IMPACTS OF FISH WASTE PILES IN ALASKA

by

Tara Martich

RECOMMENDED:

Lindsay Guzzo, B.S.,

Gabriel M. Garcia, PhD, MA, MPH

Elizabeth Hodges Snyder, PhD

Virginia Miller, DrPH, MS, MPH
Chair, Department of Health Sciences

APPROVED:

Susan H. Kaplan, PhD
Administrative Dean, College of Health

Date

IMPACTS OF FISH WASTE PILES IN ALASKA

A Project

Presented to the Faculty of the University of Alaska Anchorage

in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF PUBLIC HEALTH

By

Tara Martich, B.A.

Anchorage, Alaska

December 2015

Abstract

The goal of this practicum project was to complete a meta-analysis and identify the location, size, and impact of fish waste piles on waterbodies in Alaska in one comprehensive report. Data collection for this project included obtaining secondary data from publically available sources. Alaskan shorebased seafood processing facilities discharge water mixed with fish waste from an outfall(s). Once discharged, buoyant fish waste enters the water column and floats to the surface, while denser fragments sink. Fish waste accumulates on the seafloor and creates fish waste piles. A persistent fish waste pile depletes the oxygen from the water column, smothers benthic invertebrates, alters benthic habitat and creates dead zones, all which lead to changes in the overall ecosystem. As the deposited material breaks down, it produces hydrogen sulfide and ammonia, which may be released into the environment and affect aquatic ecosystem health. Less than fifty percent of the facilities in the data set are in compliance with the requirement to monitor their fish waste piles. At least 115 acres of the Alaska seafloor is covered by fish waste piles and the impacts of these 115 acres are not widely known. The recovery process of benthic communities is typically different than a simple reverse of the pattern observed during its decline. It is unlikely that any benthic community impacted by these fish waste piles will recover to its original state, even if the organic loading ceases.

Table of Contents

Page

List of Tables

Page

List of Figures

List of Appendices

Page

Chapter 1. Background

1.1 Introduction

There are over 500 active seafood processing facilities within Alaska (State of Alaska Department of Commerce, n.d). These facilities include boats, shellfish farms and shoreside plants (State of Alaska Department of Commerce, n.d). Of these, approximately 150 have wastewater discharge permits from the U.S. Environmental Protection Agency (EPA) and/or the State of Alaska Department of Environmental Conservation (ADEC) (ADEC, 2013a). Permitted seafood processing facilities discharge water mixed with fish waste from an outfall(s). The allowable size of the fish waste is specified in the facility's permit and ranges from 1 millimeter (0.04 inch) to 0.5 inch (ADEC, n.d.).

The fate of fish waste depends on the chemical, biological and physical features of the receiving water, as well as the chemical and physical characteristics of the waste (Mazik, Burdon, and Elliott, 2005). In general, once discharged, buoyant fish waste enters the water column and floats to the surface, while denser fragments sink (Mazik et al., 2005). Aquatic scavengers (e.g., fish and marine mammals) may feed on the waste and high volumes of discharged waste may accumulate on the seafloor (Mazik et al., 2005). Fish waste piles may also alter the benthic habitat rendering it inhospitable to many species, except for opportunistic ones.

Alaska Water Quality Standards prohibit the deposit of substances on the seafloor, except when ADEC authorizes a zone of deposit in a discharge permit (ADEC, 2002). Zones of deposits are considered a variance, or exception, to Alaska Water Quality Standards. The allowance of a zone of deposit originates from the 1985 Timber Task Force Steering Committee recommendations for the forestry industry. The Log Transfer Facility Siting, Construction, Operation and Monitoring/Reporting Guidelines evaluated log transfer facilities and recognized that in Alaska these facilities store and process logs in water (Alaska Timber Task Force, 1985). As part of the operation, bark is removed and settles to the bottom of the waterbody; hence the need for a zone of deposit (Alaska Timber Task Force, 1985). The seafood processing general permit adopted similar rationale for the zone of deposit and applied the same broad one-acre allowance for each facility that was developed for log transfer facilities. Unlike the log transfer zone of deposit, the seafood zone of deposit limit does not specify or limit a maximum thickness. Currently, log transfer facility zones of deposit are in different locations from seafood processing zones of deposit. For purposes of this project, zones of deposits are hereby referred to as fish waste piles. In Alaska fish waste piles range in size from less than one acre to over 90 acres.

The authorizations of fish waste piles are found in a general discharge permit or individual discharge permits (ADEC, 2013a). Similarly, the sizes of fish waste piles are tracked by individual facilities (ADEC, 2013a). Permittees are required to monitor the zone of deposit by completing a dive survey, which uses a diver to measure and estimate the length, width and thickness of the pile (ADEC, 2013a). The frequency of monitoring is dependent on the type of discharge permit and size of the pile. Facilities with individual discharge permits are typically required to monitor the fish waste piles annually (ADEC, 2013a). Whereas, facilities covered by the current general discharge permit are required to monitor the pile once every five years, or more frequently if the zone of deposit is larger than one-half acre (ADEC, 2013a).

Seafood processing facilities in Alaska are the only in the United States that are only required to grind fish waste to 0.5 inch prior to discharge. Seafood processors in the Lower 48 are required to treat the waste using screens or other equivalent technology and meet conventional end-of-pipe discharge limits. These discharge limits are required by regulation (40 Code of Federal Regulations (CFR) Part 408). In 1974, when EPA promulgated the final effluent limitation guidelines, the Alaskan seafood processing facilities were divided into two subcategories – remote and non-remote facilities. Remote facilities were required to grind fish waste to one-half inch or less prior to discharge; non-remote facilities were required to screen waste and meet end-of-pipe discharge limits for conventional pollutants, such as biochemical oxygen demand, total suspended solids, and oil and grease (40 CFR Part 408). The 1974 guidelines identified five cities in Alaska as non-remote locations and these included Anchorage, Cordova, Juneau, Ketchikan, Kodiak, and Petersburg (40 CFR Part 408).

In 1980, the Alaska seafood processing industry sent two petitions to EPA (U.S. EPA, n.d.). The first petition asked EPA to suspend the applicability of effluent limitations for non-remote subcategories set in the guidelines, and the second petition requested a new rulemaking (U.S. EPA, n.d.). The effluent limitations at issue were based upon screening technology. In response to the first petition, on May 19, 1980, EPA temporarily suspended the stricter limits for Anchorage, Cordova, Juneau, Ketchikan and Petersburg and instead allowed processors in those areas to use the limits for remote locations based upon grinding (U.S. EPA, n.d.). This temporary suspension left Kodiak as the only location in Alaska where the non-remote guidelines applied. Since 2010, EPA has been collecting information to update the effluent limitation guidelines in Alaska and plans to issue a final rule in 2016 (U.S. EPA, n.d.). The main reason for the difference in requirements between the Lower 48 and Alaska was recognition that in 1974, seafood processing facilities in Alaska faced unique operational challenges. The main implication of the differences between Alaska effluent guidelines and the Lower 48 is the impacts to waterbodies in Alaska.

Historically, the issue of fish waste piles was thought to be more of a legal issue (with respect to Alaska Water Quality Standards) rather than an environmental problem (ADEC, 2002).

However, the data collected from the piles and affected waterbodies document significant impacts to the benthic environment.

Since 2004, benthic assessments have been completed at approximately ten facilities, which use precise measurements to assess the health of the benthic community under and around the pile. A persistent pile depletes the oxygen from the water column, smothers benthic invertebrates and creates dead zones, which are an unsuitable habitat for fish and other organisms (Germano & Associates, 2004 & 2010). ADEC evaluates whether water quality standards are being met within a waterbody and then categorizes the waterbody. Categories used in Alaska for describing the health of waterbodies include Category 2, 3, 4a, 4b, and 5 (ADEC, 2010). A Category 2 waterbody is attaining some of the designated uses; however there is a lack of information available to determine if the remaining uses are attained (ADEC, 2010). A Category 3 waterbody is one which ADEC does not have enough information to determine their status. A Category 4a waterbody is impaired for one or more designated uses and a total maximum daily load (TMDL) has been completed (ADEC, 2010). Category 4(b) waterbodies are also impaired and have pollution controls in place. Category 5 waterbodies are impaired (this is the category for waterbodies on the 303(d) list) and need a total maximum daily load (TMDL) developed (ADEC, 2010). A TMDL is a plan to restore water quality. In accordance with Section 303(d) of the Clean Water Act, if a waterbody does not meet water quality standards, then the waterbody is identified as impaired (ADEC, 2010).

According to ADEC, five waterbodies are currently listed as impaired as a result of seafood processing facilities (ADEC, 2010). The five waterbodies and category determinations are the King Cove (Category 4a), Popof Strait (Category 5), Akutan Harbor (Category 4a), South Unalaska Bay (Category 4a), and Udagak Bay (Category 4a) (ADEC, 2010). In these five waterbodies, the parameters violating Alaska Water Quality Standards include residues, settleable solids and dissolved oxygen (ADEC, 2010).

Historically, three additional waterbodies were impaired as a result of seafood processing and currently meet Alaska Water Quality Standards. Tongass Narrows I and II in Ketchikan were listed as Category 4b waterbodies in 2002/2003 and determined to be Category 2 waterbodies in 2006 and 2008, respectively (ADEC, 2010). Captains Bay in Unalaska/Dutch Harbor was added to the 303(d) list in 1994 and removed from that list and determined to be a Category 2 waterbody in 1998 (ADEC, 2010).

Chapter 2 Literature Review

2.1 Organic Enrichment

Oxygen is a key element in metabolic processes of fish and invertebrates. Diaz & Rosenberg (1995) identified major areas with severe hypoxia in marine and estuarine regions of the world oceans. Oceans in climates most closely compared with Alaskan waters include those around Denmark, Sweden, and Norway (Diaz & Rosenberg, 1995). Hypoxia is the term used to describe low oxygen conditions (Diaz & Rosenberg, 1995).

The accumulation of fish waste piles adversely affects the benthic community (Mazik et al., 2005). This can reduce the quality of the water so that fish, crustaceans, and mammals either avoid the area or cannot survive in the area. The latter may lead to changes in the overall community structure (Mazik et al., 2005). Other effects include the transmission of disease and parasites between habitats (e.g., from fish waste to species feeding on the waste). For example, disposal of fish waste has been associated with winter mortalities of sea otters in Cordova, which were found feeding on waste material when other food sources were limited (Mazik et al., 2005). Mortalities were attributed to infection by parasites that sea otters obtained from the fish waste (Mazik et al., 2005).

Since the late 1980s, ADEC has allowed the discharge from commercial fish processors to accumulate on the seafloor. This approach is similar to ADEC's approach for log transfer facilities/pulp and paper mills in Alaska. The impacts of pulp and paper mills on the seafloor have been published in the peer-reviewed literature, beginning in 1972. Pearson described the most serious effects of pulp and paper mills are the creation of an anaerobic blanket deposit of fiber and wood chips, which eliminates the existing benthic environment. In 1986, Germano and Rhoades published a conceptual model for measuring the health of the benthic community. The impact of fish processing facilities in Canada and the United Kingdom has been published in the peer-reviewed literature. These publications explain that fish plant effluents are usually high in biochemical oxygen demand, nutrients, suspended solids, and oil and grease (Lalonde, Jackman, Doe, Garron, and Aube, 2009). When the material is deposited on top of sediments and the benthic community cannot recover, the sediment becomes anoxic, due to a lack of oxygen (Lalonde et al., 2009). As the deposited material breaks down, it produces hydrogen sulfide and ammonia, which may be released into the environment and affect aquatic ecosystem health (Lalonde et al., 2009).

These changes are also well documented throughout the aquaculture industry in the peer-reviewed literature. At fish farms, a substantial quantity of food is deposited on the sediment either directly or as fish feces (McGhie, Crawford, Mitchell, and O'Brien, 2000). If biochemical degradation and physical processes do not remove the material, it will accumulate. The rate of organic matter accumulation is influenced by the physical nature of the location, particularly water current velocities (McGhie, et al., 2000).

Effects of fish waste piles occur from the bottom-up. First, physical and chemical changes in the sediment and water column occur and in turn affect the health of the biological system (Mazik et al., 2005). Eventually impacts may occur to species on the higher level of the biological system (Mazik et al., 2005). In Alaska, several seafood processing facilities are located in close proximity to or even in, rural Alaska villages (ADEC, 2013b). Residents of the affected villages may rely on subsistence activities. Fish waste piles may affect food, nutrition and subsistence activities and ultimately diet and food security of subsistence users of the waterbodies. Changes to the biological systems as a result of fish waste piles may limit the availability of food and/or may change the types of food available to subsistence users. These potential changes may impact the overall diet of subsistence users if the users have to rely on other food sources.

Impacts to benthic ecosystems from fish waste piles varies and is dependent upon numerous factors, including the duration of organic loading and/or ecosystem disturbance, sediment type, and local hydrodynamics (Germano & Associates, 2011). If the sediments are fine-grained in size, then identification and classification of stages of communities allows scientists to determine the health of the benthic community based on which stages of communities are present. The three successional stages are Stage 1, 2, and 3 (Germano & Associates, 2011). This technique is not readily applicable to coarse-grained sediment.

According to Rhoads & Germano (1986), the distribution of successional stages in the context of the mapped disturbance gradients is one of the most sensitive indicators of the ecological health of the seafloor. Stage 3 taxa indicate that the sediment surrounding these organisms has not been disturbed severely in the recent past and that the inventory of bioavailable contaminants is relatively small (Germano, 2004). Therefore, for purposes of evaluating impacts to a benthic ecosystem, the presence of Stage 3 taxa can be a good indication of high benthic habitat stability and relative "health" (Germano, 2004). Conversely, the presence of Stage 1 taxa (in the absence of Stage 3 taxa) can indicate that the bottom is in an advanced state of organic enrichment or has received high contaminant loading. Unlike Stage 3 communities, Stage 1 taxa have a relatively high tolerance for organic enrichment and contaminants (Germano, 2004).

Another indicator of a benthic ecosystem experiencing adverse effects from organic loading is the presence of sulfur-reducing bacterial colonies, *Beggiatoa*. They can usually be found in habitats that have high levels of hydrogen sulfide (Haggit, 2010a). *Beggiatoa* can be found in marine or freshwater environments and appear as a whitish layer (Haggit, 2010a). *Beggiatoa* are indicative of low oxygen conditions and can be observed during both dive surveys and benthic assessments.

2.2 Measurement Tools

Two tools currently used to measure the size of fish waste piles in Alaska are dive surveys and benthic assessments. The primary tool used is a dive survey, in which a team of divers visually evaluates the fish waste pile according to a prescribed methodology. Historically, divers collected measurements of the pile using rulers and tape measures while on the seafloor. With the advent of technology, some divers are utilizing AutoCAD-type of software and GPS to measure the size of the pile. Figures 1 and 2 are pictures taken during dive surveys.

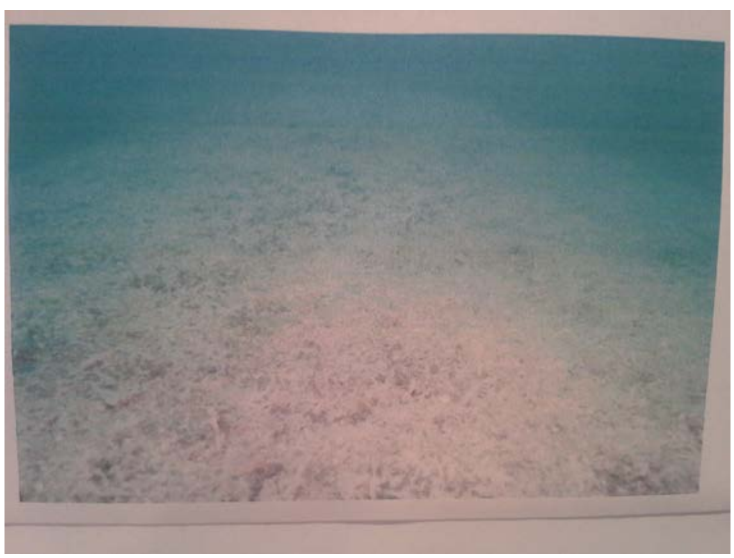

Figure 1. An overview of a fish waste pile in Sitka (Seafood Producers Cooperative, 2005)

Figure 2. Picture taken during a dive survey (Haggit, 2011b)

Benthic assessments utilize sediment profile imaging, which is collected with a specialized camera. The camera is lowered into the sediment and a cross-section picture of the sediment is taken. Typically during benthic assessments, water quality measurements (e.g., dissolved oxygen, salinity, conductivity) are also collected from the vessel. Scientists then evaluate the sediment profile images and formulate conclusions regarding the health of the benthic community and conditions of the seafloor.

Sediment profile imagery can be a powerful tool that can map gradients in sediment type, biological communities, or disturbances from physical forces or organic enrichment (Germano, 2004). It can also be helpful in deeper water where diver visibility is reduced. Figures 3a and 3b are examples of sediment profile images taken during benthic assessments.

Figure 3a. Sediment profile image of a Ketchikan fish waste pile (Germano, 2004)

Figure 3b. Stage 3 taxa (e.g., worm) noted by arrow (Germano, 2004)

Annually in Alaska, individual seafood processing facilities discharge a total mass from approximately 100,000 pounds to tens of millions of pounds of fish waste, which combined with varying localized hydrodynamics results in piles of varying thickness. These piles may also have an impact to the benthos beyond the boundary of the wastes (Germano, 2004).

2.3 Impacts to ecosystems

Viable benthic communities process, irrigate and rework the sediment and as a result, enhance sediment oxygen penetration, nutrient cycling as well as mineralization of organic matter (Villnäs et al., 2011). Benthic communities also serve as an important food source for higher tropic levels and therefore, changes in benthic community function may change the role of benthic communities within ecosystem functions (Villnäs et al., 2011).

Deposition of organic material (including fish waste) on the seafloor increases biological oxygen demand in sediments and can have an adverse impact on near-bottom water quality (Germano, 2011). In low oxygen environments, hypoxic (when dissolved oxygen is ≤2 mg/L) conditions can adversely affect near-bottom organisms and benthic communities, and anaerobic (when dissolved oxygen is < 0.1 mg/L) conditions can lead to mass mortality and benthic population crashes (Stachowitsch, 1984; Diaz and Rosenberg, 1995, 2008; Reading 1996; Lardicci et al., 1997; Parr et al., 2007).

The presence of sulfur-reducing bacterial colonies such as *Beggiatoa* is diagnostic of an area that has experienced prolonged periods of low dissolved oxygen in the overlying water column. The implications for benthic community structure and ecosystem energy cycling once an area starts to experience seasonal anoxia or hypoxia are quite dramatic (Diaz and Rosenberg, 1995).

Benthic habitats experiencing recurring hypoxia share a common set of features that are related to the interaction of oxygen dynamics and faunal response (Diaz & Rosenberg, 1995). Oxygen availability influences community structure and function by directly affecting metabolic processes and by indirectly affecting water column processes (Diaz & Rosenberg, 1995). Seasonal hypoxia is predominantly a summer-autumnal phenomena, so the elimination or suppression of macrobenthic activity during periods when biological activity should be peaking leads to an increase in organic matter in surface sediments and to an increased importance of microbes in energy cycling and carbon remineralization (Diaz & Rosenberg, 1995). Anaerobic metabolism is less efficient than aerobic pathways and does not utilize deposited organic matter as quickly. During hypoxic events the energy, from dead macrofauna and newly deposited organic matter, is sequestered by microfauna (Diaz & Rosenberg, 1995). This transfer of benthic energy to microbes still favours recolonization by macrobenthos if the duration of the hypoxia is short (Diaz & Rosenberg, 1995). As hypoxic events become longer and more intense, a larger proportion of the organic carbon will be remineralized by microbes and less energy will be available to support benthic recruitment with the return of normoxic conditions (Diaz & Rosenberg, 1995).

The effects of seasonal hypoxia on benthic community structure are consistent between ecosystems, and depend on the frequency and severity of the hypoxia (Diaz & Rosenberg, 1995). Prior to hypoxic stress, communities undergo natural cycles of annual variation. In systems that begin to experience hypoxia, communities are not conditioned to low oxygen, and results in mortality of species in advanced successional stages (Diaz & Rosenberg, 1995). Annual variation within advanced stage communities increases significantly (Diaz & Rosenberg, 1995). By the time a system experiences periodic or seasonal hypoxia, communities have undergone most of their structural and organizational changes (Diaz & Rosenberg, 1995). Ecosystems with persistent hypoxia are occupied only by early successional stage communities (Diaz & Rosenberg, 1995). Diversity, abundance, and biomass of these communities decrease along stable gradients of increasing hypoxia to the point of persistent anoxia, which is characterized by the absence of macrofauna (Diaz & Rosenberg).

Figure 4 is a model of the general behavior response pattern observed in studies evaluating impacts to benthic communities from organic enrichment (Rosenberg, 2001).

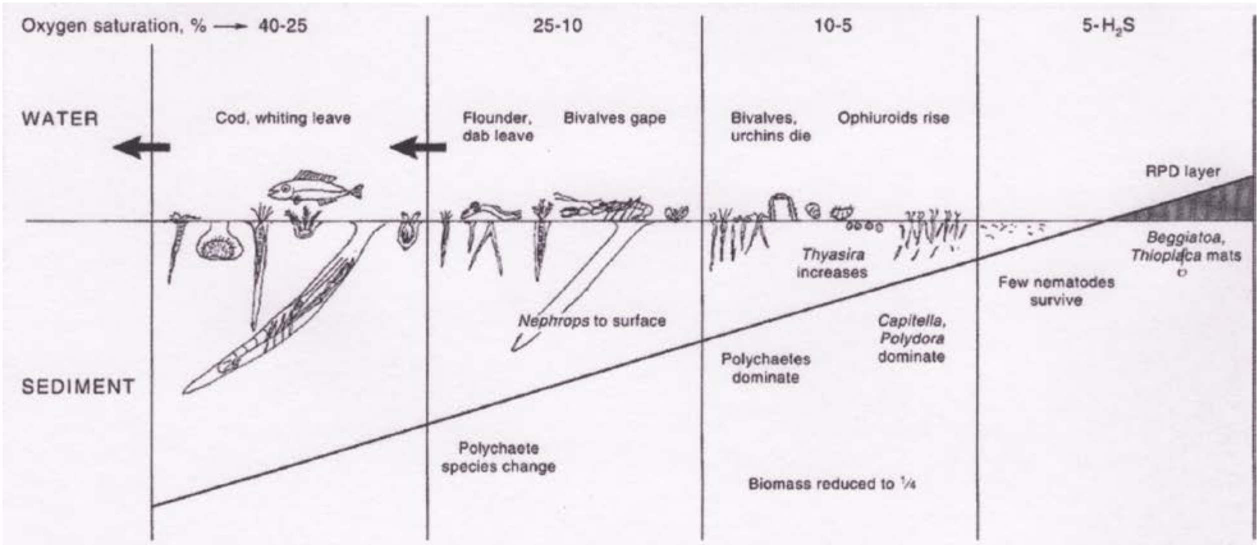

Figure 4. General ecosystem responses

2.4 Ecosystem Recovery

A common belief embodied in conservation management practices is that if the stressor can be eliminated, the ecosystem will automatically revert from an altered state to its original condition within a few years or decades (Germano & Associates, 2011). However, chronic impacts, such as discharges from fish processing facilities, profoundly alter the ecosystem (Germano & Associates, 2011). According to Germano and Kalantzi and Karakassis, the recovery process of benthic communities is typically different than a simple reverse of the pattern observed during its decline (e.g., the density and/or type of organisms) (Germano & Associates, 2011; Kalantzi and Karakassis, 2006). This conclusion is important because it may be unlikely that the ecosystems impacted by these fish waste piles throughout Alaska will return to their “original state,” considering the duration of organic loading the waterbodies have endured (e.g., 10 to 30 years).

While there are no results reported in the literature about benthic ecosystem recovery after ceasing seafood processing discharges, there are numerous studies about benthic response to other sources of organic enrichment, such as those from aquaculture (Brooks et al., 2003; Pereira, 2004; Edgar et al., 2005; Gao et al., 2005; Heilskov et al., 2006; Macleod et al., 2006, Sanz-Lázaro and Marin, 2006; Kutti et al., 2007; Villnäs et al., 2011), coastal sewage outfalls (Smith and Shackley 2006, Shin et al., 2008), treated ballast water (Blanchard et al., 2003), or experimental enrichment treatments (Posey et al., 2006 and O'Brien et al., 2009 in Germano, 2011).

Numerous studies have been conducted on how quickly the benthic environment within fish cages recovers when fish farming activities are ceased in the fish cage. In Greece, after twenty-three months, benthic recovery was not achieved (Karakassis, Hatziyanni, Tsapakis, and Plaiti, 1999). In British Columbia, benthic recovery was achieved within 6 months (Brooks, Stierns, and Backman, 2004). In Scotland, benthic recovery was achieved within fifteen months (Pereira, Black, McLusky, and Nickell, 2004). In Spain, benthic recovery was monitored at three former fish farm locations for between 7 and 33 months of the end of fish farming activities (Sanz-L**á**zaro and Marin, 2006). Even after 33 months, benthic recovery had not been achieved. Potential reasons for the wide range in recovery include factors such as length of time of accumulation, location of waterbody (e.g., water temperature and currents), water depth, and type of native sediment on seafloor (e.g., amount of sand or clay). Native sediment in this context is meant to represent the seafloor as it originally existed rather than sediments that have been deposited here or moved around as a result of the disturbances in the area.

The time of benthic community recovery after cessation of organic or nutrient enrichment varies based on numerous variables including, but not limited to, spatial latitude of the enrichement, depth, salinity, volume of organic input, sediment type, and local hydrodynamics

(Germano & Associates, 2011). According to Germano & Associates (2011), based on past studies on benthic recovery related to aquaculture impacts and recolonization studies of dredged material disposal sites, the typical recovery time for benthic communities after a substantial disturbance event ceases is somewhere between 18–60 months (depending on a variety of site-specific factors). Diaz & Rosenberg (1995) anticipated that if the input of nutrients to the ecosystem were significantly reduced and followed by increased oxygen concentrations in hypoxic/anoxic bottom water, a rapid colonization is anticipated and could restore the ecosystems within a decade.

Recovery may be slowed by the presence of seasonal or even periodic hypoxic conditions, ongoing organic loading, deeper water, and in quasi enclosed areas or areas with slower current velocities. Recovery is generally more rapid in shallow waters and in open waters with swifter currents. Studies comparing the impacts and recovery timeframes in warm water climates versus cold-water climates do not exist.

Several studies on the effects of low oxygen conditions on marine benthos exist in areas comparable to Alaska. In Sweden after low oxygen conditions lasted about six months, within two years, the benthic community had recovered to the same community composition and approximate density that existed before the adverse impact (Rosenberg et al., 2002). However, Mee et al. (2005) found in the Black Sea that if low-oxygen conditions last longer than five years, it appears that the hysteresis-like recovery response is exaggerated. In this case, recovery of the benthos was incomplete ten years after the low oxygen conditions ceased (Mee et al, 2005). These results seem to be comparable to a response recently observed in Ketchikan, Alaska.

In 2004, the result of the benthic assessment conducted in Ketchikan was that the area of seafloor experiencing adverse effects from excess organic loading around two active seafood processing facilities was almost 7 acres (Germano et. al., 2004). At that time, Germano concluded that if the fish processing plants ever ceased operations, the effects caused by the waste discharge on the benthic ecosystem would disappear over time, and the benthic community would recover within five to ten years with few adverse effects remaining from these point sources of organic loading (Germano et al., 2004). According to the 2010 benthic assessment, the fish waste pile and area of negatively impacted benthos was approximately 1 acre, despite extreme reductions in or eliminations of the discharge of seafood waste (Germano & Associates, 2011). These results demonstrate a reduction in the impacts from organic enrichment, albeit more slowly than initially predicted (Germano et al., 2004).

According to Pearson and Rosenberg (1978), benthic community disturbance due to organic enrichment will be apparent as the number of opportunist species increases followed by decreases in sensitive species. This pattern was observed in a study in Port Valdez, Alaska, which evaluated the benthic community near an effluent source of petroleum hydrocarbons (Blanchard et al., 2003). The study noted a strong association between the benthic community in Port Valdez and hydrocarbons from the diffuser effluent (Blanchard et al., 2003)

Kutti et al. (2008) evaluated benthic communities at aquaculture facilities in Norway and documented a higher density of pollutant resistant species during periods of moderate loading of organic matter and only one species during periods of high organic loading (Kutti, Ervik, and Høisæter, 2008).

Villnäs et al (2011) evaluated the benthic recovery from fish farms in the Northern Baltic Sea. The two fish farms that were included in the study had operated for 15-20 years and had ceased activities two years previous to the study (Villnäs et al., 2011). According to Villnäs et al.

(2011), macrobenthic communities close to both fish farms were degraded soon after the fish farms became operational and continued organic enrichment resulted in high species turnover rates and altered benthic community composition. A shift was recorded in the dominance of individual benthic species (Villnäs et al., 2011). This study emphasized the importance of evaluating structural and functional response patterns as well as the recovery potential of benthic communities to organic enrichment (Villnäs et al., 2011).

Smith and Shackley (2006) conducted a study on the benthos in Wales, United Kingdom, before, during and after major sewage discharges. Their study documented changes in species composition of benthic communities; noted an increase in the diversity of deposit feeders; and a decrease in diversity of filter feeders (Smith and Shackley, 2006). This study also noted a change in the bivalve benthic community and associated this specific change with winter storm activity (Smith and Shackley, 2006). Winter storm activity in Alaska has also been noted to alter the location and composition of a fish waste pile in Cordova (Envirotech, 2013(c)). This highlights the importance of conducting routine monitoring of recovering benthic communities.

2.5 Project Significance

While EPA has permitted the discharge of pollutants from shore- and vessel-based seafood processors in Alaska for decades, the various policies framing what, where and how seafood processors discharge pollutants in Alaska are decades old, not well vetted, and/or disjointed. As an example, the most recent general permit authorizing the discharge of seafood processing waste in Alaska became effective in 2001. In addition, the NPDES Program is a facility-based program; meaning the monitoring conducted by each facility is tracked separately. Given limited resources within EPA, compiling and evaluating information in a comprehensive manner across the industry has not occurred. Furthermore, since the issuance of the 2001 NPDES Permit for

Seafood Processors in Alaska, knowledge within the industry and the regulatory agencies regarding potential impacts of these piles has broadened. ADEC is developing the next general permit for seafood processors in Alaska, which EPA will review. This project report and the information contained within will provide EPA with a snapshot of the universe of permitted facilities in such a permit and aid in its review process.

Chapter 3. Project Goals, Objectives and Methods

3.1 Goal

The goal of this practicum project was to complete a meta-analysis and identify the location, size, and impact of fish waste piles on waterbodies in Alaska in one comprehensive report. For the most part, impacts from seafood processors in Alaska are evaluated on an individual facility basis; however, in some locations, where multiple facilities discharge to the same waterbody, ecosystem-wide analysis is important for impacts evaluation. Also, impacts from these seafood processing facilities are typically evaluated solely on the size of the fish waste pile. If the fish waste pile is less than the one-acre threshold identified in the 2001 General Permit for Seafood Processing in Alaska, then the underlying assumption is that the impacts are negligible.

3.2 Objectives

The project objectives were as follows:

a. Quantify the total number of acres on the bottom of waterbodies covered by fish waste piles.
b. Identify the number of permittees required to monitor piles and compare with the number of permittees that have completed the monitoring.
c. Describe trends observed with respect to changes in the size of the piles.
d. Determine if fish waste piles may be linked to changes in subsistence activities.
e. Describe watershed-wide chemical, physical, and biological impacts.
f. Compare/contrast differences in impact(s) to a waterbody by type of receiving water (flow, depth of waterbody, etc).

3.3 Methods/ Activities

The UAA Institutional Review Board approved this project on June 10, 2014. Data collection for this project included obtaining secondary data collection from publically available sources. First, a wastewater discharge permit search was conducted on ADEC's website to obtain a list of all current seafood processors in Alaska with wastewater discharge permits. This list was then filtered to include only shorebased processors. Next, a public records request was submitted to ADEC for dive surveys and benthic assessments associated with all the shorebased seafood processing facilities with current NPDES permits. ADEC provided electronic copies of dive surveys, annual report, benthic assessments, and quality assurance plans, as applicable to the list of facilities identified in the request. These reports were provided by ADEC on a CD, which was then transferred to the principle investigator's personal computer. The original CDs were placed into a locked cabinet for storage. As each report was reviewed, a Record Review Sheet was used to summarize pertinent information (see Appendix A for the Record Review Sheet). Then a project database was developed on the personal investigator's computer and information from the Record Review Sheets was entered into the project database (see Appendix B for template of database). This information included quantitative data, such as the acreage and thickness of each fish waste pile, as well as the date(s) of surveys.

Once the information from the ADEC public request was entered into the project database, a list of potentially impacted communities was identified, with respect to the size of fish waste piles. This list of potentially impacted communities was discussed with EPA, which then provided additional benthic assessments and dive surveys electronically.

Subsistence information was obtained electronically from the Community Subsistence Information System, which is maintained by the State of Alaska Department of Fish and Game. ADEC’s list of impaired waterbodies was used to obtain pertinent information regarding water quality in the waterbodies potentially impacted by the seafood processing facilities. ADEC’s list of impaired waterbodies was obtained from the ADEC website and saved electronically on the principle investigator’s personal computer. Any plans for improving water quality in impaired waterbodies (called Total Maximum Daily Load reports) were obtained from EPA’s website and also saved on the principle investigator’s personal computer. The presence of resident and anadromous fish in proximity to the potentially impacted communities was obtained through the State of Alaska Department of Fish and Game’s Fish Monitor online mapping application.

Chapter 4. Results

Out of the 81 shorebased facilities included in the ADEC records request, ADEC had annual reports and dive surveys from 39 facilities. Based on this information from 39 shorebased facilities, approximately 115 acres of seafloor in Alaska is covered by fish waste piles. This is a conservative estimate because some of the dive surveys only include “continuous” coverage of fish waste in the measured estimates. Continuous coverage is defined by 100% coverage of fish waste in a three by three square foot area (Envirotech, 2013c). In addition, numerous facilities do not have a recent dive survey on record. The average thickness of the fish waste piles in Alaska is eight feet, for the facilities that monitor fish waste piles. The facilities listed in Table 1 account for 95% of the approximately 115 acres of seafloor covered with fish waste.

Table 1. Largest fish waste piles

Community	Facility	Size of fish waste pile (acre)	Maximum Depth of pile (feet)	Waterbody	Date of Most Recent Survey
Akutan	Trident Seafoods Akutan Shore Plant	**90**	20	Akutan Harbor	2010
Chignik	Trident Seafoods Chignik Production Facility	0.85	8	Anchorage Bay	2013
	Trident Seafoods Chignik Support Facility	0.32	2.9	Anchorage Bay	2013
Chignik Total		**1.17**			
Cordova	Trident Seafoods Cordova South	0.21	2.1	Orca Inlet	2014
	Trident Seafoods Cordova North	2.06	3	Orca Inlet	2013
	Ocean Beauty Seafoods	0.09	Not specified	Orca Inlet	2012
	Copper River Seafoods	0.19	4.9	Orca Inlet	2013
Cordova Total		**2.55**			
Ketchikan	E.C. Phillips & Sons	0.44	Not specified	Tongass Narrows	2013
	Trident Seafoods	3.14	7	Tongass Narrows	2011
	Alaska General Seafoods	0.24	15 (2010)[1]	Tongass Narrows	2013
Ketchikan Total		**3.82**[2]			
King Cove	Peter Pan Seafoods	**0.89**	10	King Cove	2011
Sand Point	Trident Seafoods	**4.73**	14	Popof Strait	2011
Sitka	Seafood Producers Cooperative	0.44	9 (2011)[1]	Sitka Harbor Channel	2012
	Sitka Sounds Seafood	0.68	14 (2010)[1]	Sitka Harbor Channel	2011
Sitka Total		**1.12**[3]			
Unalaska/ Dutch Harbor	Unisea	**3.5**[4]	16.7	S. Unalaska Bay	2011
Unalaska/ Dutch Harbor	Westward Seafoods	**1.64**	16.75	Captains Bay	2012
Wrangell	Trident Seafoods	**1.6**	8	Wrangell Harbor	2013

1. Maximum depth not specified in the most recent dive survey report, thus most recent depth is noted with corresponding year; 2. Total includes data from three of four Ketchikan facilities; 3. Total includes data from one of three Sitka facilities; 4. Total includes data from one of two facilities that discharge into S. Unalaska Bay.

Table 2. Dive survey results from the remaining facilities with dive surveys

Community Name	Name of Facility	Waterbody	Pile Size (acre)	Maximum Pile Depth
Community Name	Name of Facility	Waterbody	Pile Size (acre)	Maximum Pile Depth
Alitak	Ocean Beauty Seafoods Alitak Plant	Lazy Bay	0.69 (2012) 0.70 (2008)	10' (2012) 4' (2008)
Cold Bay	Peter Pan Seafoods Port Moller Plant	Port Moller Bight	0 (2012)	0
Craig	Silver Bay Seafoods	Klawock Inlet	0.86 (2012) 0.42 (2010)	0
Dillingham	Peter Pan Seafoods Dillingham Plant	Nushagak River	0 (2009)	0
Egegik	Icicle Seafoods Egegik Plant	Egegik Bay	0 (2013, 2012, 2011. 2010, 2009, 2008)	0
False Pass	Bering Pacific Seafoods False Pass Plant	Isanotski Straits	0.03 (2012) 0 (2008)	6" (2012) 0 (2008)
Homer	The Fish Factory Homer Seafood Plant	Kachemak Bay	0.03 (2014) 0.03 (2012) 12 ft^2 (2011) 0 (2009) 0 (2007)	1' (2014) 6' (2012) 18-24" (2011) 0 (2009) 0 (2007)
Hoonah	Alaska Seafood Holdings Hoonah Cold Storage	Port Frederick	0.28 (2011)	5' (2011)
Juneau	Ocean Beauty Seafoods Excursion Inlet Plant	Excursion Inlet	0.26 (2012) 0.32 (2007) 0.23 (2003)	4.6' (2012) 3' (2007)
Juneau	SASSCo Taku Fisheries and Smokeries Juneau Plan	Gastineau Channel	0.45 (2013) 0.45 (2012) 0.53 (2011) 0.48 (2010) 0.41 (2009) 0.42 (2008)	6.4' (2013) 8.9' (2012) 7.6' (2011) 8.7' (2010) 9.4' (2009) 9' (2008)
Kenai	Pacific Star Seafoods Kenai Plant	Kenai River	0 (2008, 2009, 2010, 2011, 2012)	0
Kenai	Inlet Fish Producers Kasilof Plant	Kasilof River	0 (2008, 2009, 2020, 2012, 2013)	0
Larsen Bay	Icicle Seafoods Larsen Bay Plant	Uyak Bay	0 (2013, 2012, 2011, 2009)	0

Naknek	Alaska General Seafoods Naknek Seafood Plant	Naknek River	0 (2009)	0
Nome	Norton Sound Economic Development Nome Plant	Dry Creek & Snake River	0 (2011) 0 (2010) 0.092 (2009)	0
Petersburg	Icicle Seafoods Petersburg Plant	Wrangell Narrows	0 (2009) 0 (2008)	0
Petersburg	Trident Seafoods Petersburg Plant	Wrangell Narrows	0 (2012) 0 (2011)	0
Petersburg	Ocean Beauty Seafoods Petersburg Plant	Wrangell Narrows	8 ft^2 (2012) 0 (2008)	0
Seward	Resurrection Bay Seafoods Seward Plant (Sea Level Seafoods)	Resurrection Bay	0.17 (2013) 0.15 (2010)	3' (2013) 4' (2010)
Seward	Polar Seafoods Seward Plant	Resurrection Bay	0.0095 (2010)	0
Unalakleet	Norton Sound Seafood Unalakleet Plant	Unalakleet River	0 (2011)	0
Yakutat	Yakutat Seafoods Yakutat Plant	Mondi Bay	0.29 (2010) 1.45 (2006)	

Table 2 Continued. Dive survey results from the remaining facilities with dive surveys

Table 3 provides population information for each of the nine potentially impacted communities where the largest known fish waste piles are located. This information was obtained from the State of Alaska Department of Commerce, Community, and Economic Development (2014) Alaska Community Database Online.

Table 3. Statistics for nine potentially impacted communities

Community Name	Current Population[1]	Land (mi^2)	Name of Federally Recognized Tribe	Per Capita Income
Akutan	1052	65.58	Native Village of Akutan	$25,370
Chignik	96	11.7	Chignik Bay Tribal Council	$25,960
Cordova	2286	61.4	Native Village of Eyak	$37,992
Ketchikan	8314	3.4	Ketchikan Indian Community	$28,279
King Cove	905	25.3	Agdaagux Tribe of King Cove	$25,958
Sand Point	946	7.8	Native Village of Unga	$27,165
Sitka	9061	2874	Sitka Tribe of Alaska	$32,521
Unalaska / Dutch Harbor	4689	111	Qawalangin Tribe of Unalaska	$32,331
Wrangell	2406	2582	Wrangell Cooperative Association	$28,474

1 – 2014 Department of Labor Estimate

4.1 Fish Pile Trends, Waterbody Characteristics and Uses

This section contains information about each of the nine communities and waterbodies that contain the largest fish waste piles. One Category 4a waterbody that is not included in this list of the largest fish waste piles is Udagak Bay. This waterbody was listed on the Section 303(d) list in 1994 for settleable solids from fish waste (ADEC, 2010). One floating processor discharges seafood waste into Udagak Bay and because of the poor flushing in Udagak Bay, two piles of fish waste have accumulated at the bottom of the bay (ADEC, 2010). A TMDL was completed for Udagak Bay on September 30, 1998, and the waterbody was removed from the Section 303(d) list in 1998 and remains as a Category 4a waterbody (ADEC, 2010). Since this project focused on shore-based facilities, data from this facility was not collected.

Trends of the fish waste piles depend on three main variables - the characteristics of the waterbody, the amount of discharge, and the survey method. Waterbodies with multiple facilities rarely had dive surveys completed in the same years, which limited opportunities for trend analysis. In addition, surveyors do not calculate the area of a pile in the same way. The Alaska Seafood General Permit directs permittees to calculate the area of fish waste piles by the following equation: maximum length x maximum width x 0.67 (conversion factor) (EPA, 2001). The conversion factor is used in calculating the area due to the fact that the fish waste piles typically form a parabola shape, as opposed to a rectangular shape.

Individual seafood permits do not contain any equation for calculating the area of fish waste piles. Based on the reports received, some surveyors calculate the area of fish waste piles using the correction factor and some do not. Furthermore, there are inconsistencies with how much waste is included in each calculation. Some of the individual permits require permittees to quantify only the "continuous" waste in the area calculation; while other permits are silent on the density of fish waste to be included in the quantification of the piles. Therefore, some dive survey reports quantify the density of the fish waste in a given area (e.g., continuous versus discontinuous), while other dive survey reports do not contain this level of detail. Continuous coverage has been defined in recent surveys as 100% fish waste coverage of the seafloor within a 3 foot by 3 foot sample square and discontinuous is defined as 10 to less than 100% fish waste coverage of the seafloor (Envirotech, 2013c). For purposes of this project, the size of fish waste piles was calculated using the maximum length times maximum width as provided in the dive survey reports and included both continuous and discontinuous coverage of fish waste in the calculation, where reported and identified.

4.1.1 Akutan - Akutan Harbor

In Akutan, Trident Seafood Corporation operates the largest seafood processing facility in North America. Akutan Harbor is a Category 4a waterbody for settleable solids and dissolved oxygen (ADEC, 2010). In 1995, TMDLs for both settleable solids and biochemical oxygen demand were developed and included an approach for reducing the load of these pollutants (EPA, 1995a and 1995b). The approach for reducing settleable solids was to require the seafood processor to screen its waste into smaller pieces (EPA, 1995a). For dissolved oxygen, limits were placed on the seafood processor for the amount of loading allowed during the year (EPA, 1995b). Water quality data collected by Trident in 2008, 2009, and 2010 indicate that the Alaska Water Quality Standard for dissolved oxygen is being met and ADEC plans to remove Akutan Harbor from the impaired list for dissolved oxygen (ADEC, 2012).

There are two anadromous streams at the west side of the Akutan Harbor. These streams contain Coho salmon and are used by pink salmon for spawning (ADF&G, 2014). The community also uses the waterbody for subsistence activities. Residents harvest fish, berries, marine mammal, bird eggs and plants (ADF&G, n.d.). According to the State of Alaska Department of Fish and Game (ADF&G), 100% of residents use all resources and 94.4% participate in harvesting activities (ADF&G, n.d.).

In the past decade, dive surveys and benthic assessments in Akutan Harbor have documented the pile to increase from 8 to 15 acres in size and the maximum depth of the pile has ranged from 12 to 15 feet thick (Envirotech, 2004, 2006a, 2008b, 2010b). A benthic assessment was conducted in Akutan Harbor in 2010 and found the presence of fish waste on 90 acres and determined that approximately 50 acres of the seafloor contained anoxic sediments and depletion of the benthic community of worms/tubes (Germano, 2011). According to Germano &

Associates, the benthic communities in the sediments at the Akutan fish waste pile showed the classic pattern of benthic community response to organic enrichment (Germano, 2011).

The State of Alaska Department of Fish and Game interviewed Alaska Native hunters during the early to mid-1990s and published a compendium, which presented information about contemporary patterns of hunting and use of harbor seals and sea lions by Alaska Natives during the late 20th century (Haynes and Wolfe, 1999). According to the interviewees in Akutan Harbor, they noticed resources declining in Akutan Harbor in the early 1990s (Haynes and Wolfe, 1999). The interviewees also explained that sea lions were present around the seafood processing outfall and were observed going after the ground waste, especially the cod livers; however, during the November 1993 interviews, people stated that there are not as many harbor seals in Akutan Harbor anymore (Haynes and Wolfe, 1999). Interviewees also stated that sea lions were getting caught in the trawling nets (Haynes and Wolfe, 1999).

4.1.2 Chignik – Anchorage Bay

In Anchorage Bay, there are anadromous streams, as documented by Alaska Department of Fish and Game. These streams support pink salmon spawning and rearing and Dolly Varden trout rearing (ADF&G, 2014). According to the State of Alaska Department of Fish and Game subsistence report for 2011, 91.3% of household use the resources in Chignik Bay and approximately 65% of household harvest the resources. The subsistence report from 2003 indicated that 97% of residents in Chignik used the local resources for subsistence activities and approximately 95% of the population harvested (ADF&G, n.d.). Residents harvest fish, marine mammals, and waterfowl (ADF&G, n.d.). ADEC has not made a determination for the water quality of Anchorage Bay (ADEC, 2012).

The piles in Anchorage Bay, which are associated with two facilities, have both decreased in acreage since 2011 (Envirotech, 2011a, 2012b, 2013b). At the Chignik Support Plant, the pile and maximum depth have both decreased from 0.65 acres and 5 feet thick in 2011 to 0.32 acre and 2.9 feet thick (Envirotech, 2011a, 2013b). The Production Plant facility pile has decreased from 1.1 acre in size in 2011 to 0.85 acre in 2013 (Envirotech, 2011a, 2013b). However, the maximum thickness of the pile slightly increased from 7.5 feet thick to 8 feet thick in 2013 (Envirotech, 2011a, 2013b). It would be important for regulators to understand if this decrease in pile size was associated with a decrease in production and discharge as well. Obtaining production information was outside the scope of this project.

4.1.3 Cordova – Orca Inlet

In Cordova, four seafood processing facilities discharge into Orca Inlet within one mile of each other (ADEC, 2013b). The cumulative acreage from the four fish waste piles was 2.55 acres in 2013 (Envirotech, 2012a, 2013a, 2013c, 2013d). One of the four facilities conducted a dive survey in 2012 and not 2013; therefore, the data from the 2012 survey were used for purposes of this project (Envirotech, 2012a). With respect to trends in size of the piles, two of four piles have decreased in the past five years, one has increased slightly and one has fluctuated. The two piles at Copper River Seafoods and Trident South have decreased in area. The Copper River Seafoods pile has decreased from 0.27 to 0.19 acre (Pudwill, 2006; Envirotech, 2013a). The maximum depth of the pile in 2006 and 2013 was 1 foot and 5 feet, respectively (Pudwill, 2006; Envirotech, 2013a). The Trident South pile has decreased from 0.44 in 2010 to 0.21 in 2014 (Envirotech, 2010c, 2014d). The Trident South pile maximum depth has increased from 1.5 feet in 2012 to 2.1 feet in 2014 (Envirotech, 2013d, 2014).

Ocean Beauty’s pile increased slightly from 2009 (0 acre) to 0.09 (2012) (Global, 2009;

Envirotech, 2012a). The pile associated with the Trident North facility has fluctuated in size. In 2011 the pile was 2.58 acres and 6.6 feet deep (Envirotech, 2011b). In 2012, the pile was 5.76 acres and 4.4 feet maximum thickness (Envirotech, 2012c). In 2013, Envirotech determined the pile to be 2.06 acres with a maximum thickness of 3 feet (Envirotech, 2013c). One factor possibly contributing to the increase between 2011 and 2012 is the timing of the survey. The facilities in the Cordova area operate at their peak during salmon season (June to August). The 2011 survey was conducted from May 18-22, which is prior to salmon season, while the 2012 and 2013 surveys were conducted in October, after salmon season.

Residents harvest fish, marine mammals, waterfowl, beavers, birds, and bird eggs (ADF&G, n.d.). According to ADF&G, 91.3% of household use the resources in Orca Inlet and approximately 65% of household harvest the resources (ADF&G, n.d.). ADEC has not made a determination for whether Orca Inlet meets Alaska Water Quality Standards (ADEC, 2012).

Numerous anadromous streams flow into Orca inlet, including Eccles, Whiskey Creek, Odiak Slough, Ocean Dock Creek, and Eyak Lake (AFDG, 2014). These waterbodies contain chum salmon, cutthroat trout, Coho salmon, Dolly Varden trout, and pink salmon. Coho salmon rear in Whiskey Creek; pink salmon spawn in Odiak Slough; chum and sockeye salmon spawn in Eyak Lake (ADF&G, 2014).

4.1.4 Ketchikan – Tongass Narrows

ADEC separates the Tongass Narrows waterbody into two distinct segments – Tongass Narrows 1 and 2. Tongass Narrows 1 was placed in Category 4b for residues in 2002/2003 based on the seafood processing facility exceeding its 1-acre zone of deposit and EPA was managing the size of the zone of deposit through an enforcement actions (ADEC, 2012). A 2005 dive survey reported a reduction of 0.31 acre from the 2004 survey, with a total acreage of 1.22, and compliance with the residues impairment standard. In 2006, the EPA reported that the fish waste pile was 0.5 acre; therefore, ADEC moved Tongass Narrows 1 from Category 4b to Category 2 in 2006 (ADEC, 2012).

Tongass Narrows 2 was placed in Category 4b for residues in 2002/2003 based on the size of the fish waste pile (e.g., greater than 1 acre) (ADEC, 2012). Similar to Tongass Narrows 1, the seafood processor was under an EPA enforcement action to reduce the size of the fish waste pile (ADEC, 2012). In 2006, the fish waste pile was 0.5 acre and the facility was back in compliance with its permit (ADEC, 2012). ADEC determined that Tongass Narrows 2 was meeting water quality standards and moved it from Category 4b to Category 2 in 2008 (ADEC, 2012).

The waterbody uses for the Tongass Narrows was not as complete as the waterbodies previously described. Residents in Ketchikan harvest marine mammals; however, a percentage of the population using the Tongass Narrows was not calculated (ADF&G, n.d.). To the west of the facilities, across the Tongass Narrows are two creeks that support anadromous fish – all five species of salmon, steelhead trout and cutthroat trout (ADF&G, 2014).

Four facilities discharge into the Tongass Narrows within 1.55 miles of each other (ADEC, 2013b). Three of the four facilities have submitted dive surveys to DEC within the past 15 years. ADEC completed a benthic assessment in 2004 for each facility's pile. The studies documented that each 1-acre fish waste pile negatively impacted the benthic life for up to seven acres (Germano & Associates, 2004).

In 2004, Alaska General Seafoods agreed to cease discharging from its outfall until the waste pile was smaller in size (EPA, 2004). The pile associated with the Alaska General Seafoods plant in Ketchikan decreased from 0.97 acre in 2008 to 0.86 acre in 2010 yet the thickness of the pile increased from 6 feet in 2008 to 15 feet in 2010 (Envirotech, 2008a, 2009, 2010a). This increase in thickness of the pile may have occurred as a result of the consolidation of the pile spatially in order to decrease the acreage, which is the only limit for pile sizes in the Alaska Seafood General Permit.

E.C. Phillips operates year round and processes rockfish, sablefish, halibut, salmon, clams, urchins, sea cucumbers, shrimp, and other bottomfish (E.C. Phillips, 2010 Annual Report). E.C. Phillips submitted five dive surveys that demonstrate a steady state for pile acreage. From 2010 through 2013, the pile was 0.44, 0.45, 0.38, and 0.44 acre, respectively (Alaska Commercial Divers, 2010, 2011, 2012, 2013).

The Trident Ketchikan facility operates March through November and processes salmon (Trident, n.d.). In 2000, the fish waste pile associated with the Trident Ketchikan facility was 3.2 acres in size (Envirotech, 2000a). In 2003 the pile was 2.01 acres (Envirotech, 2003). In 2002, according to EPA, the facility's fish waste pile released bubbles that sent large mats of decomposing fish waste up to the sea surface. The releases from the pile also emitted large amounts of sulfur dioxide, which caused odors strong enough for Ketchikan residents to smell. Similar to the Alaska General Seafoods facility, Trident Ketchikan was prohibited from discharging through its outfall for three years and took efforts to remediate the fish waste pile to reduce its size (EPA, 2002).

Consequently in 2006, the pile was 0.56 acre (Envirotech, 2006b). In 2010 the pile acreage increased to 1.36 acre (Envirotech, 2010d). According to the 2010 dive survey report, Trident installed a new outfall line in 2005 in deeper -100 feet MLLW and three piles of sea urchin waste was observed to the north of Trident's fish waste pile (Envirotech, 2010d). The piles were described to be at least 16 feet thick (Envirotech, 2010d). This is an interesting discovery because the sole processor of sea urchins in Ketchikan is E.C. Phillips and its outfall is approximately 1.3 miles upstream from the Trident outfall (ADEC, 2013b). In 2011 the diver discovered that the old outfall line was snagged, likely by a vessel anchor, and moved 80 feet, where the outfall line split apart and formed a new pile (Envirotech, 2011c). In total, the Trident Ketchikan fish waste pile was 3.14 acres in 2011 (Envirotech, 2011c).

4.1.5 King Cove – King Cove

King Cove was originally added to the 1996 Section 303(d) list for residues as a result of a seafood processing facility (ADEC, 2012). In 1998, EPA completed a TMDL for King Cove and the waterbody was moved from Category 5 to Category 4a, where it remains (ADEC, 2012).

The ADF&G harvest data sets available are from 1992 and 2005. In 2005, residents reported harvesting marine mammals; however, percentages of the residential population harvesting or using the resources were not provided (ADF&G, n.d.). The most complete harvest dataset is from 1992 and includes harvest data for Sand Point and King Cove combined. The entire residential population used all resources and harvested fish, marine mammals, crustaceans, sea urchins, vegetation, birds, bird eggs, sea cucumbers (ADF&G, n.d.). One stream in the area supports anadromous fish species. Ram Creek supports the spawning of chum and pink salmon (ADF&G, 2014).

Peter Pan Seafoods is the sole seafood processing facility in King Cove. It has one of the most complete historical records of dive surveys from the past decade. In 2004, the fish waste pile at the end of the plant outfall was estimated at 0.90 acre and had a maximum depth of 18 feet thick (Peter Pan Seafoods, 2005). The size and thickness of the pile have slightly fluctuated since then. Peter Pan processes its waste solids through a fishmeal plant and remaining solids pass through a rotary screen before discharge (Peter Pan Seafoods, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011). Table 4 illustrates the trends associated with the Peter Pan King Cove plant discharge and fish waste pile.

Table 4. Peter Pan King Cove

Date of survey	**Pounds discharged**	**Acre**	**Maximum thickness (feet)**	**Pertinent notes**
December 2004	7,382,896	0.90	18	
October 2005	7,833,130	0.91	14	Gas bubbles
December 2006	8,927,420	0.92	10	White crust
October 2007	8,269,174	0.96	8	White crust and gas bubbles present; flattening of the pile likely due to severe storm activity
July 2008	3,251,760	0.82	15	
November 2009	2,513,893	0.89	10	White crust
November 2010	2,332,458	0.89	10	White crust
October 2011	1,846,454	0.89	10	Gas bubbles, black decaying material

The pile in King Cove is an example of a slow natural decomposition rate. Even though the amount of solids has decreased substantially, the pile size remains relatively stable. Given the enclosed nature of this waterbody, natural attenuation of the fish waste pile is expected to be slower. The notes provided by the diver are helpful and indicative of the presence of both *Beggiatoa* and methane gas (i.e, gas bubbles). The presence of *Beggiatoa* is an indication that the organic loading to the waterbody occurs more quickly than the ecosystem can assimilate. If more information about the impacts of this fish waste pile is warranted, a benthic assessment survey is recommended.

4.1.6 Sand Point – Popof Strait

Popof Strait was added to the Section 303(d) list in 1996 for residues as a result of fish waste discharges (ADEC, 2012). A TMDL for Popof Strait has not been developed (ADEC, 2012). There is one seafood processing facility that discharges to Popof Strait and is authorized a one-acre zone of deposit (ADEC, 2012).

Subsistence information from 2008 identified residents of Sand Point harvesting marine mammals; however, percentages of the population uses the resources were not provided (ADF&G, n.d.). According to the ADF&G, pink salmon spawn in anadromous streams near the seafood processing facility in Popof Strait (ADF&G, 2014).

Trident operates the processing facility in Sand Point. Two dive surveys were available from the last decade. One conducted in 2000 and the other in 2011. According to the 2011 dive survey, the current outfall line terminates in -26 feet MLLW. There are five fish piles and overall they are a combined area of 4.73 acres (Envirotech, 2011d). This is an increase of 0.83 acre from the size of the fish pile in 2000 (3.9 acres). In 2011, the fish piles ranged in thickness from 5 to 14 feet (Envirotech, 2011d). The plant operates year-round, processing cod, black cod, halibut, pollock, salmon and other assorted bottomfish. The facility is capable of processing up to 600,000 pounds of cod per day, 1.2 million pounds of pollock per day or 350,000 pounds of salmon per day (Trident, n.d.).

4.1.7 Sitka – Sitka Harbor Channel

Two facilities discharge into Sitka Harbor Channel – Sitka Sound Seafoods and Sitka Producers Cooperative. Sitka Sound Seafoods discharges all fish species, with the exception of salmon, year round (North Pacific Seafoods, n.d.). Salmon is discharged from June through August (North Pacific Seafoods, n.d.). The fish pile at the Sitka Sound Seafoods plant measured

4.24 acres in 2009, 1.24 acres in 2010 and 0.68 acre in 2011/2012 (Haggit, 2010b, 2011b). The 2011 dive survey report described the pile to be anoxic in the immediate vicinity of the pile with a light layer of *Beggiatoa*. The general health observed was described to be "fair of a marine ecosystem and of poor quality in the immediate vicinity of the pile" (Haggit, 2011b).

The Seafood Producers Cooperative facility discharges salmon, halibut, rockfish and sablefish from March through November. The fish pile at the end of the outfall measured 0.94 acre and 0.78 acre in 2008 and 2009, respectively (Haggit, 2010a). A joint benthic assessment was conducted in 2010 on the two piles. The Seafood Producers Cooperative pile measured 1.37 acre and a maximum thickness of ten feet (Haggitt, 2010a). The benthic assessment report explained that sediment chemistry, water chemistry and sediment profile imagery is useful in delineating qualitative and quantitative impacts of fish waste piles (Haggit, 2010a). In 2011, a dive survey measured the pile 0.40 acre with a maximum thickness of nine feet (Haggit, 2011b).

ADEC has not classified Sitka Harbor Channel with respect to meeting Alaska Water Quality Standards (ADEC, 2012). In 2006, 50% of the population harvested fish and marine mammals from local waterbodies (ADF&G, n.d.). Sitka Harbor Channel supports anadromous fish species from Peterson Creek, which has Coho salmon, pink salmon and Dolly Varden trout (ADF&G, 2014). Interviewees from the seal hunter interviews mentioned during their interview in February 1993, there are not as many sea lions in Sitka Harbor Channel because of the herring roe fisheries (Haynes and Wolfe, 1999).

4.1.8 Unalaska – S. Unalaska Bay & Captains Bay

Seafood processing facilities in Unalaska discharge into two main waterbodies – South Unalaska Bay and Captains Bay. Three facilities, Unisea, Westward Seafoods, and Alyeska Seafoods, operate in the City of Unalaska and two of the three facilities have completed dive surveys within the past decade. According to ADEC records, Alyeska Seafoods, which discharges into South Unalaska Bay, has not conducted a dive survey since 2006 and ADEC did not have a copy of the 2006 survey report (Alyeska, 2009).

South Unalaska Bay is a Category 4a waterbody (ADEC, 2012). ADEC added this waterbody to the Section 303(d) list for both settleable solids and dissolved oxygen in 1994 (ADEC, 2012). EPA issued TMDLs in 1995 and revised seafood processing permits to implement TMDL controls (ADEC, 2012).

Captains Bay is a Category 2 waterbody (ADEC 2010). This waterbody was placed on the 1994 Section 303(d) list for settleable solids based on the fish pile zone of deposit was being exceeded (ADEC, 2010). ADEC evaluated monitoring data for Captains Bay and determined that the facility was in compliance with the zone of deposit provision and in 1998 ADEC removed Captains Bay from the Section 303(d) list (DEC 2010).

Several smaller waterbodies, which support anadromous fish, are near South Unalaska Bay. The Makushin River supports spawning and rearing of Dolly Varden trout and Coho salmon, and spawning of chum and pink salmon; Coho and pink salmon spawn in the Nateekin River; Coho, pink and sockeye samlon spawn in the Iliuliuk River; and Unalaska Lake supports pink salmon and the spawning of Coho and sockeye salmon (ADF&G, 2014).

Captains Bay also contains smaller waterbodies that support anadromous fish. Coho, chum, and pink salmon spawn in the Shaishnikof River and Coho salmon rear in Captains Bay (ADF&G, 2014). In 1994, 97% of the population of Unalaska reported using all resources and 94% reported harvesting (ADF&G, n.d.). Harvested species included seaweed, berries, snails, fish, waterfowl, bird eggs, marine mammals, marine invertebrates, and crabs (ADF&G, n.d.).

The most recent harvest year available was 2008 and residents harvested marine mammals; however, the percentages of the population were not provided (ADF&G, n.d.).

Unisea discharges into South Unalaska Bay. The dive surveys from six years document a fluctuation in the size of the fish pile from 2.98 acres in 2005 to 3.5 acres in 2011 (Evans-Hamilton, 2011). The acreage of the pile increased in 2006 and 2007 to its largest reported acreage of 4.35 acres and then decreased to the 2011 size (Evans-Hamilton, 2011). The maximum depth of the fish waste pile for Unisea has ranged from 18 feet thick in 2005 to 16.7 feet thick in 2011 (Evans-Hamilton, 2011).

Westward Seafoods processes pollock, cod, halibut, black cod, king crab, snow crab, and Dungeness crab and discharges approximately 180 million pounds of waste into Captains Bay annually (Westward, 2013). Dive surveys on its fish waste pile were completed during a five-year period and generally documented an increase in the acreage of the pile. During the time period 2007 to 2012 the pile ranged from 1.2 acres to 1.64 acres, respectively (Envirotech, 2007; Envirotech, 2012d). The maximum thickness of the fish waste pile in 2012 was 16.75 feet, 0.20 acre was at least three inches thick (Envirotech, 2012d). The pile contained 0.63 acre of continuous waste and 1.01 acre of discontinuous waste (Envirotech, 2012d). A review of the historical data from the Westward facility conducted in 2012 noted “a gradual decline in the number of animals is apparent as depth increases; 0.59 acre contain anoxic sediments, 0.96 acre are suboxic and 0.10 acre normoxic” (Haggitt, 2012). Haggitt describes the primary discharge pile to be 12 feet thick (Haggitt, 2012).

4.1.9 Wrangell – Wrangell Harbor

ADF&G has not documented creeks or streams supporting anadromous fish in proximity of Wrangell Harbor (ADF&G, 2014). ADEC has not evaluated Wrangell Harbor with respect to meeting Alaska Water Quality Standards (ADEC, 2010). The ADF&G harvest data set from 2000 appeared to be the most complete for the Wrangell area. In 2000, residents harvested scallops, sea cucumbers, crab, seaweed, and marine mammals (ADF&G, n.d.). Also, 45% harvested marine invertebrates, 1-5% harvested waterfowl, 10% harvested birds and eggs, and approximately 50% harvested various types of fish (ADF&G, n.d.).

One processor discharges into the Wrangell Harbor. Trident Seafoods processes salmon and herring at this plant in the spring and summer (Trident, n.d.). Two dive surveys were reviewed, one in 2011 and one in 2013. In 2011, the fish pile was 0.75 acre with a maximum pile thickness of 5.5 feet. In 2013, the fish pile was 1.60 acre with a maximum thickness of eight feet (Envirotech, 2013e). The dive survey report explained that the increase in size is attributable to the plant outfall being moved, likely by a vessel, and a new fish pile was created. In 2013, the dive survey report identified mats of *Beggiatoa* on the pile (Envirotech, 2013e). The presence of *Beggiatoa* is an indication of heavy organic enrichment.

Chapter 5. Discussion & Recommendations

Since the Offshore Seafood General Permit in Alaska was issued in 2011, dive survey methods have been refined. ADEC-issued permits have more clarity and specific details regarding how permittees are to conduct the dive surveys. One example is the use of global positioning systems and transponders during each survey, which then allow graphic illustrations of the fish waste pile and also increases the repeatability of the survey. As a result, some increases in pile size may be attributable to the refinement of the dive survey method, rather than an increase in the physical size. Also, as other evaluations of the benthic environment are conducted, the understanding of the aquatic ecosystem and impacts increases beyond what is learned in a dive survey. These other evaluations include benthic assessments, coring studies, bathymetric studies and acoustic surveys. Fluctuations in the size of fish waste piles may be a result of a true increase in the size of the fish waste pile; however, other possibilities include a different diver or seasonal changes from tidal fluctuations. Given the subjective nature of the survey, clear methodology for dive surveys is important to increasing the reliability and repeatability of each dive survey.

Although fish waste piles have historically been monitored and managed individually, from an ecosystem perspective, an evaluation of all the piles in one waterbody is warranted. An overall ecosystem survey may reveal information about the assimilative capacity of the waterbody (i.e., how the ecosystem as a whole is handling the organic loading from multiple sources). In addition, further studies in King Cove, where the fish waste pile remains at 0.89 acre and has for nearly a decade, are warranted if reductions in the size of the fish waste pile and an understanding of the impacts of the fish waste pile are of a concern.

The seafood processing industry is critical to Alaska’s economy. Fishing is also a favorite pastime among many Alaskans. Yet the impacts from these seafood processing facilities is not widely known to the general public. One possible reason for this is that the fish waste piles are not visible. In order to increase awareness about the impacts of fish waste piles, ADEC may consider adding facility documents to its website. For example, ADEC currently has two internet-based programs that might serve as natural conduits for disseminating this information. The first is ADEC’s permit search database, which already includes facility’s permit applications and authorization letters. The second program is ADEC’s ArcGIS mapping tool, which allows users to view information about any seafood processing facility that has a wastewater discharge permit in Alaska. Information that would be beneficial for the general public to access would be a summary of the water quality data collected, the amount of fish waste discharged, and any dive survey reports. All of this information is already publically available when facilities submit their annual reports and enhancing the accessibility of the data may highlight the impacts of fish waste piles in Alaska.

Similarly, the topic of impacts from fish waste piles in Alaska is not widely discussed outside of enforcement actions with individual facilities and internally within EPA and ADEC. Increasing knowledge and awareness about the impacts of fish waste piles within the seafood processing industry could lead to open dialog about potential ways to minimize the impacts. Currently there is no formal plan to communicate the findings of this project to the seafood processing industry. However, an executive summary of this report and the tables could be used to highlight the findings of the study. In the past, EPA and ADEC have convened industry meetings for regulatory and industry collaboration. If ADEC convenes any such meeting with the seafood processing industry and choses to discuss the impacts of fish waste piles, the findings of this project could be presented to initiate discussion amongst the meeting participants.

There is an inherent conflict between community residents who rely on seafood processing facilities for employment and the residents' motivation to discuss concerns about the operations and potential impacts of these same seafood processing facilities. If either EPA or ADEC initiates dialog with community residents, it will be important for the residents to feel comfortable speaking candidly. Different approaches may be taken in order to achieve this. One approach would be for the regulatory agency to hire a third party contractor to conduct interviews or focus groups, while maintaining the confidentiality of participants. Alternatively, the regulatory agencies could conduct an online anonymous survey in the communities of interest. Regardless of the approach taken to collect this data, the lead regulatory agency should consider initial clear and direct communications regarding the data collection (e.g., what the data is to be used for and the potential outcomes). Community members may be concerned about the seafood processing facilities closing down or decreasing the number of employees at a particular location. If those concerns can be addressed by the agency up front, then community participants may be more inclined to having open dialog about any changes or issues observed.

Based on this research, a number of recommendations regarding the potential impacts of fish waste in Alaska, are proposed below. The recommendations fall into three categories – regulatory recommendations, regulatory considerations, and industry recommendations.

5.1 Regulatory Recommendations

ADEC-required dive surveys

For the 52% of facilities that have not conducted dive surveys in the past five years, it is recommended that ADEC determine if a dive survey was required. Based on this determination, it is recommended that ADEC follow-up with these facilities to ensure a dive survey is conducted. Furthermore, facilities with large fish waste piles should be required to collect additional data, such as benthic assessments and water quality samples, to comprehensively monitor impacts to water quality and the ecosystem.

Consistent methods of calculating acreage of fish waste piles

It is recommended that ADEC prescribe consistent methods of calculating the acreage of fish waste piles to include continuous and discontinuous coverage areas. There appears to be inconsistencies regarding the inclusion of discontinuous fish waste coverage in the calculation of the total area of a fish waste pile. From the information gathered, the impacts of fish waste piles are largely dependent on the characteristics of the receiving water (e.g., velocity, tidal fluctuations) and the amount of fish waste discharged. Therefore, from a water quality protection approach, including both discontinuous and continuous coverage areas allows the regulatory agencies a broader understanding of potential impacts of the fish waste piles. Unless the assimilative capacity of a specific ecosystem is understood (e.g., the point at which the system can no longer process the amount of organic loading that occurs), combining these coverages when evaluating the impacts of the fish waste pile is essential. Two attributes of piles, the volume of the pile and the actual pile density within the volume may also have significant impacts on both the ability of the ecosystem to function and on ecosystem recovery once loading has ceased or decreased.

Alternate methods for rivers

There are numerous facilities discharging into tidally influenced waters, where alternate methods for dive surveys may be appropriate, as long as the alternate methods have a prescribed methodology to ensure they are reliable and repeatable. It is recommended that ADEC identify alternate methods for completing dive surveys in rivers. A few of these facilities complete a visual inspection of the area around the outfall at slack or extremely low tide, and use a post-hole digger to determine if any fish waste has been deposited in the sediment. As long as the alternate methods satisfy the goal of the dive survey requirement, this type of data could fill a current data gap at these facilities. ADEC may also consider using methods to trace fish waste from the outfalls to gain a better understanding of the fate of fish waste from these facilities.

5.2 Regulatory Considerations

The following recommendations do not rise to the level of urging regulatory action and are offered as considerations.

Appropriateness of one-acre pile zone of deposit

Based on the data collected, the appropriateness of the historic one-acre fish waste pile size is questionable. Given the numerous factors that influence ecosystem recovery and the different types of waterbodies throughout Alaska, zones of deposit should be applied on an individual watershed/ecosystem basis. The size of the fish waste pile ADEC authorizes should consider the characteristics of each individual waterbody and the cumulative loading from seafood facilities in the area.

Permit limit for maximum thickness of fish waste piles

Instead of limiting fish waste piles solely by area, ADEC should impose a maximum depth limitation and this determination should be based on the characteristics and uses of each waterbody. The data demonstrate that impacts from fish waste piles occur as a result of both the footprint (or acreage) and the thickness. If the more advanced successional stage worms can survive, then the chances increase for the ability of the ecosystem as a whole to sustain itself. ADEC may also consider a trigger for facilities to collect water quality samples if the fish waste pile reaches a specific size, volume, thickness, or density.

Additional studies of large fish waste piles/impaired waterbodies

For facilities with larger fish waste piles, ADEC should consider requiring additional studies to evaluate the impacts of these fish waste piles on the benthic community and water quality. For facilities discharging into impaired waterbodies, at a minimum, an annual dive survey in conjunction with water quality monitoring is recommended to closely evaluate the health of the waterbody and to develop a dataset to detect changes in waterbody health. In addition, the ecosystems within impaired waterbodies are already declining and may warrant a benthic assessment for more detailed information on the health of the waterbody. If the depth of the fish waste pile is greater than 120 feet below water, there are safety considerations to account for during dive surveys, which may increase the cost of the survey. In these cases, a biannual frequency may be considered in balancing the cost of the dive survey and the need to monitor the impacts of these fish waste piles.

Collection of water quality data

Relatively few seafood processing facilities in Alaska are required to collect water quality samples. The importance of oxygen to ecosystems cannot be overemphasized. The only seafood processing facilities required to monitor dissolved oxygen in the receiving water are the ones with individual permits. It is recommended that ADEC require more facilities to collect water quality samples, including dissolved oxygen, in the receiving water.

Collect traditional ecological knowledge

It is recommended that EPA collect traditional environmental knowledge to evaluate potential impacts of the fish waste piles on subsistence activities and provide an opportunity for open dialog on this issue. In this context, traditional environmental knowledge is the knowledge and practices related to people and their environment and generally spans generations of time. EPA has a unique government-to-government relationship with tribes in Alaska and also has experience in collecting this type of information for other permits. EPA Region 10 reissued the NPDES General Permit for oil and gas exploration, development and production facilities located in state and federal waters in Cook Inlet, Alaska (U.S. EPA, 2013). During the development of the permit, the Agency worked with the federally recognized tribal governments of the Cook Inlet region to collect traditional knowledge information to assist the EPA in understanding the linkage between oil and gas exploration, development and production in Cook Inlet and tribal subsistence use areas and resources (U.S. EPA, 2013). The traditional knowledge, coupled with data evaluation, supported the EPA's development of additional permit requirements and monitoring programs to address data gaps and to ensure the discharges are properly controlled (U.S. EPA, 2013). The collection of traditional ecological knowledge among tribes potentially impacted by seafood processing facilities may address data gaps and contribute to development or modification of permit requirements.

5.3 Industry Considerations

Industry practices have also progressed in the last thirty years. Seafood processing plants may choose alternate ways of disposing of waste, rather than discharging it through an outfall into the water. Alaska is the only state in the country that allows seafood processing plants to grind and discharge its waste and create fish waste piles. Examples of alternatives to discharging include byproduct recovery plants, such as fishmeal and fish oil plants, composting, and pet food programs. Some secondary by-product plants (e.g., fish meal) require a certain volume of waste to operate and during slower production periods, it may be infeasible to operate the secondary by-product plant. In Kodiak, the seafood processing facilities utilize a community fishmeal plant. Plants in Juneau, Sitka and Naknek divert a portion of its discharge to create frozen blocks of fish waste that is then shipped to manufacturers of pet food. One plant in Kenai ceased discharging to the Kenai River and developed a composting effort by combining wood bark from spruce bark beetle trees and fish waste. One community in southeast Alaska composts its fish waste to create and sell tea (in tea bags). Plants with existing fish waste piles may also consider extending the outfall pipes into deeper water and/or higher velocity waters. Depending on production levels and plant design, it may not be feasible to divert all of the fish waste from seafood processing plant outfalls to one of the alternatives discussed above. However, lowering the volume of fish waste discharged into Alaskan waters would be beneficial.

Another industry recommendation is specific for facilities discharging to rivers. The recommendation is to complete visual monitoring for fish waste downstream of the processing facility, in areas where waste may naturally accumulate (e.g., eddy). Currently these facilities only monitor at the end of the outfall pipe; however, in a river environment, the waste may accumulate elsewhere downstream.

Another factor to discharging fish waste is the manner in which it is discharged. Prior to 1974, processors discharged large pieces of fish waste. While this approach also created problems in many waterbodies as a result of fish waste piles, the question of whether there is some environmental benefit of discharging larger pieces of waste has been raised. The Prince William Sound Science Center studied the impacts of discharging whole carcasses into Orca Inlet (Thorne et al., 2007). The main hypothesis from this study is that unground fish carcasses would be more efficiently recycled into the local food web due to their utilization by higher trophic levels (Thorne et al., 2007). In the Prince William Sound study, over 325,000 pounds of salmon heads and carcasses were dumped into Orca Inlet in one single location (Thorne et al., 2007). Underwater camera observations and boat surveys were used to monitor and evaluate impacts (Thorne et al., 2007). No waste was observed floating or accumulating on the sea surface, shoreline, or seafloor (Thorne et al., 2007). According to Thorne et al. (2007), the disposal quantities studied were less than two percent of the quantity annually discharged by the seafood processors in Cordova. However, dumping of unground fish waste may be a topic ripe for further evaluation.

5.4 Limitations/Data Gaps

Of the 81 facilities contained in the public records requested for this project, 39 facilities have conducted dive surveys in the last five years, which is 48% of the facilities. While some of the remaining facilities may not have been required to conduct a dive survey, many of these facilities are out of compliance with the permit requirement to conduct a dive survey.

In some waterbodies, such as the Naknek River, conducting a traditional diver-lead survey may be dangerous due to the strong currents and tidal fluctuations (e.g., up to 20 feet per day). However, one of the seven processors in Naknek has evaluated whether piles have accumulated at the end of the outfall. Alaska General Seafoods sends staff out at slack tide, when staff can walk to the end of the outfall, and use a post-hole digger or shovel to determine if any accumulation of fish waste is present (Alaska General Seafoods, 2010).

The Kenai River also has several processors discharging in similar areas. Pacific Star Seafoods on the Kenai has evaluated the end of the outfall in multiple years since 2008 (Pacific Star Seafoods, 2009, 2010, 2011, 2012, 2013). Staff walk to the end of the outfall at slack tide and dig around in the sediment with a shovel. Similarly, Inlet Fish Producers on the Kasilof River has monitored the end of its outfall in 2008, 2009, 2010, 2012, and 2013 (Inlet Fish Producers, 2009, 2010, 2011, 2012, 2013, 2014). No accumulations have been reported at either location.

Two processors, Icicle Seafoods in Resurrection Bay and Alyeska Seafoods in South Unalaska Bay claim to not have conducted dive surveys because the water depth at the outfall is more than -120 feet mean lower low water (Icicle, 2009; Alyeska, 2013). According to its 2013 Annual Report, Alyeska Seafoods processed 144,784,593 pounds of raw product into 59,548,666 pounds of finished product. The difference is 85,235,927 pounds (Alyeska, 2014). The annual report does not describe the amount of waste discharged; however other plants processing similar amounts of raw product (e.g., Unisea, Westward Seafoods, Trident Akutan) all have fish piles larger than 1 acre.

According to Icicle Seafoods' annual reports, the Resurrection Bay facility discharges an average of 3,559,573 pounds of fish waste per year (Icicle, 2009, 2010, 2011, 2012, 2013). There are safety considerations when diving in water greater than -120 feet deep; however, other facilities, such as Trident Akutan, successfully conduct dive surveys in depths greater than -120 feet deep.

Facilities that have not submitted dive surveys to ADEC within the past five years are identified in Table 5.

Table 5. Facilities without current dive surveys

Nearest City/Town	Name of Facility	NPDES ID	Receiving Water
Atka	Atka Pride Seafoods Atka Plant	AKG520337	Nazan Bay
Craig	EC Phillips & Son Craig Plant	AKG520445	Bucareli Bay
Dillingham	Ekuk Fisheries Ekuk Plant	AKG520037	Nushagak River
Egegik	Coffee Point Seafoods Egegik Small Plant	AKG520358	Egegik River
Egegik	Coffee Point Seafoods Egegik Large Plant	AKG520536	Egegik River
Egegik	Big Creek Fisheries Big Creek Plant	AKG520166	Bristol Bay
Emmonak	Kwikpak Fisheries Emmonak Plant	AKG520174	Yukon River
Homer	Homer Port Fish Grinding Facility	AKG520518	Kachemak Bay
Kake	Rocky Pass Seafoods Kake Plant	AKG520073	Keku Straits
Juneau	Alaska Glacier Seafoods Juneau Plant	AKG520528	Auke Bay
Kasilof	Snug Harbor Seafoods Kasilof Plant	AKG520485	Kasilof River
Kenai	Salmantof Seafoods	AKG520478	Kenai River
Kenai	Great Pacific Seafoods Kenai Plant	AKG520479	Kenai River
Kenai	Inlet Fish Producers Kenai Plant	AKG520480	Kenai River
Kenai	Snug Harbor Seafoods Kenai Plant	AKG520483	Kenai River
Ketchikan	Pacific Sun Products Ketchikan Plant	AKG520525	Tongass Narrows
Naknek	Trident Seafoods Naknek Plant	AKG520003	Naknek River
Naknek	Ocean Beauty Naknek Plant	AKG520092	Naknek River
Naknek	North Pacific Seafoods Pederson Point Plant	AKG520112	Kvichak Bay
Naknek	North Pacific Seafoods Red Salmon Plant	AKG520039	Naknek River
Naknek	Leader Creek Fisheries Naknek Plant	AKG520467	Naknek River
Pelican	Pelican Seafoods	AKG520040	Lisianski Inlet
Saint Mary’s	Boreal Fisheries Saint Mary’s Plant	AKG520229	Yukon River
Seward	Icicle Seafoods	AKG520488	Resurrection Bay
Sitka	Silver Bay Seafoods	AKG520547	Sawmill Cove
Togiak	North Pacific Seafoods Togiak Plant	AKG520055	Togiak River

Table 5 Continued. Facilities without current dive surveys

Nearest City/Town	Name of Facility	NPDES ID	Receiving Water
Unalaska/ Dutch Harbor	Alyeska Seafoods	AK0000272	S. Unalaska By
Valdez	Silver Bay Seafoods Valdez Plant	AKG520042	Port Valdez
Valdez	Peter Pan Seafoods Valdez Plant	AKG520244	Port Valdez
Whittier	Great Pacific Seafoods	AKG520160	Passage Canal
Yakutat	Dry Bay Fisheries Dry Bay Plant	AKG520495	Monti Bay

One objective that was not achieved in this project was determining if fish waste piles might be linked to changes in subsistence activities and/or food security within communities. Conducting key informant interviews of community participants was planned. Potential impacts from fish waste piles on subsistence activities and food security in rural communities may have been evaluated if key informant interviews were completed. Information regarding subsistence activities and food security is largely missing from an evaluation of these permitted seafood processing facilities and at least partially filling this data gap was one objective this research project was expected to achieve.

The key informant interviewees were expected to be community residents and/or Tribal environmental coordinators. Potential community participants were identified within the communities of interest (see Table 1) and then contacted. Contacts occurred via email, phone, and in person at two conferences (2014 Alaska Tribal Conference on Environmental Management and 2015 Alaska Forum on the Environment). These potential community participants included local tribal environmental coordinators and tribal presidents from these communities. The potential community participants perceived the questions about subsistence activities and water quality as personal and sensitive information. In addition, based on these preliminary conversations the use of non-identifying information in a graduate research project was of concern to these potential participants. If this information is of interest to regulators, then it is recommend the EPA collect traditional knowledge, in collaboration with the tribes. EPA has a unique government-to-government relationship with the tribes and collection of this sensitive information could occur in a manner that is meaningful to the tribes and allows the information to remain confidential.

Other options for data collection of this type of information may be to gain approval from local/Tribal Institutional Review Boards and/or switching the emphasis from subsistence activities to changes in fishing in these areas in general. Focused interviews with the Alaska Department of Fish and Game staff may also reveal answers to the questions regarding the potential impacts to fish in proximity to these fish waste piles.

Another limitation of this project was the lack of primary data collection. It was anticipated that primary data would be collected from agency staff through key informant interviews; however, when agency staff were contacted, the answers to questions was obtained through references to publically available information. Therefore, for purposes of this project, primary data collection did not occur.

5.5 Public Health Implications

Based on the data collected and the knowledge about benthic recovery from chronic organic loading, it is unlikely that any benthic community impacted by these fish waste piles will recover to its original state, even if the organic loading ceases. This concept is important for regulators to understand before new zones of deposit are authorized and for managing existing fish waste piles. If the benthic community is unlikely to return to its original state, then impacts to higher trophic levels may also be irreversible. This latter conclusion is difficult to state in the absence of data.

Less than fifty percent of the facilities in the data set are in compliance with the requirement to monitor their fish waste piles. At least 115 acres of the Alaska seafloor is covered by fish waste piles and the impacts of these 115 acres are not widely known. Changes to the ecosystem may limit the availability of food and/or may change the types of food available to subsistence users. As expressed during the hunter interviews, these changes in Alaska may have already occurred. Changes in subsistence practices, food security, and potential impacts to drinking water sources are not evaluated as part of fish waste pile monitoring activities conducted by seafood processing facilities.

References

Alaska Commercial Divers. (2010). Seafloor Monitoring Survey Report, E.C. Phillips Ketchikan.

Alaska Commercial Divers. (2011). Seafloor Monitoring Survey Report, E.C. Phillips Ketchikan.

Alaska Commercial Divers. (2012). Seafloor Monitoring Survey Report, E.C. Phillips Ketchikan.

Alaska Commercial Divers. (2013). Seafloor Monitoring Survey Report, E.C. Phillips Ketchikan.

Alaska General Seafoods. (2010). Annual Report for 2009.

Alaska Timber Task Force. (October 21, 1985). Log Transfer Facility Siting, Construction, Operation, and Monitoring/Reporting Guidelines.

Alyeska Seafoods. (2009). Annual Report for 2008.

Alyeska Seafoods. (2014). Annual Report for 2013.

Blanchard, A. L., H. M. Feder, and D.G. Shaw. (2003). Variations in benthic fauna underneath an effluent mixing zone at a marine oil terminal in Port Valdez, Alaska. Marine Pollution Bulletin 46: 1583–1589.

Brooks, K.M., A. R. Stierns, C.V.W. Mahnken and D. B. Blackburn. (2003). Chemical and biological remediation of the benthos near Atlantic salmon farms. Aquaculture 219: 355-377.

Brooks, K.M., Stierns, A.R., and Backman, C. (2004). Seven year remediation study at the Carrie Bay Atlantic salmon (Salmo salar) farm in the Broughton Archipelago, British Columbia, Canada. Aquaculture, 239: 81-123.

Diaz, R. J. and R. Rosenberg. (1995). Marine benthic hypoxia: A review of its ecological effects and the behvioural responses of benthic macrofauna. Oceanography and Marine Biology: An Annual Review 33: 245-303

Diaz, R. J. and R. Rosenberg. (2008). Spreading dead zones and consequences for marine ecosystems. Science 321: 926-929.

E.C. Phillips & Sons Inc. (2010). Annual Report for E.C. Phillips facility in Ketchikan.

Edgar, G.J., C.K. Macleod, R.B. Mawbey and D. Shields. (2005). Broad-scale effects of marine salmonid aquaculture on macrobenthos and the sediment environment in southeastern Tasmania. Jour. Exp. Mar. Biol. Ecol. 327: 70-90.

Enviro-Tech Diving Inc. (2000a). Seafloor Monitoring Report, Trident Ketchikan

Enviro-Tech Diving Inc. (2000b). Seafloor Monitoring Report, Trident Sand Point

Enviro-Tech Diving Inc. (2003). Seafloor Monitoring Report, Trident Ketchikan

Enviro-Tech Diving Inc. (2004). Seafloor Monitoring Report, Trident Akutan

Enviro-Tech Diving Inc. (2006a). Seafloor Monitoring Report, Trident Akutan

Enviro-Tech Diving Inc. (2006b). Seafloor Monitoring Report, Trident Ketchikan

Enviro-Tech Diving Inc. (2007). Seafloor Monitoring Report, Westward Seafoods

Enviro-Tech Diving Inc. (2008a). Seafloor Monitoring Report, Alaska General Seafoods Ketchikan

Enviro-Tech Diving Inc. (2008b). Seafloor Monitoring Report, Trident Akutan

Enviro-Tech Diving Inc. (2009). Seafloor Monitoring Report, Alaska General Seafoods Ketchikan

Enviro-Tech Diving Inc. (2010a). Seafloor Monitoring Report, Alaska General Seafoods Ketchikan

Enviro-Tech Diving Inc. (2010b). Seafloor Monitoring Report, Trident Akutan

Enviro-Tech Diving Inc. (2010c). Seafloor Monitoring Report, Trident Cordova South

Enviro-Tech Diving Inc. (2010d). Seafloor Monitoring Report, Trident Ketchikan

Enviro-Tech Diving Inc. (2011a). Seafloor Monitoring Report, Trident Chignik

Enviro-Tech Diving Inc. (2011b). Seafloor Monitoring Report, Trident Cordova North

Enviro-Tech Diving Inc. (2011c). Seafloor Monitoring Report, Trident Ketchikan

Enviro-Tech Diving Inc. (2011d). Seafloor Monitoring Report, Trident Sand Point

Enviro-Tech Diving Inc. (2011e). Seafloor Monitoring Report, Trident Wrangell

Enviro-Tech Diving Inc. (2012a). Seafloor Monitoring Report, Ocean Beauty Cordova

Enviro-Tech Diving Inc. (2012b). Seafloor Monitoring Report, Trident Chignik

Enviro-Tech Diving Inc. (2012c). Seafloor Monitoring Report, Trident Cordova North

Enviro-Tech Diving Inc. (2012d). Seafloor Monitoring Report, Westward Seafoods

Enviro-Tech Diving Inc. (2013a). Seafloor Monitoring Report, Copper River Seafoods

Enviro-Tech Diving Inc. (2013b). Seafloor Monitoring Report, Trident Chignik

Enviro-Tech Diving Inc. (2013c). Seafloor Monitoring Report, Trident Cordova North

Enviro-Tech Diving Inc. (2013d). Seafloor Monitoring Report, Trident Cordova South

Enviro-Tech Diving Inc. (2013e). Seafloor Monitoring Report, Trident Wrangell

Enviro-Tech Diving Inc. (2014). Seafloor Monitoring Report, Trident Cordova South

Evans Hamilton. (2011). Seafloor Monitoring Report, Unisea Dutch Harbor

Gao, Q.F., K.L. Cheung, S.G. Cheung and P.K. Shin. (2005). Effects of nutrient enrichment derived from fish farming activities on macroinvertebrate assemblages in a subtropical region of Hong Kong. Mar. Poll. Bull. 51: 994-1002.

Germano & Associates, Inc. (2011). Benthic Impact Assessment of Trident Seafoods' Submarine Waste Piles in Akutan & Ketchikan, Alaska

Germano & Associates, Inc., Tetra Tech, Inc, and State of Alaska Department of Environmental Conservation. (2004). Effects of seafood waste discharges on the benthic environment at Ketchikan, Alaska.

Global Diving & Salvage, Inc. (2009). Seafloor Monitoring Survey Report, Ocean Beauty Seafoods Cordova.

Haggitt Consulting. (2010). Seafloor Monitoring Survey Report, Sitka Sound Seafoods.

Haggitt Consulting. (2011). Seafloor Monitoring Survey Report, Sitka Producers Cooperative.

Haggitt Consulting. (2012). Seafloor Monitoring Survey Report, Westward Seafoods.

Hakala Diving. (2010). Seafloor Monitoring Report, Peter Pan King Cove.

Hakala Diving. (2011). Seafloor Monitoring Report, Peter Pan King Cove.

Haynes, Terry L. and Wolfe, Robert J., Editors. Alaska Department of Fish and Game, Division of Subsistence. (August 1999). Ecology, Harvest, and Use of Harbor Seals and Sea Lions: Interview Materials from Alaska Native Hunters Technical Paper No. 249.

Heilskov, A.C., M. Alperin and M. Holmer. 2006. Benthic fauna bio-irrigation effects on nutrient regeneration in fish farm sediments. Jour. Exp. Mar. Biol. Ecol. 339: 204-225.

Icicle Seafoods, Inc. (2009). Annual Report for 2008, Icicle Seafoods Seward.

Icicle Seafoods, Inc. (2010). Annual Report for 2009, Icicle Seafoods Seward.

Icicle Seafoods, Inc. (2011). Annual Report for 2010, Icicle Seafoods Seward.

Icicle Seafoods, Inc. (2012). Annual Report for 2011, Icicle Seafoods Seward.

Icicle Seafoods, Inc. (2013). Annual Report for 2012, Icicle Seafoods Seward.

Inlet Fish Producers, Inc. (2009). Annual Report for 2008.

Inlet Fish Producers, Inc. (2010). Annual Report for 2009.

Inlet Fish Producers, Inc. (2011). Annual Report for 2010.

Inlet Fish Producers, Inc. (2012). Annual Report for 2011.

Inlet Fish Producers, Inc. (2013). Annual Report for 2012.

Inlet Fish Producers, Inc. (2014). Annual Report for 2013.

Kalantzi, I. and I. Karakassis. 2006. Benthic impacts of fish farming: Meta-analysis of community and geochemical data. Mar. Poll. Bull. 52: 484-493.

Karakassis, I., Hatziyanni, E., Tsapakis, M., and Plaiti, W. (1999). Benthic recovery following cessation of fish farming: a series of successes and catastrophes. Marine Ecology Progress Series, 184: 205-218.

Kutti, T., P.K. Hansen, A. Ervik, T. Hǿisaéter and P. Johannessen. (2007). Effects of organic effluents from a salmon farm on a fjord system. II. Temporal and spatial patterns in infauna community composition. Aquaculture 262: 355-366.

Kutti, T., Ervik, A, Høisæter, T. (2008). Effects of organic effluents from a salmon farm on a fjord system. III. Linking deposition rates of organic matter and benthic productivity. Aquaculture 282, 47–53.

Lalonde, B.A., Jackman, P., Doe, K, Garron, C., and Aube, J. (2009). Toxicity Testing of Sediment Collected in the Vicinity of Effluent Discharges from Seafood Processing Plants in the Maritimes. Arch Environ Contam Toxicol, 56: 389–396.

Lardicci, C., Rossi, F. & A. Castelli. (1997). Analysis of macrozoobenthic community structure after severe dystrophic crises in a Mediterranean coastal lagoon. Marine Pollution Bulletin 34: 536-547.

Mazik, K., Burdon, D., and Elliott, M. Institute of Estuarine & Coastal Studies. (2005). Seafood-waste disposal at sea – a scientific review. Retrieved from:

http://www.seafish.org/media/Publications/FINAL_seafood_waste_disposal_at_sea_report.PDF

McGhie, T.K., Crawford, C.M., Mitchell, I.M., and O'Brien, D. (2000). The degradation of fish-cage waste in sediments during fallowing. Aquaculture, 187: 351–366.

Macleod, C.K., N.A. Moltschaniwskyj and C. M. Crawford. (2006). Evaluation of short-term fallowing as a strategy for the management of recurring organic enrichment under salmon cages. Mar. Poll. Bull. 52: 1458-1466.

Mee, L.D., J. Friedrich and M.T. Gomoiu. (2005). Restoring the Black Sea in times of uncertainty. Oceanography 18: 32-43.

North Pacific Seafoods. (n.d.). Sitka Production Plant. Retrieved from: http://northpacificseafoods.com/index.php?option=com_content&task=view&id=39&Itemid=51

O'Brien, A.L., N. Volkenborn, J. Van Beusekom, L. Morris, and J.J. Keough. (2009). Interactive effects of porewater nutrient enrichment, bioturbation and sediment characteristics on benthic assemblages in sandy sediments. Jour. Exp. Mar. Biol. Ecol. 371: 51-59.

Pacific Star Seafoods. (2009). Annual Report for 2008.

Pacific Star Seafoods. (2010). Annual Report for 2009.

Pacific Star Seafoods. (2011). Annual Report for 2010.

Pacific Star Seafoods. (2012). Annual Report for 2011.

Pacific Star Seafoods. (2013). Annual Report for 2012.

Parr, T.D., Tait, R.D., Maxon, C.L., Newton, F.C, Hardin, J.L. (2007). A descriptive account of benthic macrofauna and sediments from an area of petroleum exploration in the south Caspian Sea. Estuarine, Coastal and Shelf Science, 71.

Pearson, T., Rosenberg, R. (1978). Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanogr Mar Biol Annu Rev 16, 229-311.

Pereira, P.M.F., Black, K.D., McLusky, D.S., Nickell, T.D. (2004). Recovery of sediments after cessation of marine fish farm production. Aquaculture, 235: 315-330.

Peter Pan Seafoods. (2005). Annual Report for 2004.

Peter Pan Seafoods. (2006). Annual Report for 2005.

Peter Pan Seafoods. (2007). Annual Report for 2006.

Peter Pan Seafoods. (2008). Annual Report for 2007.

Peter Pan Seafoods. (2009). Annual Report for 2008.

Peter Pan Seafoods. (2010). Annual Report for 2009.

Peter Pan Seafoods. (2011). Annual Report for 2010.

Peter Pan Seafoods. (2012). Annual Report for 2011.

Posey, M.H., T.D. Alphin, and L. Cahoon. (2006). Benthic community responses to nutrient enrichment and predator exclusion: influence of background nutrient concentrations and interactive effects. Jour. Exp. Mar. Biol. Ecol. 330: 105-118.

Pudwill. (2006). Seafloor Monitoring Survey Report, Copper River Seafoods.

Reading, Harold G. (1996). Sedimentary Environments: Processes, Facies and Stratigraphy. Blackwell Publishing Limited. Malden, MA.

Rosenberg, R. (2001). Marine benthic faunal succession stages and related sedimentary activity. Sciencia Marina, 65 (Suppl. 2): 107-119.

Rosenberg, R., Agrenius, S., Hellman, B., Nilsson, H.C., and Norling, K. (2002). Recovery of marine benthic habitats and fauna in a Swedish fjord following improved oxygen conditions. Marine Ecology Progress Series 234: 43-53.

S&S Diving Services. (2004). Seafloor Monitoring Report, Peter Pan King Cove.

S&S Diving Services. (2005). Seafloor Monitoring Report, Peter Pan King Cove.

S&S Diving Services. (2006). Seafloor Monitoring Report, Peter Pan King Cove.

S&S Diving Services. (2007). Seafloor Monitoring Report, Peter Pan King Cove.

S&S Diving Services. (2008). Seafloor Monitoring Report, Peter Pan King Cove.

S&S Diving Services. (2009). Seafloor Monitoring Report, Peter Pan King Cove.

Sanz-Lázaro, C. and Marin, A. (2006). Benthic recovery during open sea fish farming abatement in Western Mediterranean, Spain. Marine Environmental Research, 62: 374–387

Seafood Producers Cooperative. (2005). 2004 Annual Report and Seafloor Monitoring Survey.

Shin, P.K., N.W.Y. Lam, R.S.S. Wu, P.Y. Qian and S.G. Cheung. (2008). Spatio-temporal changes of marine macrobenthic community in sub-tropical waters upon recovery from eutrophication. I. Sediment quality and community structure. Mar. Poll. Bull. 56: 282-296.

Smith, J. and S.E. Shackley. (2006). Effects of the closure of a major sewage outfall on sublittoral, soft sediment benthic communities. Mar. Poll. Bull. 52: 645-658.

Stachowitsch, M. 1984. Mass mortality in the Gulf of Trieste: The course of community destruction. P.S.Z.N.I: Marine Ecology 5(3): 243-264.

State of Alaska Department of Commerce, Community, and Economic Development. (n.d.) General Format. Retrieved from: http://commerce.alaska.gov/dnn/ded/DEV/FisheriesDevelopment/AlaskaProcessors.aspx

State of Alaska Department of Commerce, Community, and Economic Development. (2014). Alaska Community Database Online. Retrieved from: http://commerce.state.ak.us/cra/DCRAExternal/

State of Alaska Department of Environmental Conservation (ADEC). (2013a). Wastewater Permit Search Results. Retrieved from: http://dec.alaska.gov/Applications/Water/WaterPermitSearch/Search.aspx

State of Alaska Department of Environmental Conservation. (2013b). Seafood Processing Map. Retrieved from: http://www.arcgis.com/home/webmap/viewer.html?webmap=36126671010e400eb0bd1a56ba1a5a09

State of Alaska Department of Environmental Conservation. (2010). General Format. Retrieved from: http://dec.alaska.gov/water/wqsar/Docs/2010impairedwaters.pdf

State of Alaska Department of Environmental Conservation. (2002). White Paper on zones of deposits from seafood waste piles.

State of Alaska Department of Environmental Conservation. (n.d.). ADEC Water Division Seafood Processing Waste Discharges in Alaska. Retrieved from: http://dec.alaska.gov/water/wwdp/seafood/Index.html

State of Alaska Department of Fish and Game. (2014). Fish Resource Monitor. Retrieved from: http://extra.sf.ADF&G.state.ak.us/FishResourceMonitor/?mode=awc

State of Alaska Department of Fish and Game. (n.d.). Community Subsistence Information System. Retrieved from: http://www.ADF&G.alaska.gov/sb/CSIS/index.cfm?ADF&G=harvInfo.harvestCommSelComm

Trident Seafood Corporation Inc. (n.d.). Alaskan Plants. Retrieved from: http://www.tridentseafoods.com/company/plants_alaska.php

Thorne, R.E., Bishop, M.A., Crawford, R.E., Thomas, G.L., Gay III, S.M., and George, K. (May 2007). Impacts of Seafood Waste Discharge in Orca Inlet, Prince William Sound.

U.S. Department of Justice. (2007). Stipulation of Settlement and Judgment. Retrieved from: http://yosemite.epa.gov/opa/admpress.nsf/d96f984dfb3ff7718525735900400c29/2af311fa2b32ad9d8525735c006cfdb8/$FILE/Stipulation%20of%20Settlement%20&%20Judgment%20(As%20Signed%20by%20Court).pdf

U.S. Environmental Protection Agency. (n.d.). Environmental Compliance History Online database. Retrieved from: http://www.epa-echo.gov/echo/

U.S. Environmental Protection Agency. (1995a). Total Maximum Daily Load for Settleable Solids in the Waters of Akutan Harbor.

U.S. Environmental Protection Agency. (1995b). Total Maximum Daily Load for Biochemical Oxygen Demand in the Waters of Akutan Harbor.

U.S. Environmental Protection Agency. (July 18, 2001). Seafood Processors in Alaska NPDES General Permit.

U.S. Environmental Protection Agency. (November 21, 2002). Press Release for Trident Seafoods Ketchikan Settlement. Retrieved from: http://yosemite1.epa.gov/opa/admpress.nsf/6427a6b7538955c585257359003f0230/4349ef5786786d64852570cb0075e239!OpenDocument&Start=12&Count=5&Expand=12.1)

U.S. Environmental Protection Agency. (February 17, 2004). Press Release for Alaska General Seafoods Settlement. (February 2013). Plan EJ 2014 Progress Report. Retrieved from: http://yosemite.epa.gov/opa/admpress.nsf/6427a6b7538955c585257359003f0230/d00d5a05c1cdea81852570cb0075e27e!OpenDocument)

U.S. Environmental Protection Agency. (2014). Retrieved from: http://www3.epa.gov/environmentaljustice/resources/policy/plan-ej-2014/plan-ej-progress-report-2013.pdf

U.S. Environmental Protection Agency. (n.d.). Alaskan Seafood Processing Effluent Guidelines. Retrieved from: http://www2.epa.gov/eg/alaskan-seafood-processing-effluent-guidelines

Villnäs, A., J. Perus and E. Bonsdorff. (2011). Structural and functional shifts in zoobenthos induced by organic enrichment – Implications for community recovery potential. Journal of Sea Research 65: 8-18.

Westward Seafoods. (2013). Annual Report for 2012.

Appendix A

Record Review Sheet

Name of Waterbody:

Record Review Sheet

Name of Record:

Facility information:

1. Name of Facility
2. Latitude/longitude of facility and fish waste pile
3. City/Community
4. Type(s) of seafood processed
5. Time frames for processing (in days and months) by type of seafood
6. Receiving water
   a. Approximate rate of flow (e.g., current)
   b. Designated uses

Monitoring:

1. Dive survey
   a. Date(s) and name of company conducting dive survey(s)
   b. Size(s) of waste pile per dive survey, including depth
   c. Description of benthic and/or marine life observed during each dive survey
2. Benthic Assessment
   a. Date(s) and name of company conducting benthic assessment(s)
   b. Size of waste pile per benthic assessment

c. Description of health of benthic community as documented at time of the benthic assessment (including successional stages of benthic life).

d. Other pertinent notes included in the benthic assessment report

3. Inspection report(s)

    a. Date and entity conducting inspection

    b. General findings, as they pertain to waste piles and/or observations regarding health of the waterbody

4. Agency staff knowledge

    a. Name, title, and date of communication

    b. Summary of information provided

Appendix B

Project Database Template and Excerpt

Waterbody	**Community Name**	**Name of Facility**	**Permit ID**	**Pile Size (acre, unless noted otherwise)**	**Maximum Pile Depth**	**Lat/Long**	**Designated Uses**
Akutan Harbor	Akutan	Trident Seafoods Akutan Shore Plant	AK0037303	15 (2010) 7.6* (2008) 8.5 (2006) 8 (2004)	20' (2010) 25' (2006) 12' (2004)	45 07'55" N 165 47'29" W	
Lazy Bay	Alitak	Ocean Beauty Seafoods Alitak Plant	AKG520036	0.69 (2012) 0.70 (2008)	10' (2012) 4' (2008)	56 50'50" N 154 14'36" W	
Anchorage Bay	Chignik	Trident Seafoods Chignik Production Plant	AKG520053	0.85 (2013) (2012) 1.1 (2011)	8' (2013) 8.4' (2012) 7.5' (2011)	56 16'933" N 158 23'239" W	
Anchorage Bay	Chignik	Trident Seafoods Chignik Support Plant	AKG520103	0.32 (2013) 0.36 (2012) 0.65 (2011)	2.9' (2013) 3.1' (2012) 5' (2011)	56.29650 N 158.40202 W	

Waterbody	Community Name	Name of Facility	Permit ID	Pile Size (acre, unless noted otherwise)	Maximum Pile Depth	Lat/Long	Designated Uses
Port Moller Bight	Cold Bay	Peter Pan Seafoods Port Moller Plant	AKG520014	0 (2012)	N/A	55-59.49 N 160-34.22 W	within 3 miles of Port Moller State Critical Habitat Area
Orca Inlet	Cordova	Trident Seafoods Cordova South Plant	AKG520491	0.21 (2014) 0.19 (2012) 16 ft^2 (2011) 0.44 (2010)	2.1' (2014) 1.5' (2012)	60 32' 659" N 146 46' 322" W	
Orca Inlet	Cordova	Trident Seafoods Cordova North Plant	AKG520493	2.06 (2013) 5.76 (2012) 2.58 (2011)	3' (2013) 4.4' (2012) 6.6' (2011)	60 33' 010" N 145 46' 073" W	