 ng/g; and Tyonek: 0.597 ± 0.108 ng/g. The community with the highest average amount of HCH in whole-body sockeye salmon was Nanwalek: 1.536 ± 0.221 ng/g. The community with the lowest average amount of HCH in whole-body sockeye salmon was Tyonek: 0.597 ± 0.108 ng/g. Nanwalek had the highest amount of HCH in a composite whole-body sockeye salmon sample with 1.791

ng/g. Tyonek had the lowest amount of HCH in a composite whole-body sockeye salmon sample with 0.485 ng/g.

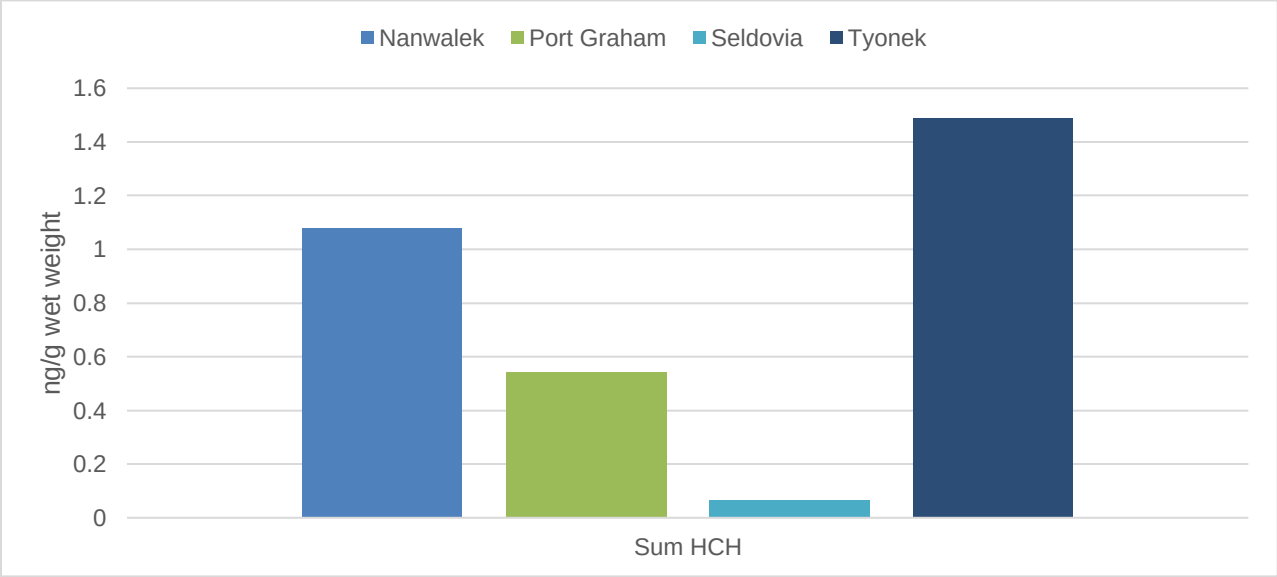


Figure 26: Sum HCH in whole-body Dolly Varden

The community with the highest amount of HCH in a composite whole-body Dolly Varden sample was Tyonek with 1.487 ng/g. The community with the lowest amount of HCH in a composite whole-body Dolly Varden sample was Seldovia with 0.066 ng/g.

6. Hexachlorobenzene:

Hexachlorobenzene is a pesticide that was widely used in the United States until its ban in 1965. It was banned after it was discovered in food crops, and found to be very persistent in the environment. It is a by-product of the manufacture of other chemicals. The EPA maximum contaminant level for hexachlorobenzene is 0.001 mg/L.

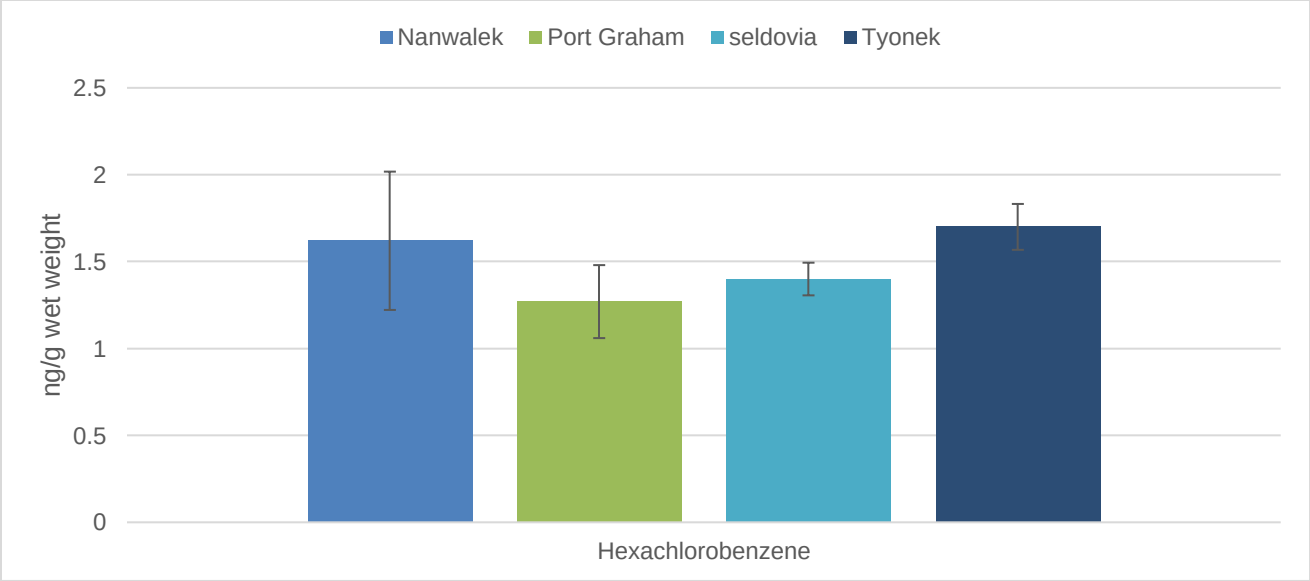


Figure 27: Hexachlorobenzene in whole-body sockeye salmon

The average amount of Hexachlorobenzene in whole body sockeye salmon was: Seldovia: 1.40 ± 0.094 ng/g; Nanwalek: 1.62 ± 0.398 ng/g; Port Graham: 1.27 ± 0.21 ng/g; and Tyonek: 1.70 ± 0.132 ng/g. The community with the highest average amount of hexachlorobenzene in whole-body sockeye salmon was Tyonek with 1.7 ± 0.132 ng/g. The community with the lowest average amount of hexachlorobenzene in whole-body sockeye salmon was Port Graham: 1.27 ± 0.21 ng/g. Nanwalek had the highest amount of hexachlorobenzene found in a composite whole-body sockeye salmon sample with 1.95 ng/g. Port Graham had the lowest amount of hexachlorobenzene found in a composite whole-body sockeye salmon sample with 1.11 ng/g.

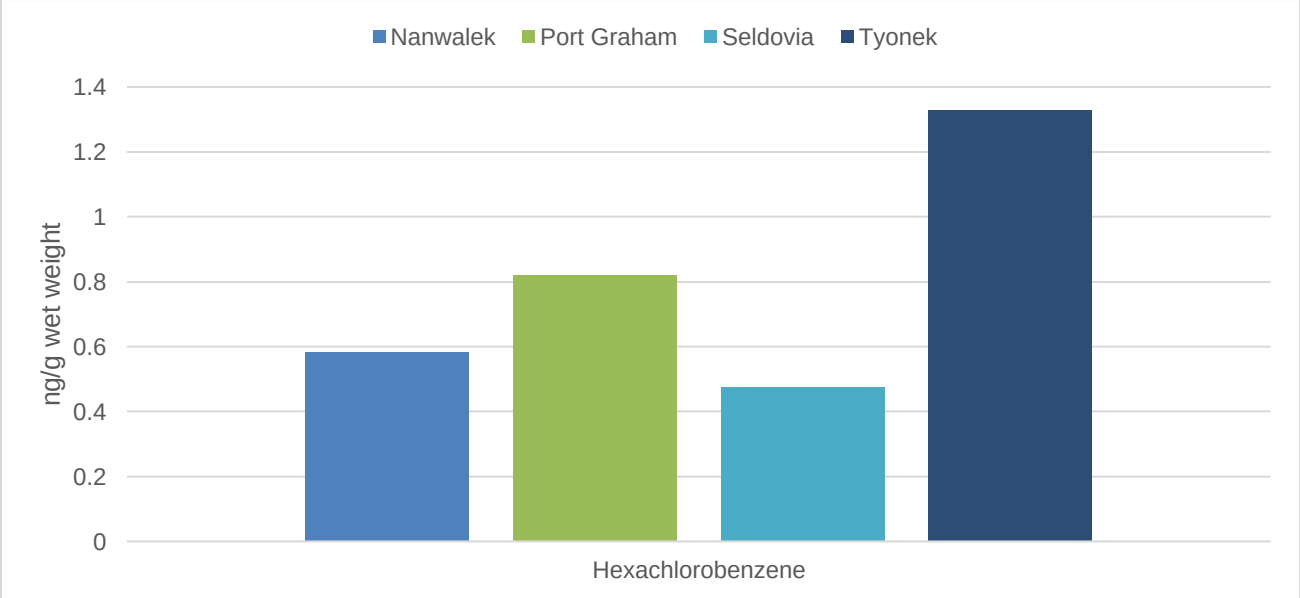


Figure 28: Hexachlorobenzene in whole-body Dolly Varden

The community with the highest amount of hexachlorobenzene found in a composite whole-body Dolly Varden sample was Tyonek with 1.33 ng/g. The community with the lowest amount of hexachlorobenzene found in a composite whole-body Dolly Varden sample was Seldovia with 0.474 ng/g.

7. Mirex:

Mirex was originally commercialized for fire ant control and later used in fire-retardant plastic, rubber, paint, paper, and electrical appliances until it was banned in 1978. Mirex was banned after it was found to be bioaccumulative and highly toxic to marine crustaceans. The EPA has set a limit for mirex in surface waters of 1.0 part per trillion. The FDA limit for fish is 0.1 ppm. There is no evidence of its effects on humans, but several studies on animals, particularly rats and mice, show effects on the liver, kidneys, stomach, intestine, eyes, thyroid, reproductive and nervous system.

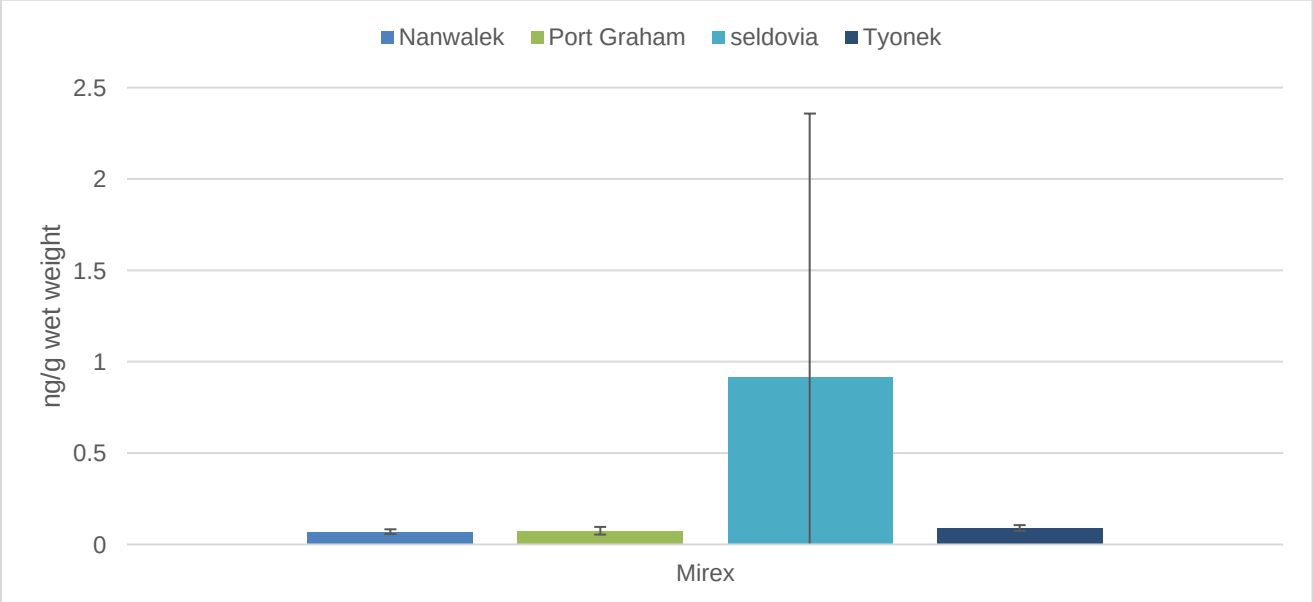


Figure 29: Mirex in whole-body sockeye salmon

The average amount of Mirex in whole-body sockeye salmon was: Seldovia: 0.918 ± 1.44 ng/g; Nanwalek: 0.07 ± 0.013 ng/g; Port Graham: 0.075 ± 0.021 ng/g; and Tyonek: 0.090 ± 0.016 ng/g. The community with the highest average amount of mirex in whole-body sockeye salmon was Seldovia: 0.918 ± 1.44 ng/g. The community with the lowest average amount of mirex in whole-body sockeye salmon was Nanwalek: 0.07 ± 0.013 ng/g. Seldovia had the highest amount of mirex found in a composite whole-body sockeye salmon sample with 2.59 ng/g. Nanwalek had the lowest amount of mirex found in a composite whole-body Sockeye salmon sample with 0.056 ng/g. Mirex was not detectable in Dolly Varden from any of the four communities.

8. Sum Nonachlor:

Sum nonachlor is the combination of trans-nonachlor and cis-nonachlor. It is a component of the insecticide chlordane. Nonachlor has been found in many marine and arctic species, including polar bears and ringed seals. Nonachlor is transferred to people who practice subsistence lifestyles, eating indigenous foods such as seal. Studies have shown a positive association between nonachlor exposure and insulin-resistant diabetes.

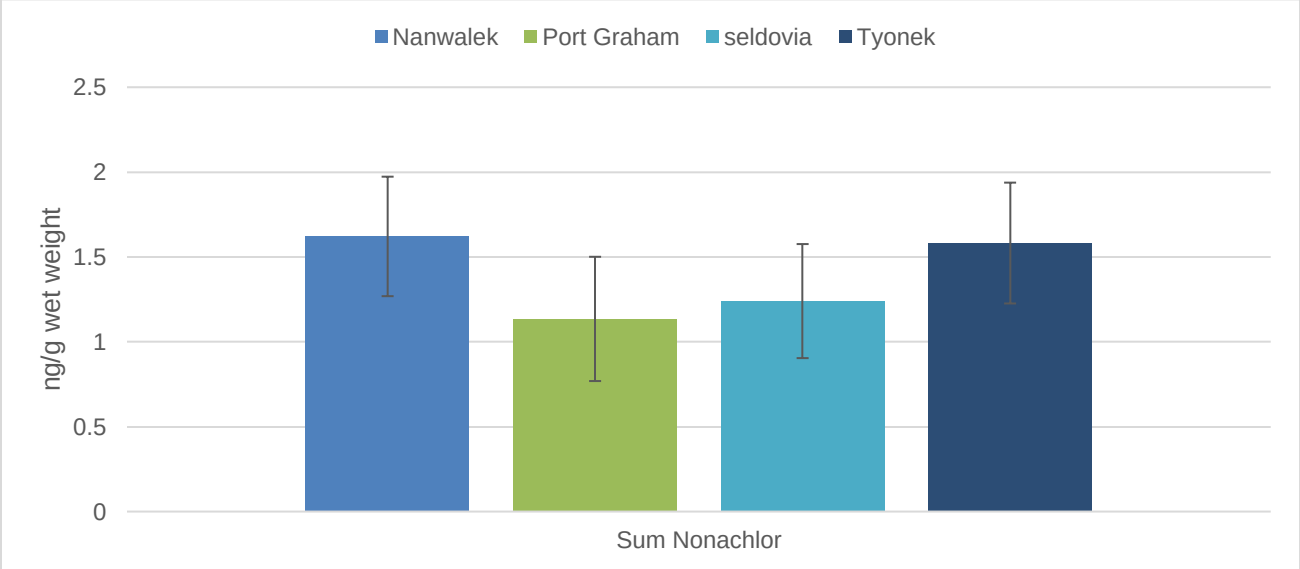


Figure 30: Sum nonachlor in whole-body sockeye salmon

The average amount of Nonachlor in whole-body sockeye salmon was: Seldovia: 1.24 ± 0.336 ng/g; Nanwalek: 1.621 ± 0.352 ng/g; Port Graham: 1.135 ± 0.366 ng/g; and Tyonek: 1.582 ± 0.356 ng/g. The community with the highest amount of nonachlor in whole-body sockeye salmon was Nanwalek: 1.621 ± 0.352 ng/g. The community with the lowest amount of nonachlor in a whole-body sockeye salmon was Port Graham: 1.135 ± 0.366 ng/g. Tyonek had the highest amount of nonachlor found a composite whole-body sockeye salmon sample with 1.939 ng/g. Port Graham had the lowest amount of nonachlor found in a composite whole-body sockeye salmon sample with 0.882 ng/g.

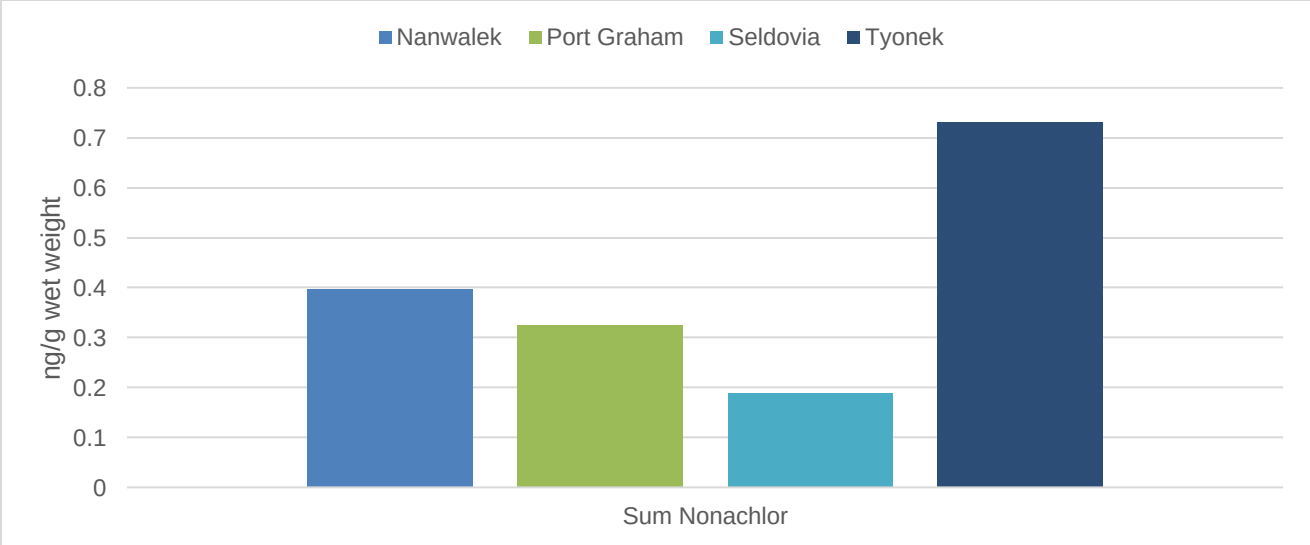


Figure 31: Sum nonachlor in whole-body Dolly Varden

The community with the highest average amount of nonachlor in whole-body Dolly Varden was Tyonek with 0.731 ng/g. The community with the lowest average amount of nonachlor found in whole-body Dolly Varden was Seldovia with 0.188 ng/g.

9. Dieldrin:

Dieldrin was an insecticide used from the 1950s to 1970s. Commonly used on corn and cotton, its use was banned in 1974 with the exception of termite control. Dieldrin has been found to be bioaccumulative. Exposure to large amounts of dieldrin can cause convulsions and death. Chronic exposure has been shown to cause headaches, dizziness, irritability, vomiting, and uncontrolled muscle movements. The FDA limit for dieldrin in fish is 0.3 ppm.

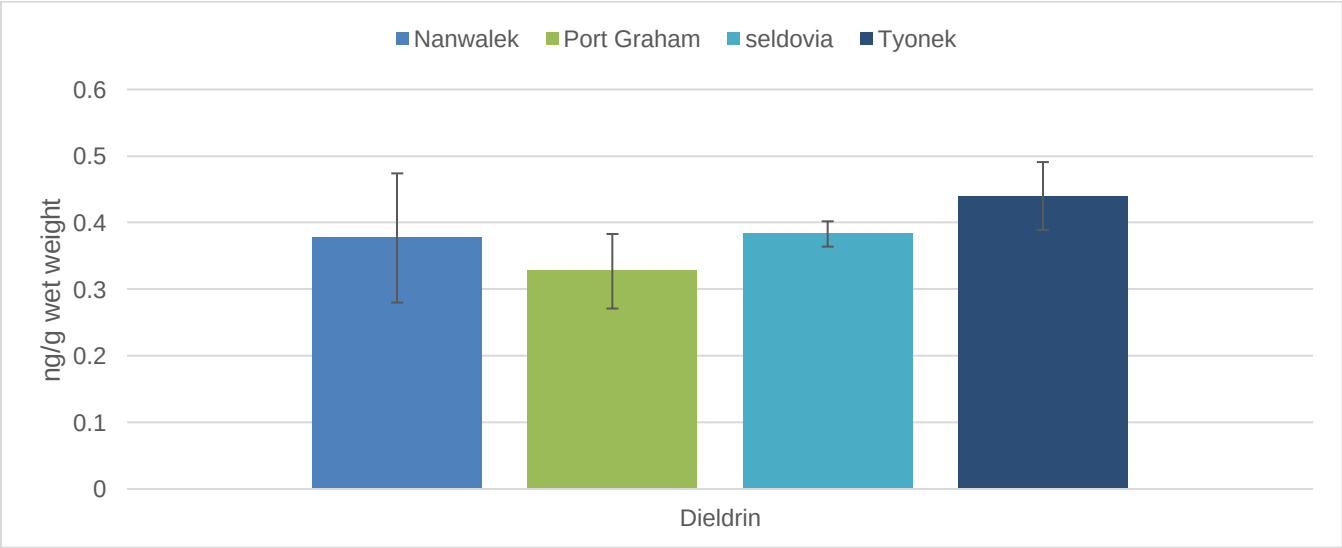


Figure 32: Dieldrin in whole-body sockeye salmon

The average amount of dieldrin in whole-body sockeye salmon was: Seldovia: 0.383 ± 0.019 ng/g; Nanwalek: 0.377 ± 0.097 ng/g; Port Graham: 0.327 ± 0.056 ng/g; and Tyonek: 0.440 ± 0.051 ng/g. The community with the highest average amount of dieldrin in whole-body sockeye salmon was Tyonek: 0.440 ± 0.051 ng/g. The community with the lowest average amount of dieldrin in whole-body sockeye salmon was Port Graham: 0.327 ng/g ± 0.056 ng/g. Tyonek had the highest amount of dieldrin found in a composite whole-body sockeye salmon sample with 0.493 ng/g. Port Graham had the lowest amount of dieldrin found in a composite whole-body sockeye salmon sample with 0.27 ng/g.

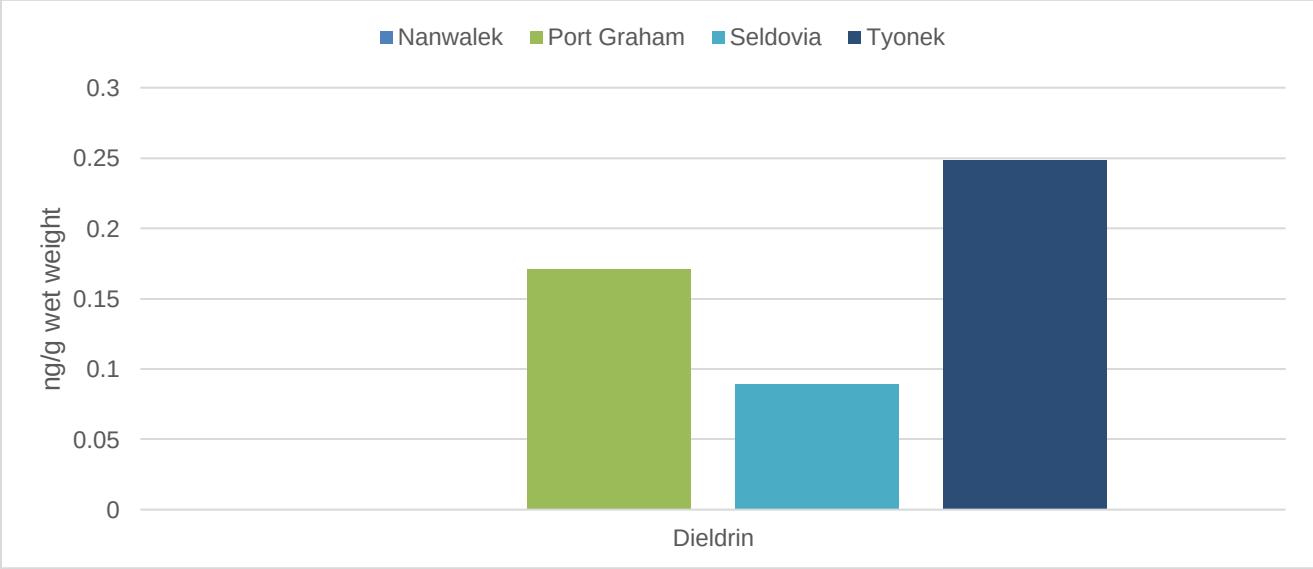


Figure 33: Dieldrin in whole-body Dolly Varden

The community with the highest average amount of dieldrin in whole-body Dolly Varden was Tyonek with 0.249 ng/g. The community with the lowest average amount of dieldrin found in whole-body Dolly Varden was Nanwalek, where dieldrin was not detected.

10. Toxaphene:

Toxaphene was used extensively as an insecticide between 1947 and 1980. Its use was banned by the EPA in 1990, and it was banned globally in 2001. Toxaphene was used on cotton, corn, fruit, vegetables, and grains as an insecticide, as well as on livestock to protect from lice, fleas, ticks, mange, and scab mites. Toxaphene was also used on flowers due to its low toxicity to bees. Numerous deaths have been reported due to ingestion of toxaphene. Ingestion of toxaphene overstimulates the central nervous system and causes damage to the kidneys, liver, spleen, and adrenal gland. The effects of chronic exposure to toxaphene are unknown, but animal tests have shown effects on development and the nervous system, as well as possible carcinogenic effects. The US EPA has a recommended limit for toxaphene in drinking water of 0.01 mg/L. The FDA recommended limit for toxaphene in bottled water is 0.003 mg/L.

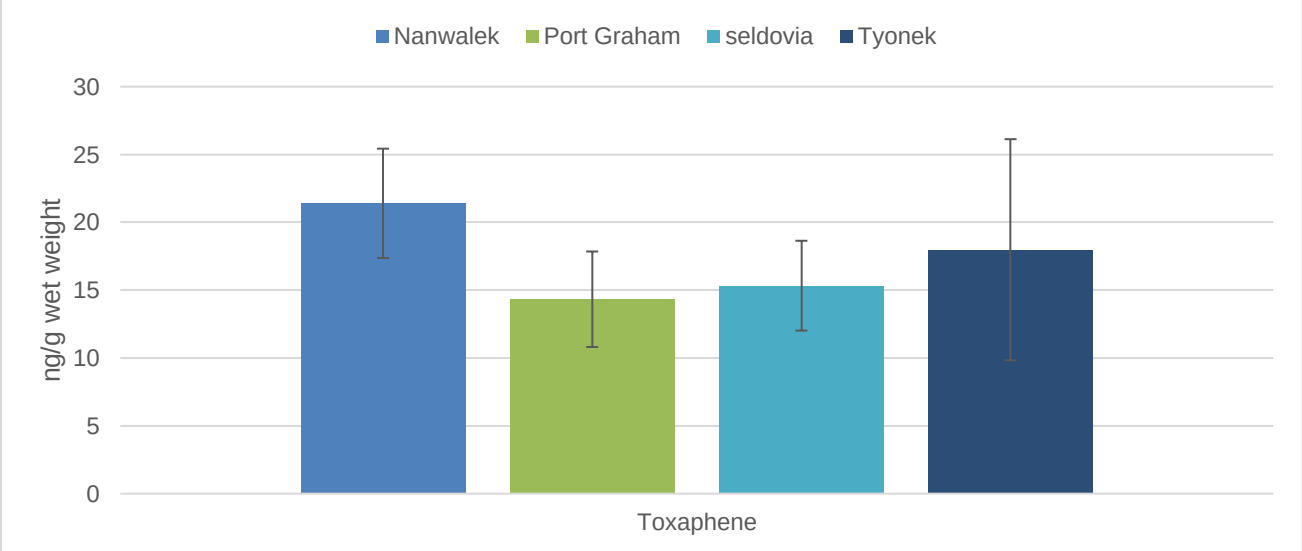


Figure 34: Toxaphene levels in whole-body sockeye salmon

The average amount of toxaphene in whole-body sockeye salmon was: Seldovia: 15.33 ± 3.31 ng/g; Nanwalek: 21.4 ± 4.03 ng/g; Port Graham: 14.33 ± 3.52 ng/g; and Tyonek: 17.98 ± 8.15 ng/g. The community with the highest average amount of toxaphene in whole-body sockeye salmon was Nanwalek with 21.4 ng/g ± 4.03 ng/g. The community with the lowest average amount of toxaphene in whole-body sockeye salmon was Port Graham with 14.33 ± 3.52 ng/g. Tyonek had the highest amount of toxaphene found in a composite whole-body sockeye salmon sample with 25.2 ng/g. Port Graham had the lowest amount of toxaphene found in a composite whole-body sockeye salmon sample with 9.15 ng/g.

Toxaphene was not detectable in Dolly Varden from any of the four communities.

11. Heptachlor:

Heptachlor was widely manufactured and used as an insecticide. In 1988 the use of heptachlor was banned in the U.S. with the exception of fire ant control in underground power transformers. The FDA has a limit of 0.3 mg/kg of heptachlor or heptachlor epoxide (an oxidation product of heptachlor) in raw seafood. The FDA limit for heptachlor in fish is 0.3 ppm.

Heptachlor was found in composite sockeye samples from all communities with the exception of Nanwalek. Heptachlor epoxide was found in one composite sockeye sample from Port Graham with 0.114 ng/g.

Heptachlor was found in all three composite sockeye samples from Port Graham with an average of 0.0336 ng/g. One composite sockeye and one composite Dolly Varden sample from Seldovia had 0.045 ng/g and 0.043 ng/g of heptachlor respectively. Two composite sockeye samples from Tyonek had detectable amounts of heptachlor (0.027 and 0.028 ng/g).

12. Endrin:

The production and use of endrin, widely used as a pesticide, was banned in 1986. There are no regulations on the amount of endrin in foods. Endrin was found in two composite sockeye samples from Tyonek, with levels of 0.14 ng/g and 0.106 ng/g. The US EPA has a proposed limit for endrin in drinking water of 0.0002 mg/L, and has a limit for ambient water quality of 0.001 mg/L.

13. Aldrin:

Aldrin was tested for but not found in any sockeye or Dolly Varden sample from any of the four communities. The FDA limit for aldrin in fish is 0.3 ppm.

Discussion

Although there were both sockeye and Dolly Varden samples with higher than average ADEC FTMP amounts of contaminants, no individual or composite sample of sockeye showed amounts exceeding FDA action levels or EPA chronic consumption threshold values for heavy metals or PCB congeners, PBDEs, or organochlorine pesticides.

There is no apparent correlation between the length or weight of the sockeye salmon sampled and the amount of metals accumulated. Neither was there an apparent correlation between length and weight and the amount of PCB congeners, PBDEs, or organochlorine pesticides accumulated.

Because the Dolly Varden were composited into one sample from each community, there is no data to determine a correlation between weight, length, or age and the levels of accumulated PCB congeners, PBDEs, or organochlorine pesticides. Individual samples, however, were tested for metals. The only apparent correlation between weight, length, or age on the accumulation of metals in sampled Dolly Varden is with a twenty-year-old Dolly Varden, which had 0.0748 mg/kg of lead, nearly twice which of the next-highest amount detected (0.0455 mg/kg). That fish was seven years old and also from Seldovia.

One Seldovia sockeye salmon had a measurable amount of lead in the fillet, but lead was not detected in any whole-body samples. Conversely, Tyonek sockeye salmon had measurable amounts of lead in whole-body samples but not fillets. Whole-body Dolly Varden from Seldovia had measurable amounts of lead and two at or above the reporting limit. This is cause for concern as these were the only fish with measurable amounts other than two other samples from separate communities. Dolly Varden from Jakolof are a heavily-used resource as they are caught and eaten year-round. The most common way of preparing Dolly Varden is to gut the fish, then bake or fry the fish whole. During the summer months,

ocean-run Dolly Varden are caught at local beaches, and ice fishing for Dolly Varden in the winter has been and is becoming more popular each year.

The sockeye salmon collected for this study that had the highest amounts of metals in ADEC's Fish Tissue Monitoring Program were:

- a whole-body sample from Seldovia with 0.12 mg/kg of cadmium;
- a whole-body sample from Seldovia with 25.5 mg/kg of copper;
- a whole-body sample from Tyonek with 0.0552 mg/kg of mercury;
- a fillet sample from Tyonek with 0.554 mg/kg of selenium;
- a whole-body from Seldovia with 3.0 mg/kg of selenium.

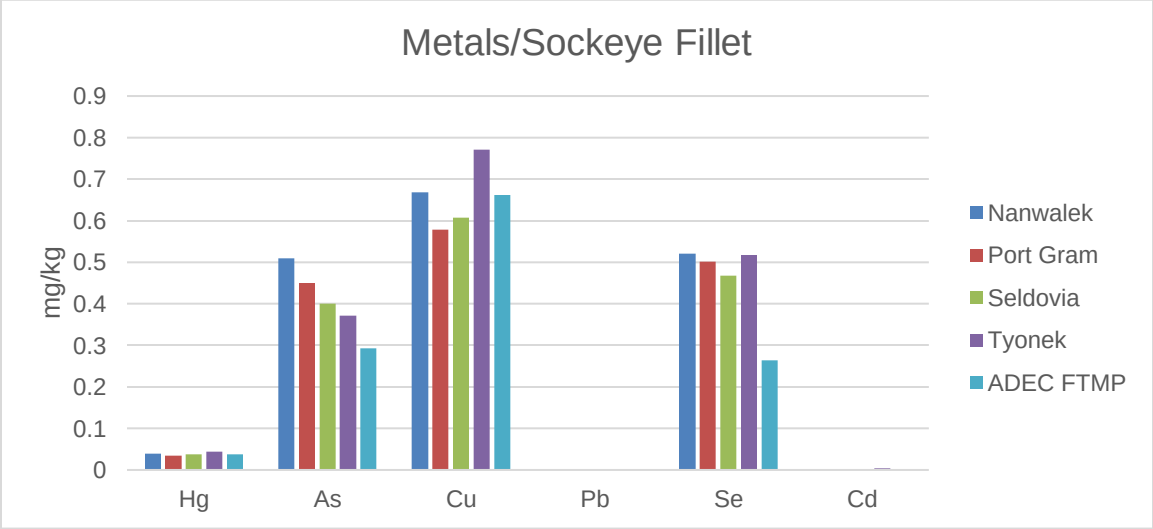


Figure 35: Metals in sockeye salmon fillets compared to FTMP averages

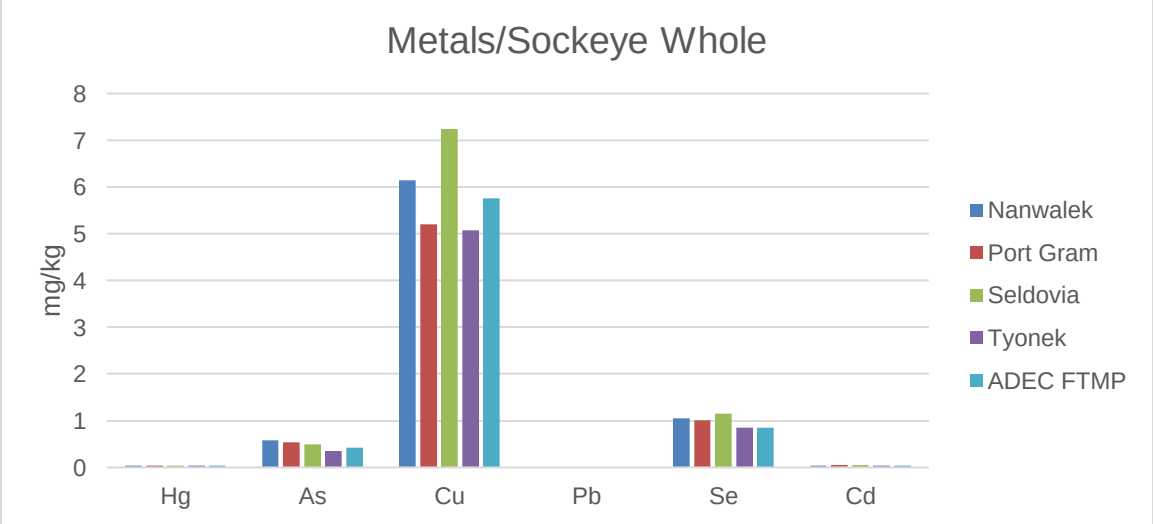


Figure 36: Metals in whole-body sockeye salmon compared to FTMP averages

Dolly Varden collected for this study that had the highest amounts of metals in ADEC's Fish Tissue Monitoring Program were:

- a fillet sample with 1.13 mg/kg of copper from Nanwalek;

- a whole-body sample with 1.65 mg/kg of copper from Nanwalek;
- a fillet sample with 0.832 mg/kg of selenium from Tyonek.

Dolly Varden collected for this study that had the lowest amounts of metals in ADEC's Fish Tissue Monitoring Program were:

- a fillet sample from Seldovia with 0.0084 mg/kg of mercury;
- a whole-body sample from Seldovia with 0.0079 mg/kg of mercury.

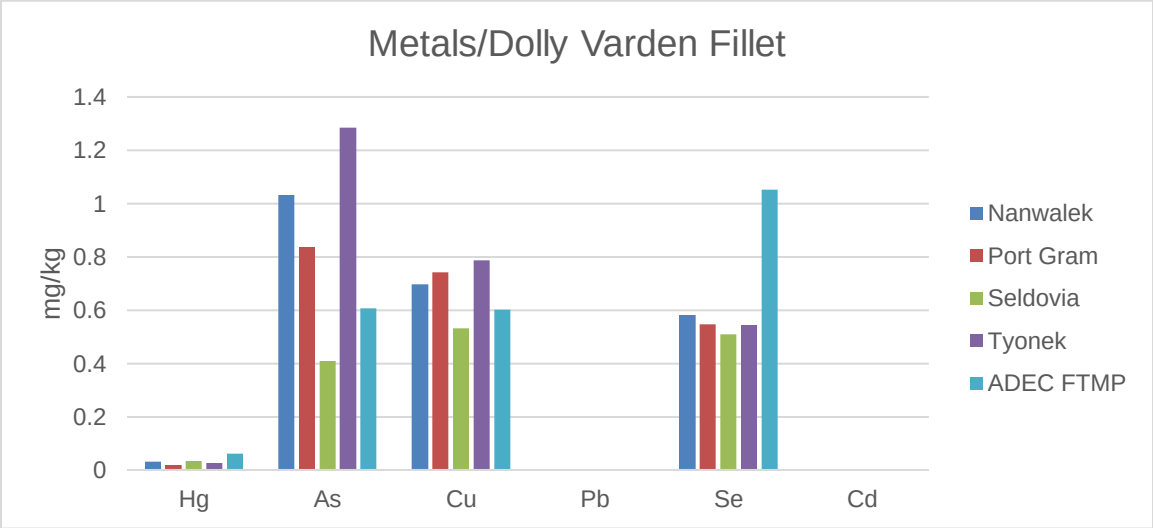


Figure 37: Metals in Dolly Varden fillets compared to FTMP averages

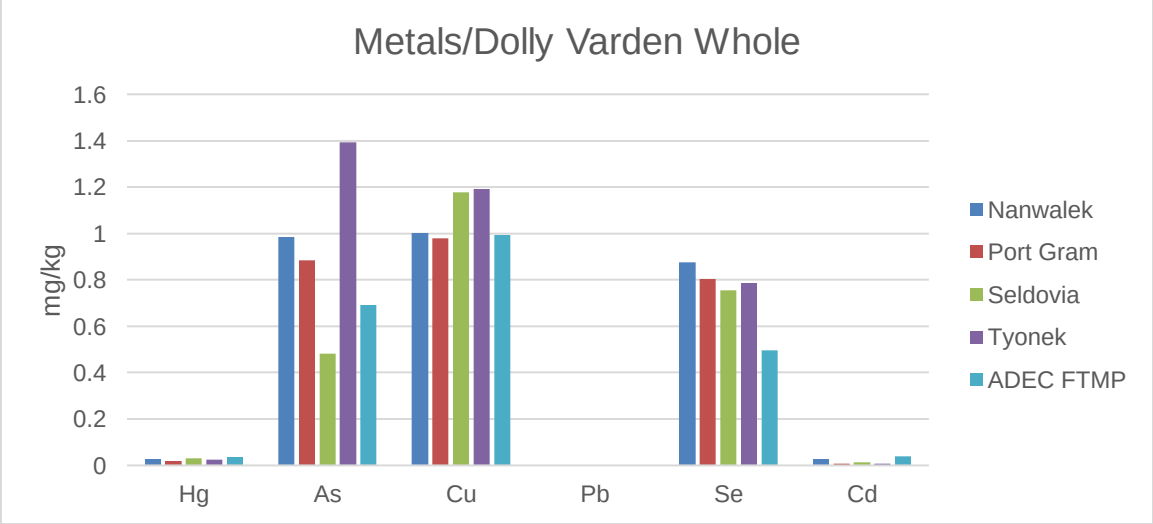


Figure 38: Metals in whole-body Dolly Varden compared to FTMP averages

Average Daily Dose

In 2012 Seldovia Village Tribe performed an assessment of the consumption of subsistence foods by tribal members in Cook Inlet. In this study the same four communities were surveyed. The results of the surveys revealed the average daily fish consumption rate was 94.8 g/day and a 95th percentile consumption

rate of 247 g/day by Cook Inlet tribal members. For the purpose of this study the ingestion/consumption rates (IR) of 94.8 and 247 grams per day will be used in the equation below. The EPA consumption rate for the general public of 17.5 g/day and 142.2 g/day for subsistence fishers will also be used for comparison. *The example used is the highest amount of copper found in a whole body sockeye sample from Seldovia.

Example:

0.0302 = (25.5*10^-3*94.8*365*70) / (80*25,550)

ADD = (C*CF*IR*EF*ED) / (BW*AT)

US Environmental Protection Agency. 1992. Guidelines for Exposure Assessment. Washington, D.C. EPA/600/Z-92/001

ADD	-	Average daily dose of a specific chemical (mg/kg/day)
C	-	Chemical concentration in fish tissue (mg/kg)
CF	-	Conversion factor (10^-3 for metals, 10^-6 for organics)
IR	-	Consumption rate (94.8/247 g/day)
EF	-	Exposure frequency (365)
ED	-	Exposure duration (70 years)
BW	-	Body weight (80 kg)
AT	-	Averaging time for exposure duration (25,550 days)

Averaging time (AT) was determined by multiplying the average lifespan (70 years) by the number of days in a year (365).

Table 7: Average daily dose of metal contaminants in sockeye salmon fillets

Metal Contaminant Average Daily Doses for Sockeye Fillets				
	Nanwalek	**Port Graham**	**Seldovia**	**Tyonek**
Mercury	mg/kg/day			
94.8 g/day	0.00004622	0.00004165	0.00004432	0.00005261
247 g/day	0.00012041	0.00010851	0.00011547	0.00013709
17.5 g/day	0.00000853	0.00000769	0.00000818	0.00000971
142.2 g/day	0.00006942	0.00006256	0.00006657	0.00007903
USEPA RfD*	0.00010000	0.00010000	0.00010000	0.00010000
ATSDR MRL	0.00300000	0.00300000	0.00300000	0.00300000
Arsenic				
94.8 g/day	0.00060364	0.00053242	0.00047424	0.00043975
247 g/day	0.00157277	0.00138721	0.00123562	0.00114577
17.5 g/day	0.00011143	0.00009828	0.00008754	0.00008118

142.2 g/day	0.00090673	0.00079975	0.00071236	0.00066056
USEPA RfD				
ATSDR MRL				
Copper				
94.8 g/day	0.00079265	0.00068517	0.00071894	0.00091281
247 g/day	0.00206523	0.00178519	0.00187319	0.00237830
17.5 g/day	0.00014632	0.00012648	0.00013272	0.00016850
142.2 g/day	0.00119064	0.00102920	0.00107993	0.00137113
USEPA RfD				
ATSDR MRL*	0.01000000	0.01000000	0.01000000	0.01000000
Cadmium				
94.8 g/day	0.00000000	0.00000323	0.00000303	0.00000461
247 g/day	0.00000000	0.00000842	0.00000790	0.00001201
17.5 g/day	0.00000000	0.00000060	0.00000056	0.00000085
142.2 g/day	0.00000000	0.00000485	0.00000455	0.00000692
USEPA RfD	0.00100000	0.00100000	0.00100000	0.00100000
ATSDR MRL	0.00050000	0.00050000	0.00050000	0.00050000
Selenium				
94.8 g/day	0.00070531	0.00067895	0.00063299	0.00070138
247 g/day	0.00183768	0.00176899	0.00164925	0.00182745
17.5 g/day	0.00011393	0.00010967	0.00010224	0.00011329
142.2 g/day	0.00092702	0.00089237	0.00083197	0.00092186
USEPA RfD	0.00500000	0.00500000	0.00500000	0.00500000
ATSDR MRL	0.00500000	0.00500000	0.00500000	0.00500000

*ATSDR MRL, intermediate-duration oral MRL 0.5 ug of cadmium/kg/day; intermediate-duration oral MRL 0.01 mg of copper/kg/day; ATSDR oral MRL for methylmercury.
The U.S. EPA reference dose for methylmercury is 0.0001 mg/kg/day.

Table 8: Average daily doses of metal contaminants in Dolly Varden fillets

Metal Contaminant Average Daily Doses for Dolly Varden Fillets				
	Nanwalek	**Port Graham**	**Seldovia**	**Tyonek**
Mercury	mg/kg/day			
94.8 g/day	0.00003745	0.00002311	0.00003934	0.00003164
247 g/day	0.00009757	0.00006021	0.00010251	0.00008244
17.5 g/day	0.00000691	0.00000427	0.00000726	0.00000584
142.2 g/day	0.00005625	0.00003471	0.00005910	0.00004753
USEPA RfD*	0.00010000	0.00010000	0.00010000	0.00010000
ATSDR MRL	0.00300000	0.00300000	0.00300000	0.00300000
Arsenic				

94.8 g/day	0.00122411	0.00099137	0.00048585	0.00152391
247 g/day	0.00318939	0.00258300	0.00126588	0.00397053
17.5 g/day	0.00022597	0.00018301	0.00008969	0.00028131
142.2 g/day	0.00005625	0.00148915	0.00072980	0.00228908
USEPA RfD				
ATSDR MRL				
Copper				
94.8 g/day	0.00082559	0.00087773	0.00063030	0.00093319
247 g/day	0.00215106	0.00228691	0.00164224	0.00243141
17.5 g/day	0.00015240	0.00016203	0.00011635	0.00017227
142.2 g/day	0.00124013	0.00131845	0.00094678	0.00140175
USEPA RfD				
ATSDR MRL*	0.01000000	0.01000000	0.01000000	0.01000000
Cadmium				
94.8 g/day	0.00000000	0.00000207	0.00000301	0.00000000
247 g/day	0.00000000	0.00000540	0.00000783	0.00000000
17.5 g/day	0.00000000	0.00000038	0.00000055	0.00000000
142.2 g/day	0.00000000	0.00000312	0.00000451	0.00000000
USEPA RfD	0.00100000	0.00100000	0.00100000	0.00100000
ATSDR MRL	0.00050000	0.00050000	0.00050000	0.00050000
Selenium				
94.8 g/day	0.00078847	0.00074188	0.00069041	0.00073646
247 g/day	0.00205433	0.00193295	0.00179887	0.00191884
17.5 g/day	0.00012736	0.00011983	0.00011152	0.00011896
142.2 g/day	0.00103632	0.00097508	0.00090744	0.00096796
USEPA RfD	0.00500000	0.00500000	0.00500000	0.00500000
ATSDR MRL	0.00500000	0.00500000	0.00500000	0.00500000

ATSDR MRL, intermediate-duration oral MRL 0.5 ug of cadmium/kg/day; intermediate-duration oral MRL 0.01 mg of copper/kg/day; ATSDR oral MRL for methylmercury. The U.S. EPA reference dose for methylmercury is 0.0001 mg/kg/day.

Table 9: Average daily doses of lead in whole-body Dolly Varden

Seldovia Dolly Varden Average Daily Dose of Lead			
94.8 g/day	**247 g/day**	**17.5 g/day**	**142.4 g/day**
0.00003755	0.00009784	0.00000693	0.00005641

All whole-body Dolly Varden from Seldovia had measurable amounts of lead. Five out of nine whole body sockeye samples from Tyonek also had measurable amounts of lead and six of ten Dolly Varden fillet samples had measurable amounts of lead. There is no EPA reference dose or ATSDR minimum risk level for lead established. This is because some health effects from lead appear to

occur at blood levels so low there essentially is no threshold limit (EPA IRIS, Lead and Compounds CASRN 7439-92-1). Average daily dose of metal contaminants was only calculated for fish fillets, with the exception of lead, as this is the most commonly eaten portion of fish and calculating for whole body fish would include many organs of fish which are known to have higher accumulations of contaminants but are not consumed by most people. Arsenic average daily doses could not be compared to an EPA reference dose or an ATSDR minimum risk level because total arsenic was analyzed in this study. The EPA and the ATSDR have reference doses for inorganic arsenic but not total arsenic.

The EPA reference dose and ATSDR minimum risk level for methylmercury are used in Table 7 and Table 8. The EPA and ATSDR do not have a reference dose or minimum risk level for total mercury in fish. Fish in this study were analyzed for total mercury. Studies have shown that over 90% of total mercury in fish is present as methylmercury (U.S. Geological Survey. Geologic studies of mercury. John E. Gray). With the assumption that 90% of the total mercury is methylmercury, sockeye fillets from all communities except Port Graham would exceed the EPA reference dose for methylmercury when a fish consumption rate of 247 g/day is used. With a fish consumption rate of 247 g/day, Dolly Varden fillets from Nanwalek and Seldovia would be just under the EPA reference dose for methylmercury if 90% or more of the total mercury is assumed to be methylmercury.

No other average daily dose of metals found in sockeye or Dolly Varden fillets meets or exceeds reference doses or minimum risk levels. Calculated average daily doses were one to four times lower in magnitude than the reference doses for both sockeye and Dolly Varden.

Table 10: Average daily doses of organic contaminants in whole-body sockeye salmon from Nanwalek

Organic Contaminant Average Daily Doses for Nanwalek Whole Body Sockeye					
	94.8 g/day	**247 g/day**	**17.5 g/day**	**142.4 g/day**	**EPA RfD**
PCB	0.00001221	0.00003180	0.00000154	0.00001255	0.00002000*
PBDE	0.00000017	0.00000045	0.00000003	0.00000026	0.00000300*
Chlordane	0.00000125	0.00000326	0.00000023	0.00000188	0.00050000
DDT	0.00001308	0.00003409	0.00000242	0.00001965	0.00050000
Gamma-HCH	0.00000074	0.00000192	0.00000014	0.00000111	0.00030000
Hexachlorobenzene	0.00000192	0.00000500	0.00000035	0.00000288	0.00080000
Mirex	0.00000008	0.00000022	0.00000002	0.00000012	0.00020000
Sum Nonachlor	0.00000192	0.00000500	0.00000035	0.00000289	
Dieldrin	0.00000045	0.00000116	0.00000008	0.00000067	0.00005000
Toxaphene	0.00002536	0.00006607	0.00000468	0.00003809	0.00200000*

Table 11: Average daily doses of organic contaminants in whole-body Dolly Varden from Nanwalek

Organic Contaminant Average Daily Doses for Nanwalek Whole Body Dolly Varden					
	94.8 g/day	**247 g/day**	**17.5 g/day**	**142.4 g/day**	**EPA RfD**
PCB	0.00000386	0.00001007	0.00000071	0.00000580	0.00002000*
PBDE	0.00000026	0.00000068	0.00000005	0.00000039	0.00000300*
Chlordane	0.00000020	0.00000052	0.00000004	0.00000030	0.00050000
DDT	0.00000212	0.00000552	0.00000039	0.00000318	0.00050000
Gamma-HCH	0.00000047	0.00000123	0.00000009	0.00000071	0.00030000
Hexachlorobenzene	0.00000069	0.00000180	0.00000013	0.00000104	0.00080000
Mirex	0.00000000	0.00000000	0.00000000	0.00000000	0.00020000
Sum Nonachlor	0.00000047	0.00000123	0.00000009	0.00000071	
Dieldrin	0.00000000	0.00000000	0.00000000	0.00000000	0.00005000
Toxaphene	0.00000000	0.00000000	0.00000000	0.00000000	0.00200000*

Table 12: Average daily doses of organic conaminants in whole-body sockeye from Port Graham

Organic Contaminant Average Daily Doses for Port Graham Whole Body Sockeye					
	94.8 g/day	**247 g/day**	**17.5 g/day**	**142.4 g/day**	**EPA RfD**
PCB	0.00000816	0.00002127	0.00000151	0.00001226	0.00002000*
PBDE	0.00000018	0.00000047	0.00000003	0.00000027	0.00000300*
Chlordane	0.00000099	0.00000259	0.00000018	0.00000149	0.00050000
DDT	0.00000809	0.00002109	0.00000149	0.00001216	0.00050000
Gamma-HCH	0.00000017	0.00000044	0.00000003	0.00000025	0.00030000
Hexachlorobenzene	0.00000150	0.00000392	0.00000028	0.00000226	0.00080000
Mirex	0.00000009	0.00000023	0.00000002	0.00000013	0.00020000
Sum Nonachlor	0.00000134	0.00000350	0.00000025	0.00000202	
Dieldrin	0.00000039	0.00000101	0.00000007	0.00000058	0.00005000
Toxaphene	0.00001698	0.00004424	0.00000313	0.00002551	0.00200000*

Table 13: Average daily doses of organic contaminants in whole-body Dolly varden from Port Graham

Organic Contaminant Average Daily Doses for Port Graham Whole Body Dolly Varden					
	94.8 g/day	**247 g/day**	**17.5 g/day**	**142.4 g/day**	**EPA RfD**
PCB	0.00000885	0.00002306	0.00000163	0.00001330	0.00002000*
PBDE	0.00000022	0.00000056	0.00000004	0.00000032	0.00000300*
Chlordane	0.00000023	0.00000060	0.00000004	0.00000035	0.00050000
DDT	0.00000163	0.00000426	0.00000030	0.00000245	0.00050000
Gamma-HCH	0.00000011	0.00000029	0.00000002	0.00000017	0.00030000

Hexachlorobenzene	0.00000097	0.00000253	0.00000018	0.00000146	0.00080000
Mirex	0.00000000	0.00000000	0.00000000	0.00000000	0.00020000
Sum Nonachlor	0.00000039	0.00000101	0.00000007	0.00000058	
Dieldrin	0.00000020	0.00000053	0.00000004	0.00000030	0.00005000
Toxaphene	0.00000000	0.00000000	0.00000000	0.00000000	0.00200000*

Table 14: Average daily doses of organic contaminants in whole -body sockeye from Seldovia

Organic Contaminant Average Daily Doses for Seldovia Whole Body Sockeye					
	94.8 g/day	**247 g/day**	**17.5 g/day**	**142.4 g/day**	**EPA RfD**
PCB	0.00000688	0.00001794	0.00000127	0.00001034	0.00002000*
PBDE	0.00000017	0.00000044	0.00000003	0.00000025	0.00000300*
Chlordane	0.00000121	0.00000315	0.00000022	0.00000182	0.00050000
DDT	0.00001020	0.00002658	0.00000188	0.00001533	0.00050000
Gamma-HCH	0.00000042	0.00000110	0.00000008	0.00000063	0.00030000
Hexachlorobenzene	0.00000166	0.00000432	0.00000031	0.00001533	0.00080000
Mirex	0.00000109	0.00000283	0.00000020	0.00000163	0.00020000
Sum Nonachlor	0.00000147	0.00000383	0.00000027	0.00000221	
Dieldrin	0.00000045	0.00000118	0.00000008	0.00000068	0.00005000
Toxaphene	0.00001817	0.00004733	0.00000335	0.00002729	0.00200000*

Table 15: Average daily doses of organic contaminants in whole-body Dolly Varden from Seldovia

Organic Contaminant Average Daily Doses for Seldovia Whole Body Dolly Varden					
	94.8 g/day	**247 g/day**	**17.5 g/day**	**142.4 g/day**	**EPA RfD**
PCB	0.00001339	0.00003489	0.00000247	0.00002011	0.00002000*
PBDE	0.00000017	0.00000045	0.00000003	0.00000026	0.00000300*
Chlordane	0.00000130	0.00000340	0.00000024	0.00000196	0.00050000
DDT	0.00000082	0.00000214	0.00000015	0.00000123	0.00050000
Gamma-HCH	0.00000000	0.00000000	0.00000000	0.00000000	0.00030000
Hexachlorobenzene	0.00000056	0.00000146	0.00000010	0.00000084	0.00080000
Mirex	0.00000000	0.00000000	0.00000000	0.00000000	0.00020000
Sum Nonachlor	0.00000022	0.00000058	0.00000004	0.00000033	
Dieldrin	0.00000011	0.00000027	0.00000002	0.00000016	0.00005000
Toxaphene	0.00000000	0.00000000	0.00000000	0.00000000	0.00200000*

Table 16: Average daily doses of organic contaminants in whole-body sockeye salmon from Tyonek

Organic Contaminant Average Daily Doses for Tyonek Whole Body Sockeye					
	94.8 g/day	**247 g/day**	**17.5 g/day**	**142.4 g/day**	**EPA RfD**
PCB	0.00000688	0.00001794	0.00000127	0.00001034	0.00002000*
PBDE	0.00000018	0.00000047	0.00000003	0.00000027	0.00000300*
Chlordane	0.00000166	0.00000432	0.00000031	0.00000249	0.00050000
DDT	0.00001282	0.00003341	0.00000237	0.00001926	0.00050000
Gamma-HCH	0.00000014	0.00000038	0.00000003	0.00000022	0.00030000
Hexachlorobenzene	0.00000201	0.00000525	0.00000037	0.00000303	0.00080000
Mirex	0.00000011	0.00000028	0.00000002	0.00000016	0.00020000
Sum Nonachlor	0.00000187	0.00000488	0.00000035	0.00000282	
Dieldrin	0.00000052	0.00000136	0.00000010	0.00000078	0.00005000
Toxaphene	0.00002131	0.00005551	0.00000393	0.00003200	0.00200000*

Table 17: Average daily doses of organic contaminants in whole-body Dolly Varden from Tyonek

Organic Contaminant Average Daily Doses for Tyonek Whole Body Dolly Varden					
	94.8 g/day	**247 g/day**	**17.5 g/day**	**142.4 g/day**	**EPA RfD**
PCB	0.00001351	0.00003520	0.00000249	0.00002029	0.00002000*
PBDE	0.00000065	0.00000169	0.00000012	0.00000097	0.00000300*
Chlordane	0.00000046	0.00000119	0.00000008	0.00000068	0.00050000
DDT	0.00000221	0.00000575	0.00000041	0.00000332	0.00050000
Gamma-HCH	0.00000053	0.00000137	0.00000010	0.00000079	0.00030000
Hexachlorobenzene	0.00000158	0.00000411	0.00000029	0.00000237	0.00080000
Mirex	0.00000000	0.00000000	0.00000000	0.00000000	0.00020000
Sum Nonachlor	0.00000087	0.00000226	0.00000016	0.00000130	
Dieldrin	0.00000030	0.00000077	0.00000005	0.00000044	0.00005000
Toxaphene	0.00000000	0.00000000	0.00000000	0.00000000	0.00200000*

*Commercial PCB products were known as Aroclors. The RfD for Aroclor 1254 is used for PCBs.
EPA reference doses for all contaminants were found in the EPA Integrated Risk Information System (IRIS).

Average daily dose of PCBs, PBDEs, and organochlorine pesticides were only calculated for whole-body fish as they were only analyzed in whole-body samples. Given the EPA's fish consumption rate for the general public (17.5 g/day) none of the calculated average daily doses of any organic contaminant in sockeye or Dolly Varden met or exceeded the EPA reference dose. Average daily doses calculated for sockeye using the EPA fish consumption rate for subsistence users (142.4 g/day) did not exceed the EPA reference dose. With

the fish consumption rate of 142.4 g/day, the average daily dose of PCBs in Dolly Varden from Seldovia and Tyonek slightly exceeded the EPA reference dose.

Using the SVT average fish consumption rate of 94.8 g/day, no average daily dose calculated for any organic contaminant in sockeye or Dolly Varden met or exceeded an EPA reference dose.

With a fish consumption rate of 247 g/day, no average daily dose for organic contaminants met or exceeded the EPA reference dose in sockeye or Dolly Varden, with the exception of PCBs. The average daily dose for PCBs in sockeye from Nanwalek is over the EPA reference dose. The average daily doses for PCBs in sockeye from Port Graham was just over the EPA reference dose. Seldovia, and Tyonek were slightly under the EPA reference dose. Using the fish consumption rate of 247 g/day, the average daily doses of PCBs in Dolly Varden from Seldovia and Tyonek were almost two times the EPA reference dose. Using the fish consumption rate of 247 g/day, the average daily dose of PCBs in Dolly Varden from Port Graham was slightly above the reference dose.

Comparison to *NPRB Project 1019: Assessment of contaminant body burdens and histopathology of fish and shellfish species frequently used for subsistence food by Alaskan Native communities. Apeti, A.D., Hartwell, S.I., Myers, M., Hetrick, J. and Davenport, J. 2013. [NPRB] North Pacific Research Board.*

In 2010, with funding from the North Pacific Research Board (NPRB) and NOAA Center for Coastal Ocean Science, the National Oceanic and Atmospheric Association (NOAA) and the Chugach Regional Resource Commission, Alutiiq Pride Shellfish Hatchery (CRRC, APSH) assessed contaminant body burdens of chum and sockeye salmon, as well as cockles and soft-shell clams from Nanwalek, Port Graham, and Seldovia. Similar to this study, samples were collected by community members with the assistance of NOAA scientists who conducted quality assurance procedures. Salmon samples were also collected using gill nets in traditional harvest areas. Muscle and liver samples from five male and five female of each species were collected. Samples were grouped by collection site, species, and sex to create composite samples.

Table 18: Contaminant concentrations in liver and muscle tissue of salmon collected from Nanwalek, cited in *Assessment of Contaminant Body Burdens and Histopathology of Fish and Shellfish Species Frequently used for Subsistence Food*

	Chum f		Chum m		Sockeye f		Sockeye m		AK FMP Sockeye		FDA	EPA
	liver	muscle	liver	muscle	liver	muscle	liver	muscle	Kodiak	Matanuska	fish	fish
Chlordanes	0.77	1.6	1.97	1.04	3.73	2.64	1.04	2.38	11.32	6.88	1,200	704.8
Chlorobenzene	2.27	2.78	2.72	2.05	2.99	2.84	3.55	2.22	5.00	4.00		1127.8*
Chlorpyrifos	0	0	0	0	2.59	0	0	0				422.9
DDT	0.46	2.43	15.45	2.88	21.84	9.74	1.58	5.99	38.12	19.04	20,000	704.8
Dieldrins	0.4	0.62	0.56	0.24	0.42	0.45	2.15	0.61	1.76	0.88	1,200	70.5
Endosulfan	0.19	0.12	0.8	0.23	2.05	1.32	0.3	0.17				8458
HCHs	0.63	5.52	3.85	10.08	5.29	12.56	3.32	0.31	6.72	0.52		422.9#
Mirex	0	0	0	0	0	0.6	0	0			400	281.9
PCBs	3.86	6.79	17.78	9.29	15.35	14.7	7.45	11.11	23.60	11.85	8,000	28
									Kenai R.			
Arsenic	1.44	0.83	1.42	0.73	1.31	0.90	1.66	1.06	1.20	1.20		
Cadmium	2.21	0.01	3.09	0.01	3.59	0.01	3.83	0.02	0.00	0.00		1.41
Chromium	0	0	0	0	0	0	0	0	0.00	0.00		
Copper	73.5	2.01	329	2.11	365	1.81	1500	1.83		0.82		
Iron	449	17.6	563	15.4	558	13.9	452	12.4				
Lead	0.05	0	0.06	0	0	0	0	0	0.00	0.00		
Manganese	7.2	0.321	5.19	0.37	9.03	0.374	5.61	0.301				
Mercury	0.138	0.104	0.131	0.093	0.194	0.134	0.228	0.098	0.120	0.100	4000	0.14
Nickel	0.07	0.13	0.09	0.06	0.20	0.00	0.19	0.05	0.00	0.00		
Selenium	7.21	1.14	18.6	1.3	26.1	0.99	79.4	0.89	0.88	0.84		7.05
Silver	2.63	0	4.95	0	6.19	0	7.4	0				
Tin	0	0	0	0	0	0	0	0				
Zinc	98.9	13.6	108.0	13.9	128	12.2	173	14.3				

*Hexachlorobenzene
#gamma HCH

Table 19: Contaminant concentrations in liver and muscle tissue of salmon collected from Port Graham, cited in *Assessment of Contaminant Body Burdens and Histopathology of Fish and Shellfish Species Frequently Used for Subsistence Food*

	Chum f		Chum m		Sockeye f		Sockeye m		AK FMP Sockeye		FDA	EPA
	liver	muscle	liver	muscle	liver	muscle	liver	muscle	Kodiak	Matanuska	fish	fish
Chlordanes	0.35	1.3	0.64	1.13	1.69	3.12	2.81	3.2	11.32	6.88	1,200	704.8
Chlorobenzene	1.78	1.47	2.01	1.6	1.71	1.83	2.98	2.18	5.00	4.00		1127.8*
Chlorpyrifos	0	0	0	0	0	0	0	0				422.9
DDT	0.8	1.46	1.3	2.22	1.79	10.19	3.49	9.02	38.12	19.04	20,000	704.8
Dieldrins	0.42	0.31	1.82	0.33	0.89	0.6	0.47	0.49	1.76	0.88	1,200	70.5
Endosulfan	0	0	0.44	0	0.66	0.38	0	0.26				8458
HCHs	0.38	0.38	1.17	0.24	0.79	0.35	0.74	2.92	6.72	0.52		422.9#
Mirex	0	0	0	0	0	0	0	0			400	281.9
PCBs	3.07	3.98	1.76	4.92	2.35	14.33	1.35	11.97	23.6	11.85	8,000	28
									Kenai R.			
Arsenic	1.28	0.77	1.43	0.91	1.21	0.90	1.23	0.80	1.20	1.20		
Cadmium	2.67	0.02	4.13	0.02	3.10	0.02	5.45	0.02	0.00	0.00		1.41
Chromium	0	0	0	0	0	0	0	0	0.00	0.00		
Copper	151	2.1	423	1.97	415	1.94	1440	1.68		0.82		
Iron	627	16	1130	14.9	649	13.2	518	12.9				
Lead	0	0	0.10	0	0	0	0	0	0.00	0.00		
Manganese	6.93	0.35	5.21	0.39	7.57	0.39	4.28	0.37				
Mercury	0.133	0.121	0.118	0.091	0.231	0.127	0.347	0.141	0.120	0.100	4000	0.14
Nickel	0.08	0.06	0.12	0.06	0.22	0.08	0.33	0.09	0.00	0.00		
Selenium	8.29	1.23	21.10	1.14	27.30	0.92	51.60	0.95	0.88	0.84		7.05
Silver	3.84	0	6.46	0	5.56	0	7.84	0				
Tin	0	0	0	0	0	0	0	0				
Zinc	101.0	12.6	106.0	15.1	125.0	13.2	152.0	18.6				

*Hexachlorobenzene
#gamma HCH

Table 20: Contaminant concentrations in liver and muscle tissue of salmon collected from Seldovia, cited in *Assessment of Contaminant Body Burdens and Histopathology of Fish and Shellfish Species Frequently Used for Subsistence Food*

	Chum f		Chum m		Sockeye f		Sockeye m		AK FMP Sockeye		FDA	EPA
	liver	muscle	liver	muscle	liver	muscle	liver	muscle	Kodiak	Matanuska	fish	fish
Chlordanes	1.01	1.16	4.46	1.25	2.59	2.33	1.91	1.8	11.32	6.88	1,200	704.8
Chlorobenzene	3.01	1.72	1.94	3.65	1.49	1.96	2.1	1.56	5.00	4.00		1127.8*
Chlorpyrifos	0.79	0	0	0	0	0	3.48	0				422.9
DDT	3.67	2.14	7.24	3.47	15.54	6.99	33.67	8.79	38.12	19.04	20,000	704.8
Dieldrins	0.47	0.26	1.72	0.31	0.45	0.4	0.63	0.4	1.76	0.88	1,200	70.5
Endosulfan	0.61	0.57	0	0.42	2.16	1.1	1.67	0.98				8458
HCHs	5.39	10.58	3.68	15.45	5.84	16.72	6.17	14.35	6.72	0.52		422.9#
Mirex	0	0.18	0	0.24	0	0.52	0	0.46			400	281.9
PCBs	8.15	9.33	9.65	7.76	12.99	18.16	16.05	13.61	23.6	11.85	8,000	28
									Kenai R.			
Arsenic	1.32	0.79	1.38	0.88	1.34	1.29	1.46	1.18	1.20	1.20		
Cadmium	2.40	0.01	4.57	0.03	2.88	0.02	3.87	0.04	0.00	0.00		1.41
Chromium	0	0	0	0	0	0	0	0	0.00	0.00		
Copper	86.3	2.23	404	2	593	2.19	1570	1.86		0.82		
Iron	685	17.7	1060	15	249	12.1	427	13.9				
Lead	0.13	0	0.08	0	0	0	0	0	0.00	0.00		
Manganese	7.21	0.52	6.38	0.67	7.62	0.36	4.33	0.304				
Mercury	0.124	0.108	0.122	0.092	0.221	0.125	0.262	0.114	0.120	0.100	4000	0.14
Nickel	0	0	0.09	0.07	0.15	0.07	0.18	0	0.00	0.00		
Selenium	7.26	1.18	20.70	1.13	32.50	0.93	69.30	0.93	0.88	0.84		7.05
Silver	3.03	0	6.33	0	5.56	0	8.13	0				
Tin	0	0.04	0	0	0	0	0	0				
Zinc	98.3	13.8	119.0	16.2	134.0	12.8	135.0	12.7				

*Hexachlorobenzene
#gamma HCH

The mean of the combined female and male sockeye concentrations of metals from the NPRB Project 1019 study was calculated for comparison as male and female sockeye were not differentiated in SVT's study. Below, the concentrations of metals in fillet samples from this study are compared to NPRB Project 1019 respectively. No conversion is necessary between the two amounts as 1 µg/g = 1 mg/kg.

Nanwalek

- arsenic: 0.5094 mg/kg (SVT) compared to 1.235 µg/g (NPRB)
- cadmium: undetectable (SVT) compared to 0.015 µg/g (NPRB)
- copper: 0.6689 mg/kg (SVT) compared to 1.82 µg/g (NPRB)
- mercury: 0.038956 mg/kg (SVT) compared to 0.116 µg/g (NPRB)
- selenium: 0.520278 mg/kg (SVT) compared to 0.94 µg/g (NPRB)

Port Graham

- arsenic: 0.4493 mg/kg (SVT) compared to 1.05 µg/g (NPRB)
- cadmium: 0.002727 mg/kg (SVT) compared to 0.02 µg/g (NPRB)
- copper: 0.5782 mg/kg (SVT) compared to 1.81 µg/g (NPRB)
- mercury: 0.035144 mg/kg (SVT) compared to 0.134 µg/g (NPRB)

- selenium: 0.501333 mg/kg (SVT) compared to 0.935 µg/g (NPRB)

Seldovia
- arsenic: 0.4002 mg/kg (SVT) compared to 1.235 µg/g (NPRB)
- cadmium: 0.002558 mg/kg (SVT) compared to 0.03 µg/g (NPRB)
- copper: 0.6066 mg/kg (SVT) compared to 2.025 µg/g (NPRB)
- mercury: 0.037378 mg/kg (SVT) compared to 0.1195 µg/g (NPRB)
- selenium: 0.467444 mg/kg (SVT) compared to 0.93 µg/g (NPRB)

Average lead concentrations were undetectable in both studies.

The majority of concentrations of metals in sockeye from this study are lower than those in NPRB Project 1019. One reason for this could be the difference in sampling protocol. In SVT's study, one whole skinless fillet from each sockeye was homogenized and a subsample (~20 grams) was taken for metals analysis. The whole fish, including the remainder of the fillet sample, was then homogenized in a commercial meat grinder. Subsamples of each homogenized carcass were taken for metals and organics analysis (C. Furin, ADEC, personal communication, February 8, 2017). TDI Brooks and Texas A&M University did the contaminant analysis for NPRB Project 1019. For that study, a strip of skin was removed from behind the head parallel to and about five to ten mm dorsal to the lateral line, then two separate blocks of muscle tissue were removed from the exposed area. One block of muscle tissue was used for metal contaminants and the other organic contaminants. Metal contaminants were also measured in dry weight in the Project 1019 study, versus wet weight in SVT's study.

Organic contaminant samples were also processed differently. As stated in the "methods" section, in the SVT study, three whole-body sockeye were composited into three samples for each community. Then the average was taken of these three composite samples. Samples in NPRB Project 1019 were skinless blocks of muscle tissue, as mentioned before. Therefore an accurate comparison of organic contaminants cannot be made between the two studies.

Comparison to *Evaluation of seafood and plant data collected from Cook Inlet near the native villages of Port Graham, Nanwalek, Seldovia, and Tyonek, Alaska. [ATSDR] Agency for Toxic Substances and Disease Registry 2009. Atlanta, Georgia*

In 2003 (at the request of Port Graham, Nanwalek, Seldovia, and Tyonek) the Agency for Toxic Substances and Disease Registry (ATSDR) determined the potential health implications from contaminants in traditional foods. ATSDR did not have fish and plants analyzed; rather, data was compiled from the following three studies:

- *1997. Survey of Chemical Contaminants in Fish, Invertebrates, and Plants Collected in the Vicinity of Tyonek, Seldovia, Port Graham, and Nanwalek – Cook Inlet, AK. Environmental Protection Agency.*
- *2002. Fish Monitoring Study. Alaska Department of Environmental Conservation.*
- *1993, 1996, 2000. Environmental Monitoring Program (EMP). Cook Inlet Regional Citizen Advisory Council.*

Table 21: Concentrations of Metals in Fish from Cook Inlet (ppb wet weight). Cited in *Evaluation of Seafood and Plant Data Collected From Cook Inlet Near the Native Villages of Port Graham, Nanwalek, Seldovia, and Tyonek, Alaska. [ATSDR] 2009. Atlanta, Georgia*

Chemical	Min ppb	Max ppb	Average ppb[1]	n[2]	Min ppb	Max ppb	Average ppb	n	Min ppb	Max ppb	Average ppb	n	Min ppb	Max ppb	Average ppb	n	CV[3] ppb
	Chinook salmon fillet[4] (Homer Spit)				Chum salmon fillet (Homer)				Pink salmon fillet (Homer)				Red salmon fillet (Homer)				
Arsenic	230	880	472	6/6	220	280	244	5/5	120	290	205	6/6	220	330	293	3/3	2(c)
Cadmium	3	7	5	5/5	5	19	8	6/6	2	3	2	4/4	3	8	5	6/6	NA
Chromium	6	7	4	2/6	7	62	20	6/6	8	27	16	6/6	6	16	8	4/6	NA
Lead	20	30	27	6/6	30	30	30	6/6	20	30	25	6/6	20	30	18	4/6	NA
Methyl-mercury	44	94	48	5/6	27	41	33	6/6	12	20	17	6/6	22	41	32	6/6	29(nc)
Nickel	ND	ND	ND	0/6	ND	ND	ND	0/6	ND	ND	ND	0/6	90	90	23	1/6	NA
Selenium	70	130	95	6/6	180	220	202	6/6	110	180	140	6/6	110	170	142	6/6	NA
	Silver salmon fillet (Homer Spit)				Cod fillet (Kachemak Bay)				Pollock fillet (Kachemak Bay)				Halibut roast (throughout lower Cook Inlet)				NA
Arsenic	280	510	402	6/6	4,090	13,400	7,125	6/6	810	7,060	3,598	11/11	670	4,010	1,745	8/8	2(c)
Cadmium	4	6	5	6/6	2	4	3	6/6	3	8	5	7/7	3	3	3	1/1	NA
Chromium	ND	ND	ND	0/6	10	320	62	4/6	6	104	37	11/11	8	8	4	1/8	NA
Lead	ND	ND	ND	0/6	20	30	17	3/6	20	40	19	5/11	30	40	31	8/8	NA
Methyl-mercury	19	47	31	6/6	31	75	56	6/6	17	109	38	8/11	26	337	101	18/18	29(nc)
Nickel	ND	ND	ND	0/6	130	130	30	1/6	30	30	14	2/11	ND	ND	ND	0/8	NA
Selenium	140	190	163	6/6	150	250	193	6/6	90	210	139	11/11	250	610	406	8/8	1,500

Source: ADEC 2005a

[1] To calculate averages, non-detects were substituted with a value equal to half the detection limit.

[2] n = number of detections per individuals sampled.

[3] CV= comparison value; EPA risk-based consumption limits (unrestricted monthly fish consumption) (EPA 2000b); (c)=cancer health endpoint, (nc)=non-cancer endpoint.

[4] Weight (kg), length (cm), and age (years) of individuals reported by species as a range. Age reported for halibut only. Chinook salmon: 1.7–8.0 kg, 50-89 cm. Chum salmon: 1.4–3.4 kg, 50-68 cm. Pink salmon: 1.4–2.0 kg, 49–55 cm. Red salmon: 1.4–3.0 kg, 54–65 cm. Silver salmon: 3.2–4.2 kg, 64–68 cm. Cod: 0.8–3.2 kg, 43–66 cm. Pollock: 0.4–1.4 kg, 37–54 cm. Halibut: 3.2–37.6 kg, 65–140 cm, 6–20 years old.

ND = not detected

NA = not available

Below, the concentrations of metals in fillets from this study are compared to ATSDR's data of metal concentrations in sockeye fillets from Cook Inlet.

Nanwalek

- arsenic: 0.5094 mg/kg (SVT) compared to 0.293 mg/kg (ATSDR)
- cadmium: undetectable (SVT) compared to 0.005 mg/kg (ATSDR)
- lead: undetectable (SVT) compared to 0.018 mg/kg (ATSDR)
- selenium: 0.520278 mg/kg (SVT) compared to 0.142 mg/kg (ATSDR)

Port Graham

- arsenic: 0.4493 mg/kg (SVT) compared to 0.293 mg/kg (ATSDR)
- cadmium: 0.002727 mg/kg (SVT) compared to 0.005 mg/kg (ATSDR)

- lead: undetectable (SVT) compared to 0.018 mg/kg (ATSDR)
- selenium: 0.501333 mg/kg (SVT) compared to 0.142 mg/kg (ATSDR)

Seldovia
- arsenic: 0.4002 mg/kg (SVT) compared to 0.293 mg/kg (ATSDR)
- cadmium: 0.002558 mg/kg (SVT) compared to 0.005 mg/kg (ATSDR)
- lead: undetectable (SVT) compared to 0.018 mg/kg (ATSDR)
- selenium: 0.467444 mg/kg (SVT) compared to 0.142 mg/kg (ATSDR)

Tyonek
- arsenic: 0.3711 mg/kg (SVT) compared to 0.293 mg/kg (ATSDR)
- cadmium: 0.003889 mg/kg (SVT) compared to 0.005 mg/kg (ATSDR)
- lead: undetectable (SVT) compared to 0.018 mg/kg (ATSDR)
- selenium: 0.5179 mg/kg (SVT) compared to 0.142 mg/kg (ATSDR)

All arsenic and selenium levels in sockeye fillets from this study exceeded the levels in sockeye fillets collected from Cook Inlet. Cadmium and lead levels in sockeye fillets from this study had lower levels than those found in sockeye fillets collected from Cook Inlet. Mercury levels could not be compared as this study measures total mercury and the ATSDR study only shows methyl-mercury levels in sockeye fillets.

Table 22: Average Concentrations of Metals in Fish Fillets Collected from Cook Inlet Compared to Fish Collected from Marine Waters Throughout Alaska (ppb wet weight). Cited in *Evaluation of seafood and plant data collected from Cook Inlet near the native villages of Port Graham, Nanwalek, Seldovia, and Tyonek, Alaska. [ATSDR] Agency for Toxic Substances and Disease Registry 2009. Atlanta, Georgia*.

Chemical	Chinook salmon fillet		Chum salmon fillet		Pink salmon fillet		Red salmon fillet	
	Cook Inlet	Across Alaska	Cook Inlet	Across Alaska	Cook Inlet	Across Alaska	Cook Inlet	Across Alaska
Arsenic	**470**	450	240	**260**	210	**220**	290	**320**
Cadmium	5	5	**8**	5	2	**4**	5	**7**
Chromium	4	**7**	**20**	8	**16**	15	**8**	5
Lead	**27**	22	**30**	24	**25**	22	18	**22**
Methylmercury	**48**	34	**33**	31	**17**	16	**32**	27
Nickel	ND	**10**	ND	**10**	ND	**20**	**23**	12
Selenium	95	**145**	**202**	196	140	**150**	142	**146**
Chemical	**Silver salmon fillet**		**Cod fillet**		**Pollock fillet**		**Halibut roast**	
	Cook Inlet	Across Alaska	Cook Inlet	Across Alaska	Cook Inlet	Across Alaska	Cook Inlet	Across Alaska
Arsenic	**400**	340	7,100	**11,300**	3,600	**6,100**	**1,750**	1,570
Cadmium	**5**	4	3	3	**5**	3	**3**	2
Chromium	ND	**50**	**62**	17	**37**	24	3.6	**4.6**
Lead	ND	**20**	17	**22**	19	**17**	31	31
Methylmercury	**31**	27	56	**89**	38	**45**	100	**220**
Nickel	ND	**70**	**30**	18	14	**20**	ND	**10**
Selenium	**160**	130	190	**210**	139	**148**	**410**	260

Source: ADEC 2005a, 2005c
To calculate averages, non-detects were substituted with a value equal to half the detection limit.
Bold indicates the higher value between Cook Inlet fillet samples (ADEC 2005a) and fillet samples collected throughout Alaska (ADEC 2005c).

Below, the concentrations of metal contaminants in fillets from this study are compared to ATSDR's data of metal concentrations of sockeye fillet collected from marine waters throughout Alaska.

Nanwalek
- arsenic: 0.5094 mg/kg (SVT) compared to 0.320 mg/kg (ATSDR)
- cadmium: undetectable (SVT) compared to 0.007 mg/kg (ATSDR)
- lead: undetectable (SVT) compared to 0.022 mg/kg (ATSDR)
- selenium: 0.520278 mg/kg (SVT) compared to 0.146 mg/kg (ATSDR)

Port Graham
- arsenic: 0.4493 mg/kg (SVT) compared to 0.320 mg/kg (ATSDR)
- cadmium: 0.002727 mg/kg (SVT) compared to 0.007 mg/kg (ATSDR)
- lead: undetectable (SVT) compared to 0.022 mg/kg (ATSDR)
- selenium: 0.501333 mg/kg (SVT) compared to 0.146 mg/kg (ATSDR)

Seldovia
- arsenic: 0.4002 mg/kg (SVT) compared to 0.320 mg/kg (ATSDR)
- cadmium: 0.002558 mg/kg (SVT) compared to 0.007 mg/kg (ATSDR)
- lead: undetectable (SVT) compared to 0.022 mg/kg (ATSDR)
- selenium: 0.467444 mg/kg (SVT) compared to 0.146 mg/kg (ATSDR)

Tyonek
- arsenic: 0.3711 mg/kg (SVT) compared to 0.320 mg/kg (ATSDR)
- cadmium: 0.003889 mg/kg (SVT) compared to 0.007 mg/kg (ATSDR)
- lead: undetectable (SVT) compared to 0.022 mg/kg (ATSDR)
- selenium: 0.5179 mg/kg (SVT) compared to 0.146 mg/kg (ATSDR)

All arsenic and selenium levels in sockeye fillets from this study exceeded the levels in fillets collected throughout Alaska. Cadmium and lead levels in sockeye fillets from this study had lower levels than those found in fillets collected throughout Alaska. Mercury levels could not be compared as this study measures total mercury and the ATSDR study only shows methyl-mercury levels in sockeye fillets.

No data specifically on organic contaminants in sockeye salmon was presented by the ASTDR. Consequently no comparison was made between the two studies.

Conclusions and Recommendations

Based on the results of this contaminant assessment, a closer look at contaminants in Nanwalek, Seldovia, and Tyonek is recommended. Funding may be sought from the BIA or EPA to conduct a third phase of this study. Further analysis of subsistence resources from these villages may lead to an explanation of the above statewide average levels of contaminants.

The amounts of lead in fish from Seldovia particularly raised concern, as there is no recommended tolerable amount in fish. Testing for chromium and nickel is also recommended for the fish of Seldovia, as chromium ore from the Red Mountain area was transported to Kasitsna bay for loading. There were also four dump sites and a log yard near the head of Jakolof Bay and Jakolof Creek that could be possible sources of contaminants.

Dolly Varden from Tyonek had the highest average amounts of organic contaminants for every contaminant tested. Unlike salmon, which spend years at sea, Dolly Varden spend their lives closer to shore, swimming the coastline and occasionally exploring different streams. This may be a contributing factor to their higher levels of these contaminants. Further contaminant testing of the subsistence resources of Tyonek could also determine if the proximity of the village to oil platforms in Cook Inlet contributes to the elevated contaminants. Sockeye from Nanwalek had the highest levels of organohalogen pollutants of the four villages.

It is also recommended that more species be tested for contaminants, most importantly pink salmon from these three communities. Due to their abundance, pink salmon are a heavily used resource, possibly more so than sockeye salmon. There are also multiple hatcheries that produce millions of pink salmon in and around these villages. A highly-debated topic and common fear throughout villages is that hatchery salmon contain more contaminants than wild-stock salmon. Pink and/or sockeye salmon from known streams with large hatchery runs that are commonly used for subsistence purposes could be analyzed for contaminants. Hatchery and wild-stock salmon could be differentiated through analysis of otoliths so contaminant levels could be compared. There appears to be little data on this highly debated topic in Alaska.

Sediment samples would also be helpful in determining where contaminants may be coming from. Collecting macro-invertebrates to be tested for contaminants is also recommended, as contaminant levels in prey of these fishes may give clues to sources of these contaminants.

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Appendices

Appendix A. Sockeye Salmon Sampling Procedures.

SOCKEYE SALMON TISSUE SAMPLING OPERATING PROCEDURES

1) EMPTY COOLER

2) RIGHT BEFORE GETTING READY TO COLLECT FISH, GET AND PUT ICE IN COOLER, PUT THERMOMETER INSIDE COOLER

3) BRING SAMPLING SUPPLIES AND COOLER (NOW FILLED WITH ICE) WITH YOU WHEN YOU GO TO COLLECT FISH. **AVOID PUTTING COOLER NEAR BOAT EXHAUST OR ANY GASOLINE PRODUCTS**

4) AS YOU PULL FISH FROM NET, STOP IF YOU GET A SOCKEYE SALMON THAT IS 18 INCHES OR LONGER FROM SNOUT TO TAIL TIP (IF YOU AREN'T SURE OF LENGTH, 18 INCHES IS MARKED OUT ON

COOLER). **IF SOCKEYE SALMON IS NOT 18 INCHES OR LONGER IN LENGTH, DO NOT USE AS SAMPLE**

5) CHECK TO SEE IF SOCKEYE SALMON IS HATCHERY REARED. **IF HATCHERY REARED, DO NOT USE AS A SAMPLE**

6) ONCE YOU HAVE A SOCKEYE SALMON THAT MEETS THE CRITERIA FOR A SAMPLE, **PUT ON A FRESH PAIR OF LABORATORY (NITRILE) GLOVES. KEEP SAMPLES AWAY FROM BOAT EXHAUST OR GASOLINE PRODUCTS**

7) GENTLY AND CAREFULLY REMOVE FISH FROM NET (WITHOUT DAMAGING FISH (I.E. RIPPING, CUTTING, TEARING))

8) **USING LABORATORY GLOVES,** PLACE SAMPLE IN AN X-LARGE ZIPLOC BAG (ONE FISH PER X-LARGE ZIPLOC BAG). **USE A FRESH PAIR OF GLOVES EACH TIME YOU BAG A NEW SAMPLE**

9) **WITH PENCIL,** FILL OUT ALL INFORMATION ON SAMPLE LABEL AND FISH SAMPLING FORM. **INCLUDE GPS LATITUDE AND LONGITUDE OF LOCATION WHERE YOU GOT SAMPLE.** LAT AND LONG COORDINATES SHOULD BE IN WGS 84 AND IN HDDD°MM'SS.S"

10) PLACE SAMPLE LABEL IN SMALL ZIPLOC BAG. PLACE SMALL ZIPLOC BAG INSIDE X-LARGE ZIPLOC BAG CONTAINING FISH SAMPLE

11) **USING PERMANENT MARKER,** WRITE SAMPLE # ON OUTSIDE OF EACH X-LARGE ZIPLOC BAG

12) **AFTER BAGGING AND LABELING FISH SAMPLES, IMMEDIATELY PLACE SAMPLES INSIDE COOLER ON ICE**

13) AFTER SAMPLES HAVE BEEN COLLECTED, AND ALL INFORMATION FILLED OUT FOR THE SAMPLES ON THE FISH SAMPLING FORM, FOLD UP FISH SAMPLING FORM AND PLACE INSIDE SMALL ZIPLOC BAG. PLACE THE SMALL ZIPLOC (CONTAINING THE FISH SAMPLING FORM) INSIDE COOLER

14) **AS SOON AS POSSIBLE, RETURN TO SHORE AND IMMEDIATELY PUT FISH SAMPLES IN FREEZER.** DO NOT REMOVE SAMPLES FROM BAGS. PUT THERMOMETER INSIDE FREEZER AND KEEP WITH FISH SAMPLES. **FISH SHOULD BE FROZEN AT OR BELOW -20°C OR -4°F.**

15) EMPTY ICE FROM COOLER

16) CONTACT CHRISTOFF G. FURIN AT ADEC FISH TISSUE MONITORNG PROGRAM (christoff.furin@alaska.gov or 907-375-8211) AND LET HIM KNOW SAMPLES HAVE BEEN COLLECTED AND WILL BE SHIPPED TO HIM WITHIN 24 HRS. KEEP HIM INFORMED OF SHIPPING ARRANGEMENTS.

17) LEAVE FISH SAMPLES IN FREEZER OVERNIGHT. THEY SHOULD BE FROZEN SOLID WHEN YOU SHIP THEM.

18) MAKE ARRANGEMENTS WITH AIRLINES TO SEND FISH SAMPLES TO CHRISTOFF G. FURIN (SHIPPING INFORMATION PROVIDED IN SHIPPING LABELS) WITHIN 24 HRS. SAMPLES SHOULD ARRIVE IN ANCHORAGE THE SAME DAY THEY ARE SHIPPED. **BILLING INFORMATION FOR AIRLINES IS THE SAME AS SHIPPING INFORMATION.**

19) WHEN READY TO PUT SAMPLES ON PLANE, FILL COOLER BACK UP WITH ICE. TAKE FISH SAMPLES OUT OF FREEZER AND TRANSFER THEM IMMEDIATELY TO THE COOLER. PUT THERMOMETER INSIDE COOLER. **MAKE SURE FISH SAMPLING FORM (INSIDE SMALL ZIPLOC BAG) IS INCLUDED IN COOLER ALONG WITH SAMPLES.**

20) TAPE SHIPPING LABEL (PROVIDED TO YOU) ONTO COOLER AND SEAL UP COOLER WITH PACKAGING TAPE.

21) TAKE COOLER TO PLANE AND LOAD UP COOLER ONTO PLANE. CALL CHRISTOFF G. FURIN AND LET HIM KNOW SAMPLES ARE ON THEIR WAY AND WHEN HE SHOULD EXPECT THEM TO ARRIVE.

*** GOAL IS TO HAVE 6 SOCKEYE SALMON COLLECTED DURING 1ST SAMPLING EVENT AND ANOTHER 3 COLLECTED DURING A 2ND SAMPLING EVENT**

Appendix B. Dolly Varden Sampling Procedures.

DOLLY VARDEN TISSUE SAMPLING OPERATING PROCEDURES

1) COORDINATE SAMPLING OF DOLLY VARDENWITH SOCKEYE SALMON SO THAT FISH ARE COLLECTED ON THE SAME DAY AND SHIPPED TOGETHER

2) START WITH AN EMPTY COOLER

3) RIGHT BEFORE GETTING READY TO COLLECT FISH, GET AND PUT ICE IN COOLER, PUT THERMOMETER INSIDE COOLER

4) BRING SAMPLING SUPPLIES AND COOLER (NOW FILLED WITH ICE) WITH YOU WHEN YOU GO TO COLLECT FISH. **AVOID PUTTING COOLER NEAR BOAT EXHAUST OR ANY GASOLINE PRODUCTS**

5) CATCH DOLLY VARDENEITHER BY NET OR HOOK AND LINE. **KEEP ONLY DOLLY VARDENBETWEEN THE SIZES OF 100 MM (3.94") TO 400 MM (15.75") AS SPECIMENS.** GOAL IS TO COLLECT FIVE DOLLY VARDEN DURING 1ST SAMPLING EVENT AND ANOTHER FIVE DURING A 2ND SAMPLING EVENT. PREFERABLY, FIVE OF THE SAMPLES WILL BE JUVENILES (BETWEEN 100 MM (3.94") TO 150 MM (5.91")) IN SIZE AND FIVE FISH WILL BE OVER 150 MM (5.91") IN SIZE (CONSIDERED ADULTS)

   a. IF CATCHING BY NET:
      i. Follow same SOPs for sockeye
   b. If USING HOOK AND LINE:
      i. Bring them in quickly
      ii. Do not drag in mud or damage by hitting it with a club or rock to kill it.
      iii. Put each fish in an individual Ziploc bag. Put each Ziploc bag (containing fish) on ice. Follow same procedures as salmon and follow sampling protocols for paperwork
      iv. Freeze and send in with sockeye

6) ONCE YOU HAVE A DOLLY VARDEN THAT MEETS THE CRITERIA FOR A SAMPLE, **PUT ON A FRESH PAIR OF LABORATORY (NITRILE) GLOVES. KEEP SAMPLES AWAY FROM BOAT EXHAUST OR GASOLINE PRODUCTS**

7) GENTLY AND CAREFULLY REMOVE FISH (WITHOUT DAMAGING FISH (I.E. RIPPING, CUTTING, TEARING))
8) **USING LABORATORY GLOVES,** PLACE SAMPLE IN AN 1-GALLON ZIPLOC BAG (ONE FISH PER 1-GALLON ZIPLOC BAG). **USE A FRESH PAIR OF GLOVES EACH TIME YOU BAG A NEW SAMPLE**

9) **WITH PENCIL,** FILL OUT ALL INFORMATION ON SAMPLE LABEL AND FISH SAMPLING FORM. **INCLUDE GPS LATITUDE AND LONGITUDE OF LOCATION WHERE YOU GOT SAMPLE.** LAT AND LONG COORDINATES SHOULD BE IN WGS 84 AND IN HDDD°MM'SS.S"

   a. PLEASE NOTE- YOU CAN INCLUDE THE DOLLY VARDEN INFORMATION ON THE SAME FISH SAMPLING FORM AS THE

SOCKEYE SALMON FOR SAMPLES COLLECTED ON THE SAME DAY

10) PLACE SAMPLE LABEL IN SMALL ZIPLOC BAG. PLACE SMALL ZIPLOC BAG INSIDE 1-GALLON ZIPLOC BAG CONTAINING FISH SAMPLE

11) **USING PERMANENT MARKER,** WRITE SAMPLE # ON OUTSIDE OF EACH 1-GALLON ZIPLOC BAG

12) **AFTER BAGGING AND LABELING FISH SAMPLES, IMMEDIATELY PLACE SAMPLES INSIDE COOLER ON ICE.** SOCKEYE SALMON SAMPLES MAY ALREADY BE IN COOLER – THAT'S OKAY.

13) FOLLOW STEPS 13-21 ON SOCKEYE SALMON TISSUE SAMPLING SOPS. DOLLY VARDENAND SOCKEYE SALMON COLLECTED ON THE SAME DAY CAN BE SHIPPED TOGETHER IN THE SAME COOLER. **INFORMATION FOR SAMPLES COLLECTED ON THE SAME DAY (NO MATTER IF DOLLY VARDEN OR SOCKEYE SALMON) CAN GO ON THE SAME FISH SAMPLING FORM.**

***GOAL IS TO HAVE 6 SOCKEYE SALMON AND 5 DOLLY VARDENSAMPLES COLLECTED DURING 1ST SAMPLING EVENT (TOTAL OF 11 FISH) AND 3 SOCKEYE SALMON AND 5 DOLLY VARDEN TROUT COLLECTED DURING 2ND SAMPLING EVENT (TOTAL OF 8 FISH) = GRAND TOTAL FOR SUMMER OF 19 FISH**

Appendix C. Inventory Check List.

VILLAGE: _____

INVENTORY LIST:

- ☐ 2 coolers
- ☐ 2 Sharpie permanent markers
- ☐ 2 pencils
- ☐ 11 Zip ties
- ☐ 2 spare AA batteries

- ☐ GPS unit (batteries included) serial number:_____
- ☐ GPS manual
- ☐ 1 box of large gloves
- ☐ 1 clip board
- ☐ 1 first aid kit
- ☐ 1 thermometer
- ☐ 2 rolls of packaging tape
- ☐ 5 shipping labels
- ☐ 5 fish sampling forms
- ☐ 24 sampling labels
- ☐ 25 small Ziploc bags
- ☐ 1 copy of SOPs for sockeye salmon
- ☐ 1 copy of SOPs for Dolly Varden
- ☐ 11 1-gallon Ziploc bags
- ☐ 2 boxes of x-large Ziploc bags +2 loose x-large Ziploc bags (total of 10 x-large Ziploc bags)

Appendix D. Method Detection Limits for Contaminants under ADEC's Fish Tissue Monitoring Program.

Dioxins, furans, PCBs, PBDEs

PCBs

Compound	Congener Number		Method Detection Limit pg/g1
Non-Ortho PCBs			
3,3',4,4'-TetraPCB	77		4.9
3, 4, 4', 5-TetraCB	81		1.1
3,3'4,4,'5-PentaCB	126		5.1
3, 3'4, 4'5, 5'-HexaCB	169		1.0
Mono-Ortho PCBs			
2,3,3',4,4'-PentaCB	105		5.3
2, 3, 4, 4','5-PentaCB	114		0.8

2,3',4,4',5-PentaCB	118		4.9
2',3,4,4',5-PentaCB	123		0.8
2,3,3',4,4',5-HexaCB	156		0.8
2,3,3',4,4',5'-HexaCB	157		0.8
2,3',4,4',5,5'-HexaCB	167		0.6
2,3,3',4,4',5,5'-HeptaCB	189		0.4

1 – Quantitation limits listed for fish tissue samples are based on wet weight.

Additional PCB congeners

Compound	**Congener Number**		**Method Detection Limit pg/g1**
2,2',5-TriCB	18		1.8
2,4,4'-TriCB	28		4.2
2,2',5,5'-TetraCB	52		4.3
2,2',4,5'-TetraCB	49		1.4
2,2',3,5'-TetraCB	44		4.3
2,4,4',5-TetraCB	74		2.3
2,3',4,4'-TetraCB	66		5.2
2,2',4,5,5'-PentaCB	101		3.7
2,2',4,4',5-PentaCB	9		1.1
2,2',3,4,5'-PentaCB	87		4.5
2,3,3',4',6-PentaCB	110		0.9
2,2',3,5,5',6-HexaCB	151		4.0
2,2',3,4',5',6-HexaCB	149		0.8
2,2',3,4',5,5'-HexaCB	146		0.8
2,2',4,4',5,5'-HexaCB	153		4.0
2,2',3,4,4',5'-and 2,3,3',4,4',6-HexaCB	138, 158		5.4
2,2',3,3',4,4'-HexaCB	128		3.7
2,2',3,3',5,5',6-HeptaCB	178		0.8
2,2',3,4',5,5',6-HeptaCB	187		4.3
2,2',3,4,4',5',6-HeptaCB	183		1.1
2,2',3,3',4',5,6-HeptaCB	177		0.3
2,2',3,3',4,5,5'-HeptaCB	172		0.5
2,2',3,4,4',5,5'-HeptaCB	180		4.5

2,2',3,3',4,4',5-HeptaCB	170		5.0
2,2',3,3',4,5',6,6'-OctaCB	201		4.9
2,2',3,3',4,4',5',6-and 2,2',3,4,4',5,5',6-OctaCB	196, 203		0.8
2,2',3,3',4,4',5,6-OctaCB	195		4.9
2,2',3,3',4,4',5,5'-OctaCB	194		1.1
2,2',3,3',4,4',5,5',6-NonaCB	206		4.5
2,2',3,3',4,4',5,5',6,6'-DecaCB	209		5.0
3,4,4'-TriCB	37		0.4
2,2',3,5',6-PentaCB 2,2',4,4',6-PentaCB 2,2',3,5,6-PentaCB 2,2',4,5,6'-PentaCB 2,2',3',4,6-PentaCB	95, 100, 93, 102, 98		2.1
2,2',3,4,4',5-HexaCB	137		0.4

PBDEs

PBDPEs (polybrominated diphenyl) (fire retardant)	47	-	0.6
PBDPEs (polybrominated diphenyl) (fire retardant)	99, 100	-	0.6, 0.6
PBDPEs (polybrominated diphenyl) (fire retardant)	153, 154	-	0.8, 0.5

1 –Quantitation limits listed for fish tissue samples are based on wet weight.

EH LABORATORY ANALYSIS:

Organochlorine pesticides and metals

Organochlorine Pesticides

Compound		**Method Detection Limit pg/g**
Hexachlorobenzene		0.25
alpha HCH		0.30
beta HCH		0.35
gamma HCH		0.40

Heptachlor		0.35
Aldrin		0.20
Oxychlordane		1.60
trans-Chlordane		0.20
cis-Chlordane		0.20
o,p'-DDE		0.15
p,p'-DDE		0.15
trans-Nonachlor		0.31
cis-Nonachlor		0.10
o,p'-DDD		0.20
o,p'-DDT		0.12
p,p'-DDT		0.12
Mirex		0.10
Total Toxaphene (EI)		17.0
Hexachlorobutadiene		0.28
Delta HCC		0.35
Heptachlor epoxide		0.50
Endosulphan I		0.15
Dieldrin		0.55
Endrin		0.92
Endosuplhan II		0.45
Endrin aldehyde		0.65
Endosulphan sulfate		0.35
Endrin ketone		0.30
Methoxychlor		1.20

Inorganic Arsenic

Compound		**Method Detection Limit µg/g**
Total Inorganic Arsenic		0.05

Appendix E. Chain of Custody Form

CHAIN-OF-CUSTODY			Date Received at Lab:		
Name of Sampler:			**Affiliation of Sampler:**		
Source of Fish (Sampling Gear**)**			**Remarks:** (condition of samples)		
Sample Number	**Species**	**Date Collected**	**Latitude**	**Longitude**	**Area**
1.					
2.					
3.					
4.					
5.					
6.					
7.					

8.					
9.					
10.					

Shipment Number:	From:	Release Signature	Release Date:	Delivered via: ˆ US Mail ˆ Overnight EX ˆ Other
	To:	Receipt Signature:	Receipt Date:	
Shipment Number:	From:	Release Signature	Release Date:	Delivered via: ˆ US Mail ˆ Overnight EX ˆ Other
	To:	Receipt Signature:	Receipt Date	