Ocean Discharge Criteria Evaluation
Alaska Offshore Seafood Processors
APDES General Permit AKG523000

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ACRONYMS

AAC	Alaska Administrative Code
ACMP	Alaska Coastal Management Program
BAT	Best available pollution control technology economically achievable
BCT	Best conventional pollution control technology
BOD	Biochemical oxygen demand
BPT	Best practicable control technology
CFR	Code of Federal Regulations
CMP	Coastal Management Plan
COD	Chemical oxygen demand
CWA	Clean Water Act
CZMP	Coastal Zone Management Program
EFH	Essential Fish Habitat
ELG	Effluent limitations guidelines
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FC	Fecal coliform
GC/MS	Gas chromatography/mass spectrometry
gpd	Gallons per day
gpm	Gallons per minute
HPC	Habitat of Particular Concern
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
MLLW	Mean lower low water
MMPA	Marine Mammal Protection Act
MSA	Magnuson-Stevens Act
nm	Nautical mile
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NSPS	New Source Performance Standards
ODCE	Ocean Discharge Criteria Evaluation
ppm	Parts per million
ppt	Parts per thousand
TSS	Total suspended solids
USFWS	U.S. Fish and Wildlife Service

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1.0 Introduction

1.1 Purpose of Evaluation

The Alaska Department of Environmental Conservation (ADEC or Department) intends to issue an Alaska Pollution Discharge Elimination System (APDES) General Permit (permit) for Offshore Seafood Processing Facilities in Alaska. Section 403(c) of the Clean Water Act (CWA) requires that APDES permits for such ocean discharges be issued in compliance with EPA's Ocean Discharge Criteria for preventing unreasonable degradation of ocean waters. The purpose of this Ocean Discharge Criteria Evaluation (ODCE) report is to identify pertinent information and concerns relative to the Ocean Discharge Criteria and discharges from and vessel-based seafood processing facilities, discharging between 0.5 nautical miles (nm) and 3.0 nm from the Alaskan shoreline or baseline.

EPA's Ocean Discharge Criteria (40 [Code of Federal Regulations (CFR)] Part 125, Subpart M) set forth specific determinations of unreasonable degradation that must be made prior to permit issuance. "Unreasonable degradation of the marine environment" is defined (40 CFR 125.12[e]) as follows:

1. Significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities
2. Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms
3. Loss of aesthetic, recreational, scientific, or economic values, which are unreasonable in relation to the benefit derived from the discharge

This determination is to be made on the basis of considering the following 10 criteria (40 CFR 125.122):

1. The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged
2. The potential transport of such pollutants by biological, physical or chemical processes
3. The composition and vulnerability of the biological communities that may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act (ESA), or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain
4. The importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism.

5. The existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs.
6. The potential impacts on human health through direct and indirect pathways.
7. Existing or potential recreational and commercial fishing, including finfishing and shellfishing.
8. Any applicable requirements of an approved Coastal Zone Management Plan.
9. Such other factors relating to the effects of the discharge as may be appropriate.
10. Marine water quality criteria developed pursuant to Section 304(a)(1).

If the Department determines that the discharge will not cause unreasonable degradation to the marine environment, an APDES permit may be issued. An individual APDES permit may be issued for distinct locations within Alaska necessitating special consideration due to sensitivity or biological concern. If the Department determines that the discharge will cause unreasonable degradation of the marine environment, an APDES permit may not be issued.

If the Department has insufficient information to determine, prior to permit issuance that there will be no unreasonable degradation to the marine environment, an APDES permit will not be issued unless the Department, on the basis of the best available information, determines that all the following are true:

1. Such discharge will not cause irreparable harm to the marine environment during the period in which monitoring will take place, and
2. There are no reasonable alternatives to the onsite disposal of these materials, and,
3. The discharge will be in compliance with certain specified permit conditions (40 CFR 125.123(d)).

1.2 Scope of Evaluation

Issuance of the permit for offshore seafood processing facilities in Alaska would authorize discharges from facilities engaged in processing raw seafood to surface waters of the United States within and continuous to the State of Alaska between 0.5 nm from shore and 3.0 nm from shore as delineated by mean lower low water (MLLW) or baseline. Facilities covered under the permit would be vessel-based, but acting as industrial facilities and not as a vessel.

This document relies on information provided in the ODCE drafted in 1993, prior to the issuance of the existing statewide permit, AKG520000, issued July 18, 2001; the existing statewide AKG520000 general permit itself; the existing AKG520000 general permit fact sheet; the AKG520000 general permit response to comments document; the May 2008 ODCE drafted in 2008 prior to the issuance of the Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) permit, AKG524000;annual reports submitted by the dischargers; and an extensive literature review. The language for

the two offshore discharge sections from the draft permit will be cited in this report. For more detailed information concerning certain topics, where appropriate, this document will refer the reader to some of the above publications.

1.2.1 Area of Coverage of the Permit and Applicability of this ODCE

This document evaluates the impacts of waste discharges as will be authorized under the permit for offshore fish processing facilities in Alaska pursuant to Section 403(c) of the CWA. Offshore facilities are located throughout coastal Alaska from Ketchikan in the southeast panhandle, west to Atka in the western Aleutian Islands and north to Kotzebue Sound, at least 0.5 NM from the Alaskan shoreline.

The permit will addresses discharges from two types of facilities:

1. Operators of mobile seafood processing plants, discharging seafood processing waste between 0.5 nm and 1.0 nm from shore as delineated by MLLW, engaged in the processing of fresh, frozen canned, smoked, salted, or pickled seafood; or the processing of unwashed mince; or the processing of meal and other secondary by-products.
2. Operators of mobile seafood processing plants, discharging seafood processing waste between 1.0 nm from shore and 3.0 nm from shore as delineated by MLLW or baseline, engaged in the processing of fresh, frozen canned, smoked, salted, or pickled seafood or the processing of seafood mince, paste, or meal.
3. An operator of a processor that discharges less than 1,000 pounds of seafood processing waste per day and less than 30,000 pounds of seafood processing waste per calendar year between 0.5 and 3.0 nm from shore is not required to obtain permit coverage.

1.3 Excluded Areas of the Permit

The permit does not authorize seafood processing waste discharges to excluded waters except where authorized in a waiver, which are identified in the AKG523000 permit Appendix H, *Waivers to Discharge to an Excluded Area:*

1.3.1 Protected Water Resources

1.3.1.1 Protected waters are within 1.0 nm of the boundary of the following:

State Game Refuges and Sanctuaries. Including but not limit to: Anchorage Coastal, Cape Newenham, Goose Bay, Mendenhall Wetlands, Palmer Hay Flats, Susitna Flats, Trading Bay, Yakataga, Izembek, McNeil River, Stan Price, and Walrus Islands.

State Designated Critical Habitat Areas. Including but not limited to: Cinder River, Clam Gulch, Copper River Delta, Egegik, Fox River Flats, Kachemak Bay, Kalgin Island, Pilot Point, Port Heiden, Port Moller, Redoubt Bay, and Tugidak.

State Parks. Including but not limited to: Afognak Island State Park, Chilkat State Park, Denali State Park, Kachemak Bay State Park, Kachemak Bay State Wilderness Park, Point Bridget State Park, Shuyak Island State Park, and Wood/Tikchik State Park.

State Marine Parks. Including but not limited to: Bettles Bay, Beecher Pass, Big Bear/Baby Bear Bays, Boswell Bay Beaches, Canoe Passage, Chilkat Islands, Dall Bay, Decision Point, Driftwood Bay, Entry Cove, Funter Bay, Granite Bay, Horseshoe Bay, Jack Bay, Joe Mace Island, Kayak Island, Magoun Islands, Oliver Inlet, Safety Cove, Saint James Bay, Sandspit Point, Sawmill Bay, Security Bay, Shelter Island, Shoup Bay, South Ester Island, Sullivan Island, Sunny Cove, Surprise Cove, Taku Harbor, Thoms Place, Thumb Cove, and Ziegler Cove.

National Parks, Preserves, and Monuments. Including but not limited to: Bering Land Bridge, Katmai, Kenai Fjords, Lake Clark, Wrangell-St. Elias, Glacier Bay, Aniakchak, and Cape Krusenstern.

National Wilderness Areas. Including but not limited to Aleutian Islands, Andreafsky, Becharof, Bering Sea, Bogoslof, Chamisso, Chuck River, Coronation Island, Denali, Endicott River, Forrester Island, Gates of the Arctic, Glacier Bay, Hazy Islands, Innoko, Izembek, Karta River, Katmai, Kenai, Kobuk Valley, Kootznoowoo, Koyukuk, Kuiu, Lake Clark, Maurille Islands, Misty Fjords National Monument, Mollie Beattie, Noatak, Nunivak, Petersburg Creek-Duncan Salt Chuck, Pleasant/Lemusurier/Inian Islands, Russell Fjord, Saint Lazaria, Selawik, Semidi, Simeonof, South Baranof, South Etolin, South Prince of Wales, Stikine-LeConte, Tebenkof Bay, Togiak, Tracy Arm-Fords Terror, Tuxedni, Unimak, Warren Island, West Chichagof-Yakobi, and Wrangell-Saint Elias. See http://www.wilderness.net/ for interactive maps of wilderness areas.

National Wildlife Refuges. Including but not limited to: Alaska Maritime, Alaska Peninsula, Becharof, Izembek, Kenai, Kodiak, Togiak, and Yukon Delta, which exist in the vicinity of potential seafood processing activities.

Critical Habitat Areas for the Steller's eider or spectacled eider, including nesting, molting and wintering units. During breeding season (May through August) Steller's and spectacled eider nesting critical habitat units are located on the Yukon-Kuskokwim Delta and North Slope. Molting habitat (July through October) for Steller's eiders includes Izembek Lagoon, Nelson Lagoon and Seal Islands. Molting habitat for spectacled eider includes Ledyard Bay and Norton Sound. Wintering habitat (October through March) for Steller's eider includes Nelson Lagoon, Izembek Lagoon, Cold Bay, Chignik Lagoon and several other locations along the Aleutian Islands. Wintering habitat for spectacled eider is in the Bering Sea between St. Lawrence and St. Matthews Islands. Critical habitat areas are listed and depicted at http://www.fakr.noaa.gov/protectedresources/seabirds/eider.htm.

Critical Habitat Areas for Northern Sea Otter (Enhydra lutris kenyoni), Southwest Alaska Distinct Population Segment. The areas are listed and depicted in 50 CFR Part 17 and at http://alaska.fws.gov/fisheries/mmm/seaotters/criticalhabitat.htm.

Nesting Areas. The nesting area of a colony of one thousand or more of the following seabirds during May 1 through September 30: auklets, cormorants, fulmars, guillemots, kittiwakes, murres, petrels, puffins and/or terns and other local aggregations of seabirds, including non-colony nesting birds such as eiders and murrelets. See http://alaska.fws.gov/mbsp/mbm/northpacificseabirds/colonies/default.htm for interactive maps of north pacific seabird colonies.

1.3.1.2 Protected waters are within 3.0 nm of the boundary of the following:

A rookery or major haulout of the Steller's sea lion. These areas are designated as critical habitat for the Steller's sea lion. They are listed and depicted in 50 CFR Part 226 and 227.12, the ODCE, and Biological Evaluation (EPA 2008a). See http://www.fakr.noaa.gov/protectedresources/stellers/habitat.htm for maps and other information regarding haulouts.

A rookery or terrestrial haulout of the Pacific walrus. Including but not limited to Round Island (Walrus Islands), Cape Pierce (Togiak NWR), Cape Newenham (Togiak NWR), and Cape Seniavin (Near Port Moller). See http://alaska.fws.gov/fisheries/mmm/walrus/wmain.htm for more information on Pacific walrus.

In 2009, a request to establish a walrus protection zone at the southwest shore of Hagemeister Island (Togiak NWR) was proposed to the North Pacific Fishery Management Council. If a protection zone is established during life of the permit for Hagemeister Island, waters within 3.0 nm of the protection zone will also be protected. See http://www.fakr.noaa.gov/NPFMC/current_issues/ssl/Walrus110909.pdf for more information.

1.3.2 At-Risk Water Resources

Areas with water depth of less than 10 fathoms (60 feet) at MLLW that have poor flushing, including but not limited to sheltered waterbodies such as bays, harbors, inlets, coves and lagoons and semi-enclosed water basins bordered by sills of less than 10 fathom depths are excluded from coverage under the permit. For the purposes of this section, "poor flushing" means average water currents of less than one third (0.33) of a knot within 300 feet of the outfall. It is the responsibility of the operator to prove adequate flushing for each proposed discharge location.

1.3.3 Special Water Resource

1.3.3.1 Lost Harbor, Akun Island.

1.3.3.2 Orca Inlet

No discharge of uncooked fish processing waste residues may occur during the months of November, December, January, February and March in Orca Inlet where sea otters, which are protected under the Marine Mammal Protection Act, are attracted to the discharge and waste deposit as a food source.

1.3.3.3 Living substrates, such as submerged aquatic vegetation, kelp, and eelgrass in shallow coastal waters (generally less than 10 fathoms (60 feet) at MLLW.)

1.3.3.4 The territorial seas surrounding St. Paul Island and St. George Island.

1.3.4 Degraded Water Resource

Any water body included in ADEC's most recent *Final Integrated Water Quality Monitoring Assessment Report* of waters which are impaired or water quality-limited. See http://www.dec.state.ak.us/water/wqsar/waterbody/integratedreport.htm for the most recent integrated report.

1.3.5 Small Waterbodies

Any waterbody that would not meet the minimum requirements for mixing zone size specification under 18 AAC 70.255: "the cumulative linear length of all mixing zones intersected on any given cross section of an estuary, inlet, cove, channel or other marine water may not exceed 10 percent of the total length of that cross section and the total horizontal area allocated to all mixing zones may not exceed 10 percent of the surface area." Since the maximum authorized mixing zone has a diameter of 200 feet, a bay or channel that is less than 2,000 feet across fails to meet these criteria and is designated as a "small" waterbody excluded from coverage under the permit.

1.3.6 Areas Covered by Other APDES Permits

The permit does not authorize the discharge of pollutants to receiving waters covered by other general or individual APDES seafood permits.

1.4 Authorized Discharges

The permit identifies a number of discharges associated with seafood processing facilities. The permit would authorize the following discharges:

1. Seafood processing waste, including the waste fluids, heads, organs, flesh, fins, bones, skin, chitinous shells, and stickwater produced by the modification of the physical condition of a fishery resource from a raw form to a marketable form. Seafood processing is any activity that modifies the physical condition of a fishery resource except processing does not include gutting, gilling or icing fish, or decapitating shrimp while on a fishing vessel on the fishing grounds.

2. Wash-down water, including EPA-approved disinfectants added to wash-down water to facilitate the removal of wastes and to maintain sanitary standards during processing or to sanitize seafood processing areas.
3. Sanitary wastewater.
4. Graywater.
5. Other wastewater generated in the seafood processing operation, including seafood catch transfer water, live tank water, refrigerated seawater, cooking water, boiler water, cooling water, refrigeration condensate, freshwater pressure relief water, clean-up water, and scrubber water.

1.5 Overview of Report

The evaluation focuses on the sources, fate, and potential effects of seafood processing discharges on various groups of aquatic life.

The types and nature of the discharges are detailed in Section 2.0 including anticipated volumes of wastes, proximate chemical composition, and concentrations.

The fate, transport, and persistence of the wastes is examined in Section 3.0, which describes the development of a seafood waste deposition, accumulation, and decay model and the evaluation of 12 general modeling scenarios. Note that the model was developed for the 1993 ODCE and is carried forward to this document without revision. The case scenarios presented evaluate the effects of water depth, current speed, discharge depth, and bottom slope on the model-predicted accumulation of seafood solid waste in the vicinity of stationary seafood waste discharges. This information is used to assess the potential of the deposited material to exceed the permit specified maximum size of a zone of deposit (ZOD) of 1 acre and the probability of burying benthic infaunal invertebrates or otherwise modifying their habitat chemically or physically (e.g., via changes in grain sizes).

Before discussing potential biological and ecological effects, an overview of aquatic communities and important species is presented in Section 4.0.

The means by which seafood discharges could impact marine life and concentrations at which effects have been documented are presented in Section 5.0.

The potential for the discharges to adversely impact threatened and endangered species as identified under the ESA is discussed in Section 6.0.

Particularly important uses and plans for the permit area, including commercial, recreational and subsistence harvests, special aquatic sites, and coastal management plans are discussed in Sections 7.0 and 8.0.

Section 9.0 discusses compliance of expected seafood discharges with federal and state water quality criteria.

Section 10 summarizes the findings of this report.

2.0 Composition and Quantities of Materials Discharged

2.1 Introduction

Seafood processing is conducted throughout coastal Alaska from Ketchikan in the south, west through the Aleutian Islands and north to the Chukchi Sea. Processing facilities may be vessel-based or located onshore. The permit will consider two categories of seafood processors – offshore facilities discharging between 0.5 and 1.0 nm from shore and offshore facilities discharging between 1.0 nm from shore and 3.0 NM from shore or baseline. The permit defines each category as follows:

Operators of offshore processors discharging between 0.5 and 1.0 nautical miles (nm) from shore –Operators of mobile seafood processing plants that discharge seafood processing waste between 0.5 nm and 1.0 nm from shore as delineated by mean lower low water (MLLW) and are engaged in the processing of fresh, frozen, canned, smoked, salted, or pickled seafood; the processing of unwashed mince; or the processing of meal and other secondary by-products.

Operators of offshore processors discharging between 1.0 nm from shore and 3.0 nm from shore or baseline –Operators of mobile seafood processing plants that discharge seafood processing waste between 1.0 nm from shore and 3.0 nm from shore as delineated by MLLW or baseline and are engaged in the processing of fresh, frozen, canned, smoked, salted, or pickled seafood; the processing of seafood mince or paste; or the processing of meal and other secondary by-products.

An operator of a processor that discharges less than 1,000 pounds of seafood processing waste per day and less than 30,000 pounds of seafood processing waste per calendar year between 0.5 and 3.0 nm from shore or baseline is not required to obtain permit coverage or submit a Notice of Intent.

Target species of commercial fishing operations in Alaska include groundfish (including walleye pollock, Pacific cod, sablefish, rockfish species, and other species of flatfish), five species of salmon, herring, halibut, species of crab (Dungeness and species of king and Tanner crab), shrimp, clams, scallops, abalone, sea urchins, and sea cucumbers.

2.2 Alaskan Marine Fisheries

The following section describes unique characteristics of each of the major fisheries conducted in marine waters off the shores of Alaska. Commercial fishing operations target a number of assemblages including groundfish (e.g., walleye pollock, Pacific cod, sablefish, rockfish species, and other species of flatfish), five species of salmon, herring, and shellfish (e.g., species of crab, shrimp, clams, scallops, abalone, sea urchins, and sea cucumbers).

2.2.1 Groundfish Fishery.

The fishery for groundfish is generally conducted in the Gulf of Alaska, Bering Sea, and relatively deep offshore waters off the Aleutian Islands. The groundfish fishery off Alaska has undergone a dramatic transformation from an essentially foreign venture as late as 1981, with most processing

occurring in the EEZ, to an exclusively domestic fishery by 1991, with processing occurring at shore-based facilities in Alaska as well as at sea (Kinoshita et al.1991). The more important species in terms of catch volume and economics are walleye pollock, Pacific cod, sablefish, and rockfish species.

The Alaskan groundfish fishery is closely managed by a combination of limits on target and bycatch species for specific management zones, and areas that are off-limits to fishing for the provision of safe spawning areas [e.g., Herring Savings Areas (HSAs)] or for the protection of marine mammals. The groundfish season begins on the first of January and continues throughout the year unless the fishery in a particular zone is closed because harvest or bycatch quotas have been reached.

A significant portion of catch harvested during the groundfish fishery consists of non-target species, prohibited species, spoilage, or target species with unsuitable characteristics that are discarded and returned to the sea unprocessed (North Pacific Management Council 1989). A conservative estimate of the discarded amount of groundfish, crab, halibut, herring, and salmon resulting from the Alaska commercial groundfish fishery during 1992 was equivalent to 13 percent by weight of the total groundfish harvest of 1.89 million metric tons (4.17 billion pounds) (Pacific Associates 1993). Ninety-two percent of the estimated amount of fish discarded were groundfish. The discard of catch occurs for regulatory, economic, and operational reasons. Regulations prohibit the retention of prohibited species such as halibut, crab, and salmon and these species must be returned whole. For economic reasons spoiled target species or species that are too small may also be discarded. For operational reasons, target species that are too small or large for mechanized processing equipment may also be discarded.

2.2.2 Salmon Fishery.

The salmon fishery is managed by the Alaska Department of Fish and Game (ADF&G). Five species of salmon are managed in four distinct management regions. These management regions are

1) the Southeastern Region including Yakutat,

2) the Central Region including Prince William Sound (Copper and Bering Rivers), Cook Inlet, and Bristol Bay,

3) the Arctic-Yukon-Kuskokwim (AYK) Region including Norton and Kotzebue Sound, and

4) the Westward Management Region which includes Kodiak, Chignik, and the Alaska Peninsula-Aleutian Islands.

Preliminary 2005 statistics released by ADF&G indicate that the harvest of the five species combined for a total of 954,500,000 pounds (ADF&G 2006). Table 1 presents a summary of the harvest by species and area.

Table 1 Preliminary commercial salmon harvests by fishing area and species in 2005 (in 1,000 pounds)

	Chinook	Sockeye	Coho	Pink	Chum	TOTAL
Southeast Region	6,496	9,069	13,368	207,103	57,087	293,123
Central Region	2,666	195,737	5,758	214,426	3,732	444,457
AYK Region	1,050	808	2,600	0	2,589	7,047
Westward Region	415	57,346	4,493	133,660	8,986	204,900
TOTAL	10,600	262,960	26,219	555,189	94,532	949,527

The predominant commercial species harvested on an annual basis are the pink and sockeye salmon, which accounted for about 85 percent of the total salmon in 2005 (Table 2.1). Overall, the most salmon are harvested within the Central Region while the AYK region harvests significantly less than the others.

The timing of the salmon harvest is closely tied to the period when each salmon species returns to spawn. The fishing season for each salmon species depends on the management region and the type of gear used, but generally spans the period between June and September. The relatively short salmon fishing seasons and large runs of fish result in short but intense periods of seafood processing activity in this sector of the industry.

2.2.3 Herring Fishery.

The herring fishery is also managed by the ADF&G. Herring are harvested for food and for the bait used in the crab and longline fisheries. Sac roe is harvested immediately prior to spawning when the eggs are mature. Spawn-on-kelp fisheries are permitted in the Southeast Region, Prince William Sound, and Bristol Bay. The food or bait harvest of herring occurs in January and February in the Southeast Region and in the Kodiak Area, and in September through November in Prince William Sound. Roe fisheries typically occur in March through June, although the fishery in any particular area may last for one month or less.

2.2.4 Shellfish Fisheries.

The fisheries for crab, shrimp, scallops, clams, abalone, sea cucumber, and sea urchins are managed by the ADF&G. The largest shellfish fisheries are for crabs including red, brown, and blue king crab, opilio and bairdi Tanner crab, and Dungeness crab. Crab fishing seasons vary depending on the region and species. Stocks of many species have been depressed for over a decade, the explanations for which include over harvest, changes in climatic conditions, and bycatch (ADF&G 2005). As a result of the depressed stocks, additional restrictions on the fishery remain in place. Between 1998 and 2002, the average harvest of king crabs was nearly 22 million pounds with Bristol Bay red accounting for nearly half. During the same time period, over 110 million pounds of Tanner/snow crabs and 4.5 million pounds of Dungeness crab were harvested throughout the state (ADF&G 2005).

Shrimp fisheries are concentrated in Southeast Alaska, Cook Inlet. Prince William Sound, and in the vicinity of Kodiak and the Alaska Peninsula. The Alaskan

shrimp fishery has declined even more than the crab fishery with an annual average total harvest of 2.2 million pounds between 1998 and 2002. Scallop fishing generally occurs throughout the year, primarily in the Gulf of Alaska, Bering Sea and Aleutian Islands. An average of 686,000 pounds were harvested by eight vessels (ADF&G 2005).

2.3 Seasonality and Location of Seafood Processing Operations

The quantity and character of the seafood wastes generated vary considerably over the course of a year and among regions reflecting the distribution of exploitable fishing stocks, seasonal variation in their abundance, and the openings and closings of the fishing seasons that are used to manage stocks. Generally, groundfish and shellfish wastes constitute much of the discharges in the winter and early spring with salmon processing wastes occurring in the summer (along with groundfish). Groundfish constitute the largest amount of solid waste discharged on a state-wide basis but regionally constitute the largest volume of discharge from the Bering Sea/Aleutian Island region. The largest volume of waste discharged in all other regions comes from the salmon fisheries. Figure 2.2 presents a graphical depiction of discharges by month based on data submitted in 2005 annual reports by facilities covered under the existing general permit. The spike early in the year represents the early groundfish season while the mid-summer spike reflects increases in salmon production.

2.4 Waste Production

Commercial seafood processing in Alaska generated over one billion pounds of solid waste in 2005 based on data submitted in annual reports. Data reported for 2005 discharges indicate that on-shore facilities accounted for over 259 million pounds of solid wastes discharges while vessels discharged over 824 million pounds of solid waste (note that the data set made no distinction between near-shore and off-shore vessels discharging more than 3.0 nm from shore). Over 729 million pounds of the total waste discharged by all facilities combined consisted of groundfish, with pollock alone accounting for over 500 million pounds of waste alone. Figure 1 summarizes the total solid waste discharges statewide and includes a break down by region.

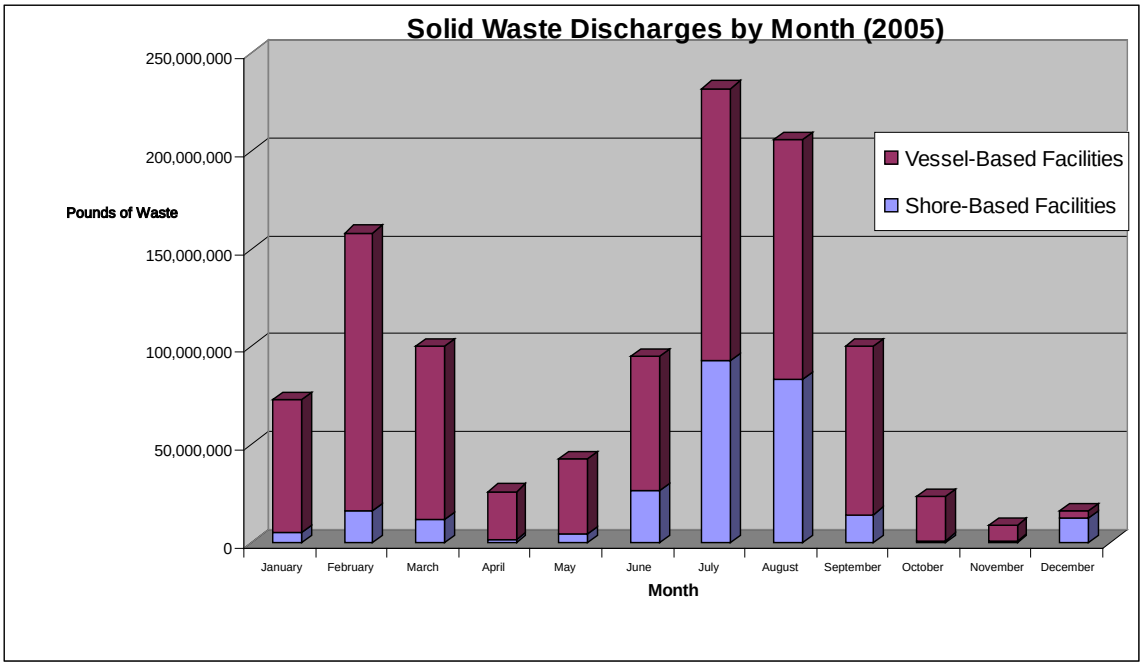


Figure 1Distribution of discharges by month for all vessel-based and shore-based facilities that submitted annual reports in 2005 (ADEC 2007, pers comm).

2.5 Seafood Processing Techniques

Seafood processing facilities use a variety of techniques and equipment to produce marketable seafood products. Detailed descriptions of specific seafood processing facilities (e.g., salmon canning, fish meal production) are provided in EPA (1975) and Swanson et al. (1980). The processes involved in the production of marketable seafood products range from packaging whole fresh or frozen seafood for shipment, which produce relatively little solid or liquid waste, to mechanical filleting or deboning processes that produce relatively large amounts of solid and liquid waste. Solid wastes remaining after other production steps may be further processed into fish meal, converting much of the solid waste to marketable products. New techniques in recent years have been developed to convert seafood waste to a salmon hydolysate. This is used as dietary supplements, fertilizer and in pet food.

2.5.1 Finfish.

Whole fish may first be scaled mechanically or by hand before further processing. Finfish products include whole or dressed (i.e., gutted) fish with the head left on or removed. Recovery rates from this type of processing range from 50 to almost 100 percent. The fish may also be processed into fillets which may be skinless and/or boneless with recovery rates ranging from 25 to 50 percent. Several products specific to the type of fish species are also produced. For example, canned salmon products recover from 60 to 70 percent of the whole fish. Roe are sometimes extracted from whole herring with a recovery rate ranging from 3 to 18

percent. Surimi production, a minced flesh product produced from walleye pollock, recovers from 11 to 22 percent of the whole fish. In some cases, solid waste material may be rendered into fish meal at a nearby meal processing facility.

2.5.2 Shellfish

Shellfish is used here as a general category that includes crabs, shrimp, scallops, clams, abalone, sea cucumber, and sea urchins. Like finfish, recovery rates depend on the species and the product. Crab processing generally results in raw or cooked crab with recoveries of between 50 and 90 percent based on whether they are cooked whole or in sections. Crab meat may also be separated from the shell, producing additional waste. The production of cooked meat results in a recovery of 17 to 25 percent depending on the species processed. Shrimp processing may result in a number of products that include headed raw shrimp, whole cooked shrimp, and cooked or raw peeled shrimp. The recovery of whole cooked shrimp is about 90 percent with lower recoveries for raw headed shrimp (45 to 53 percent), raw peeled shrimp (30 to 38 percent) and cooked peeled shrimp (25 to 26 percent).

The recovery of marketable products from clams, abalone, and scallops is generally low (typically less than 60 percent) because the heavy shells from these animals are typically discarded. However, shell wastes from these species are not typically ground and discharged through the waste handling system of the processing facility but rather disposed of in nearby landfills or returned to the shellfish beds.

2.6 Facility Classifications

The Department and EPA maintain databases of Notices of Intent (NOIs) submitted by seafood processors requesting coverage under the existing permit, AKG520000. Under the existing permit off-shore processors were identified only as more than 1.0 nm from shore. The Department conducted a survey of facilities in the databases to estimate the number of facilities that could seek coverage by the permit, those facilities discharging between 0.5 and 3.0 nm from shore. A review of the data shows that approximately 30 facilities could request coverage to discharge under the permit. The number of facilities requesting coverage could increase. EPA issued a National Pollutant Discharge Elimination System (NPDES) general permit, AKG524000, for off-shore seafood processors discharging more than 3.0 nm from Alaskan shores.

Based on Annual Report data for 2005, floating seafood processing facilities accounted for the majority of solid wastes generated (824,139,329 pounds) while shore-based facilities discharged 259,068,396 pounds of solid wastes (ADEC 2007, pers. comm.). Discharges by floating facilities operating nearshore or less than 3.0 nm could not be identified separately and are therefore included with the numbers reported for floating facilities. The existing permit, AKG520000, did not require reporting of the volume of liquid or dissolved wastes discharged; therefore data on liquid wastes is not available.

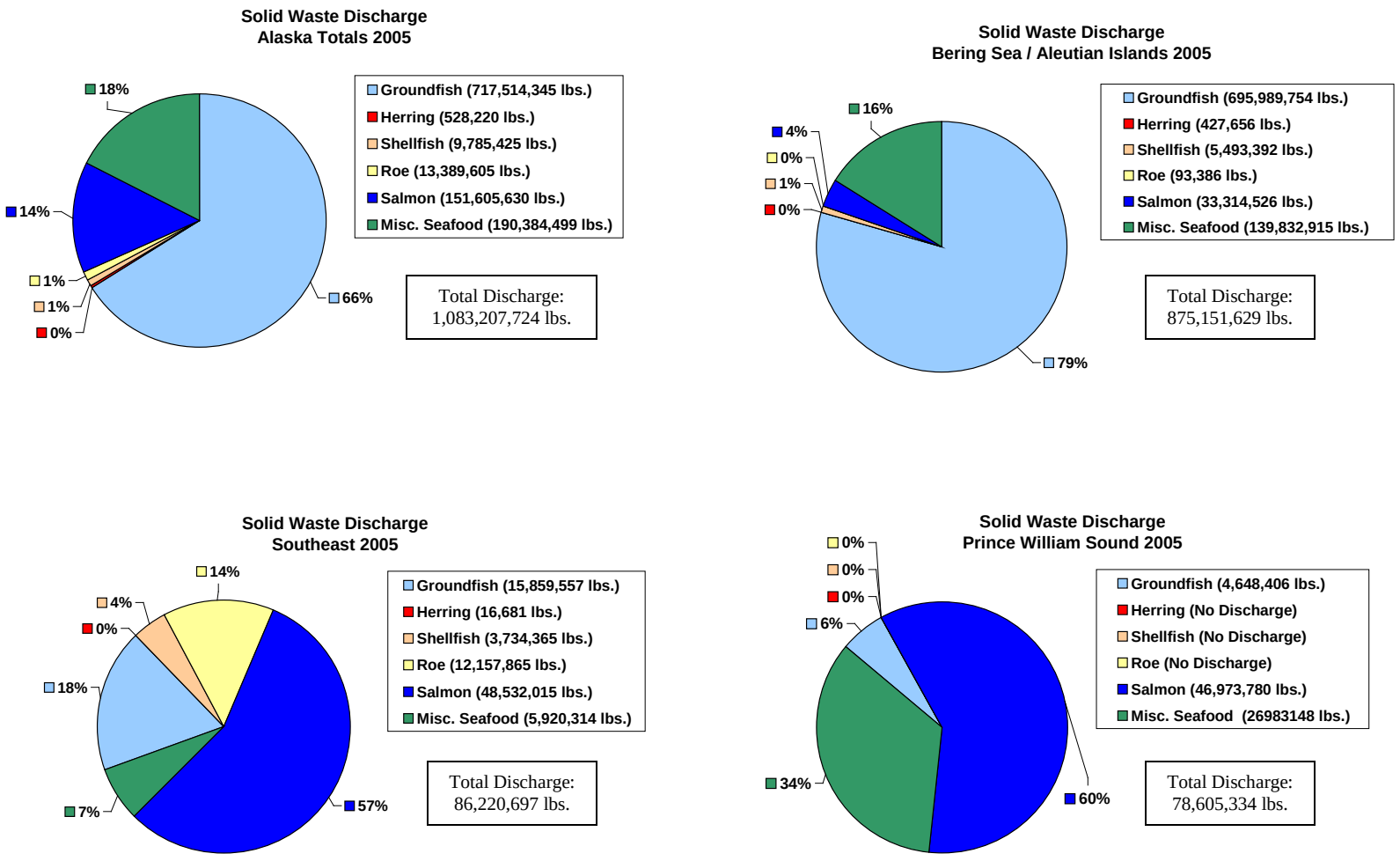
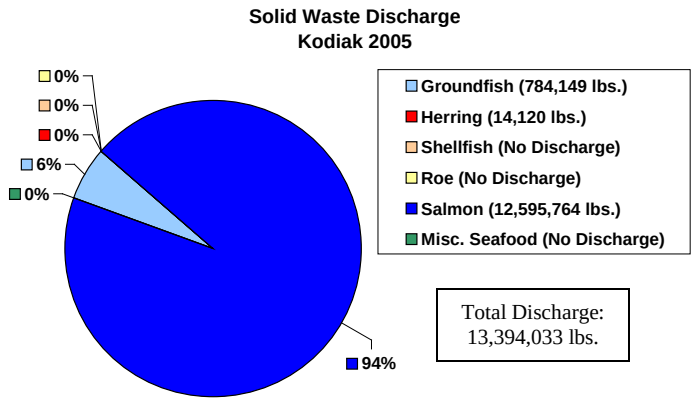
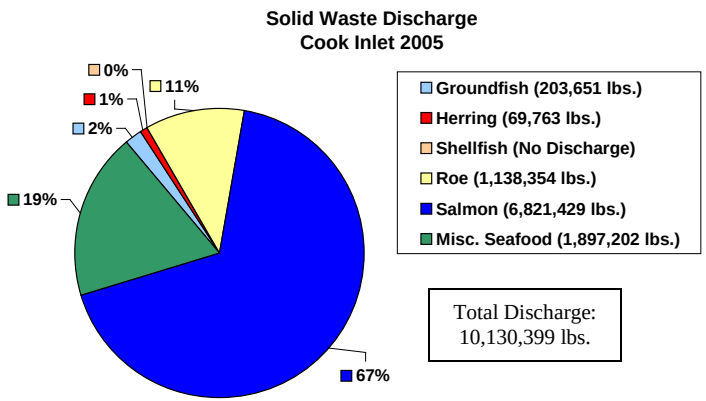


Figure 2 Seafood Processing Solid Waste Discharges by Species and Region (in pounds)





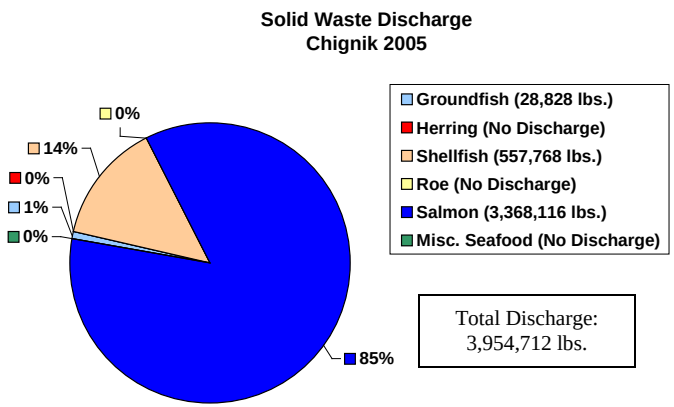


Figure 3Seafood Processing Solid Waste Discharges by Species and Region (in pounds) – continued

2.7 Seafood Processing Waste Characteristics

Discharges from seafood processing facilities may be classified into solid (particulate) and dissolved (soluble) wastes. Solid wastes consist primarily of unused portions of fish and shellfish that have been processed. The unused portions of processed raw fish and shellfish include heads, skin, scales, viscera, tail fins, and shells discarded during cleaning and butchering operations. Dissolved wastes include solubilized organic matter and nutrients leached from fish and shellfish tissues after processing. The specific chemical composition of these wastes depends on the amount of protein, fat, bone, chitin, and connective tissue present. Elevated nitrogen content, for example, has been attributed to high blood and slime content in seafood processing effluent. The character and quantity of solid and liquid seafood processing wastes is assessed below.

2.8 Solid Wastes

The chemical composition of the solid waste discharged by seafood processing facilities determines the effects that the discharges may produce on the aquatic environment. As noted above, seafood processing solid waste consists of both organic and inorganic material including protein, fat (oil and grease), and ash. Tables 2 and 3 present details on the contents and theoretical composition of fish wastes in Alaska. Most of the solid fish waste contains at least 75 percent water. The percentages of protein were similar for most types of fish waste sampled (approximately 10-15 percent wet weight). The percentage of fat was generally less than 3 percent, although heads of halibut and salmon, and viscera from pollock had a much higher fat content (16-17 percent and 40 percent of wet weight, respectively). The percentage of ash, which represents the inorganic component of fish waste, was generally less than 5 percent wet weight, although crab waste, with its large fraction of connective tissue (chitin), had ash percentages of approximately 10 percent wet weight. The percent of carbon, nitrogen, phosphorus, and sulfur based on wet weights is estimated at 16.7, 2.9, 0.3 and 0.3 percent respectively.

Table 2 Proximate Composition (Percent) of Alaskan Fishery Wastes.

Type	Sample	n	Moisture	Protein	Fat	Ash	Source
Cod	Hand fillet	6	79.5	14.3	1.7	3.9	Crapo 1988
Cod	Hand fillet	n/a	78.5	15.6	2.1	4.3	Crawford et al. 1972
Cod	Machine fillet (winter)	6	79.4	14.1	2.0	3.8	Crapo 1988
Cod	Machine fillet (spawning)	4	80.6	13.5	0.9	4.1	Crapo 1988
Cod	Skinner wastes	6	78.8	20.3	0.6	2.6	Crapo 1988
Cod	Trimming table	6	85.1	14.9	0.6	0.8	Crapo 1988
Cod	Roe	2	71.5	23.5	2.5	1.4	Crapo 1988
Pollock	Machine fillet (winter)	4	81.3	11.3	3.0	3.6	Crapo 1988
Pollock	Machine fillet (spawning)	4	82.0	12.5	1.9	3.7	Crapo 1988
Pollock	Hand fillet	n/a	74.8	13.8	8.9	2.7	Babbitt 1982
Pollock	Heads	n/a	81.1	13.6	1.4	4.9	Babbitt 1982
Pollock	Viscera	n/a	45.0	8.2	40.1	0.8	Babbitt 1982
Pollock	Frame	n/a	80.4	15.9	0.7	3.3	Babbitt 1982
Pollock	Skin	n/a	81.8	18.0	0.3	0.9	Babbitt 1982
Pollock	Bloodwater	3	98.5	0.9	0.2	0.3	Crapo 1988
Surimi	Filet waste	3	81.3	11.3	3.0	3.6	Crapo 1988
Surimi	Bloodwater	3	97.9	1.3	0.4	0.3	Crapo 1988
Surimi	Deboner waste	3	86.1	10.7	0.8	0.7	Crapo 1988
Surimi	Refiner waste	3	86.4	12.1	0.7	0.4	Crapo 1988
Surimi	Rotary screen wastewater	3	98.8	0.8	0.2	0.2	Crapo 1988
Halibut	Heads	3	65.5	11.6	16.2	4.1	Crapo 1988
Salmon	Heads	3	67.3	13.3	15.8	4.2	Crapo 1988
Salmon	Heads	n/a	65.1	15.0	17.5	3.6	Kizevetter 1971
Salmon	Viscera	3	80.5	16.2	2.5	1.6	Crapo 1988
Salmon	Viscera	n/a	76.0	18.0	4.0	2.0	Kizevetter 1971
Crab	Tanner	3	76.7	8.9	1.1	9.2	Crapo 1988
Crab	King	3	71.7	13.8	1.6	10.3	Crapo 1988
Flatfish	Not specified	3	79.4	13.8	3.8	3.2	Crapo 1988

Table 3 Theoretical Composition of Seafood Waste

Constituent	Percent Wet Weight	Approximate [a] Density (g/cm^3)	Percent Dry Weight
Water	75	1.0	-
Protein	7	1.5	60
Fat/Carbohydrates	15	0.9	28
Bone/Chitin	3	3.0	12
Total Estimated Wet Weight Density	-	1.13	-
Carbon	16.7[b]	-	50.0[b]
Nitrogen	2.9 [c]	-	8.8 [c]
Phosphorus	0.27 c	-	0.8 c
Sulfur	0.27 c	-	0.8 c

[a] Typical values listed in the Handbook of Chemistry and Physics (Weast 1982).
[b] Typical dry weight carbon (C) content of organic matter used.
[c] Estimated concentration of nitrogen (N) and phosphorus (P) based on the Redfield ratio of C:N:P (106:16:1) in organic matter (Redfield 1958; Redfield et al. 1963).
Ratio of sulfur to phosphorus assumed to be 1:1.

2.8.1 Bottom Accumulations of Solid Waste (Zones of Deposition)

Accumulations of waste material (residue) on the bottom of the receiving water indicates that the rates of deposition exceed the rates at which material can be assimilated by the benthic community. Facilities discharging to the near-shore environment are more likely to generate accumulations because of their stationary outfalls and the greater opportunity for conditions (e.g., current speed, waste particle settling velocities, and waste decay rate) to support accumulation compared to discharges from moving off-shore vessels.

The permit retains a provision for allowing a zone of deposit of up to one acre for each authorized discharge location where residues are allowed to accumulate on the bottom of the receiving water. All facilities discharging seafood processing waste to waters less than 1 nm from shore for more than 7 days (168 hours) shall conduct seafloor monitoring. The seafloor survey shall determine the depth, total area, outer boundary of continuous coverage, and the outer boundary of discontinuous coverage of seafood processing waste. The survey will use a deposition which is 0.5 inches or thicker on the bottom (seafloor) as the minimum detection level. The purpose of the survey is to determine compliance with Alaska water quality standards (WQS) and the authorized zone of deposit.

Accumulated wastes are the only seafood processing waste discharges that have led to water bodies being designated as water quality impaired. Impairments have been identified for residues and dissolved oxygen (ADEC 2006). In the case of Akutan Harbor, the impairment resulted from three facilities discharging into receiving waters with very low average current speeds (approximately 1 cm/sec), allowing all but the smallest particles (>0.5 mm) to settle rather than remain suspended (EPA 1995 a-b).

Four facilities discharging through a combined outfall to a receiving water with low current speeds (approximately 5 cm/sec) contributed to Unalaska Bay being designated as impaired for residues and dissolved oxygen (EPA 1995c-d). In other cases, discharges from a single facility were sufficient to cause accumulations sufficient to exceed the residue standard (ADEC 2006). The discharge of seafood processing waste residue between 0.5 nm and 1 nm from shore in waters less than -120 feet at MLLW shall not exceed 3.3 million pounds per calendar year at a single location. A single location refers to the anchorage of a processor within a circular area with a radius equal to 0.5 nm. This limitation helps to reduce the likelihood of waste piles exceeding the 1-acre ZOD.

ADEC conducted a review of the annual dive reports required under the existing permit between 2001 and 2004. During that four-year time period, approximately 110 shore-based and nearshore facilities were in operation; however only 21 annual reports submitted to ADEC report on the accumulation of bottom wastes. The average pile size of the facilities that submitted reports was 0.41 acre with the maximum and minimum reported sizes being 0.92 and 0.08 acre, respectively. Since the available data on waste accumulations only represents a fraction of the dischargers, these numbers may not be representative of all dischargers or of actual conditions in the water. ADEC has noted that the dive surveys are not consistently completed using the appropriate methodology and facilities were allowed to request waivers exempting them from the survey process (ADEC 2007, pers. comm.). Therefore, it is not possible to extrapolate about the total accumulation of bottom wastes that occurs.

2.9 Dissolved Wastes

High biochemical oxygen demand (BOD), total suspended solids (TSS), oil and grease, and nitrogen levels characterize effluents from seafood processing facilities. Most of the BOD and TSS, and approximately 60 percent of the oil and grease present in the discharge originate from the butchering process (NovaTec, 1994). Since these materials may be present at many stages during processing operations, the permit requires that all wastes coming in contact with seafood, including scupper and floor drain wastes, pass through a waste conveyance and treatment system. The existing permit does not require discharge monitoring; therefore, current effluent data on specific discharges are not available. Table 2-3 presents effluent characteristics of dissolved wastes from dischargers operating in 1992 and 1993, when effluent data was collected. Discharge characteristics are not expected to have changed since these data were collected. Caution should be used when comparing the median and maximum values for each effluent type because the data points, even if equal in number, may be from different facilities or time periods.

Table 4 Effluent data for Alaskan shore-based seafood processors discharging under individual permits in 1992 and 1993

Product[2]		TSS mg/L		Oil & Grease (mg/L)		BOD (mg/L)	
		Monthly Avg.	Daily Max.	Monthly Avg.	Daily Max.	Monthly Avg.	Daily Max.
Bottomfish	Median	105	150	73	91	n/a	n/a
	n	120	124	101	106	n/a	n/a
	Minimum	10	6.0	2.8	4.5	n/a	n/a
	Maximum	4,553	3,324	1,621	1,486	n/a	n/a
Crab	Median	36	43	13	18	n/a	n/a
	n	16	18	15	17	n/a	n/a
	Minimum	5.5	8.0	1.0	2.0	n/a	n/a
	Maximum	1,513	3,376	351	369	n/a	n/a
Salmon	Median	176	215	90	116	n/a	n/a
	n	26	28	34	35	n/a	n/a
	Minimum	15	16	6.3	9.0	n/a	n/a
	Maximum	1,214	1,668	1,130	2,250	n/a	n/a
Halibut	Median	67	104	49	81	n/a	n/a
	n	17	17	16	17	n/a	n/a
	Minimum	12	12	6.3	12	n/a	n/a
	Maximum	325	325	273	359	n/a	n/a
Herring	Median	78	82	28	85	n/a	n/a
	n	7.0	8.0	5.0	6.0	n/a	n/a
	Minimum	39	39	1.2	1.2	n/a	n/a
	Maximum	418	1,284	184	277	n/a	n/a
Total	Median	150	202	141	166	155	164
	n	233	236	221	223	19	20
	Minimum	2.0	1.0	0.4	0.5	3.7	2.8
	Maximum	3,576	4,500	1,480	5,456	6,852	22,400
Meal	Median	88	142	28	44	80	120
	n	18	18	18	18	15	15
	Minimum	16	24	1.4	1.4	36	36
	Maximum	1,330	1,949	153	284	13,356	39,750
Stickwater	Median	4,900	9,540	2.1	5.6	7,600	7,600
	n	53	53	25	25	47	47
	Minimum	9	23	0.2	0.2	1.5	2
	Maximum	84,000	110,000	91,139	203,800	148,950	432,000
Surimi	Median	1,079	1,366	208	257	2,323	1,845
	n	25	25	25	25	6	6
	Minimum	24	33	8	17	286	286
	Maximum	6,209	7,808	282,400	295,200	7,328	7,750

n/a = not available

[1] Obtained from Discharge Monitoring Reports (DMRs) submitted to EPA's Permit Compliance System (PCS)

[2] Product Classifications are as follows:

Bottomfish = Bottomfish (pollock, cod, sablefish, etc.) **Crab** = Crab, including crab meat and crab sections
Salmon = Includes both hand butchered and mechanized salmon operations
Halibut = Halibut and other headed/gutted bottomfish **Herring** = Herring including fillets and roe
Total = Multiple, single, or unspecified species **Meal** = Fishmeal
Stickwater = Stickwater from fish meal operations **Surimi** = Surimi production from pollock

In addition to BOD, TSS, oil and grease, other contaminants can be present in effluent from seafood processing facilities. The dissolved wastes may include disinfectants used to maintain sanitary conditions in compliance with requirements for the production of food for human consumption. The following sections provides greater detail on stickwater, surimi wastewater, wash down water, sanitary wastewater and other wastewaters.

2.9.1 Stickwater

Stickwater is the mixture of water, oil, proteins, fats and ash separated from the press liquor generated during the production of fish meal. Since the permit places no restrictions on fish meal production, stickwater may be discharged from any of the facilities, regardless of location. Effluent data summarized in the 1993 ODCE showed that stickwater has of the highest median concentrations for TSS and BOD compared to other wastewaters (see Table 2.3). The average volume of stickwater discharged at two seafood processing facilities currently operating under individual permits is as much as 160,000 gallons per day, equating to an average of two to four percent of the total daily discharge at each facility. The 1993 ODCE indicated that the monthly median discharge of stickwater from 22 fish processors was 1.0 million gallons per day (MGD) ranging from a minimum of 0.04 MGD to a maximum of 2.4 MGD.

2.9.2 Surimi Wastewater

Surimi is a minced fish product made from walleye pollock. The manufacturing process includes gutting, heading, deboning and filleting followed by mincing and washing. Surimi wastewater is relatively high in TSS and BOD and had the highest median and maximum values for oil and grease compared to other liquid wastes as reported in the 1993 ODCE. The 1993 ODCE also noted that 26 facilities discharged a median monthly average of 1.7 MGD of surimi wastewater. Surimi production falls within the category of washed seafood mince, the discharges from which the permit only authorizes for offshore facilities.

2.9.3 Wash-Down Water

Wash-down water is used to remove wastes and maintain sanitary standards during processing operations. In addition to the organic materials, these discharges may include EPA-approved disinfectants that could contain chlorine-, iodine-, or ammonium chloride-based solutions. These wastes are generally low volume.

2.9.4 Sanitary Wastewater

Sanitary waste is human body waste discharged from toilets and urinals. The pollutants associated with this discharge include suspended solids, BOD_5, fecal coliform, enterococci, and residual chlorine. This is a minor discharge which USEPA has estimated at 30 gallons per person per day (USEPA 2002). The permit requires processors to meet applicable US Coast Guard pollution control standards for a Type II MSD.

2.9.5 Graywater

Graywater is water from galleys, baths, showers, lavatory sinks, and laundry facilities. This is a minor discharge, but there is no estimate of volume produced. The permit requires best management practice controls on the discharge of graywater modeled after the 2008 EPA Vessel general permit.

2.9.6 Other Wastewaters

Other wastewaters are the other liquid wastes generated during seafood processing operations. These low-volume wastes include, seafood catch transfer water, live tank water, refrigerated seawater, cooking water, boiler water, cooling water refrigerator condensate, pressure relief waster, clean-up water and scrubber water. These wastes would not be expected to contain concentrations of contaminants that would be detrimental to marine organisms. The permit requires that these wastewaters not contain foam, floating solids, grease or oily wastes that produce a scum or sheen on the water surface nor wastes that accumulate on the seafloor or shoreline. Wastewaters not having contact with seafood are not required to be discharged through the seafood process waste-handling system.

2.10 **Summary**

Seafood processing facilities are located throughout coastal Alaska and either discharge near shore (shore-based and near-shore facilities) or in off-shore waters (off-shore floating facilities). Processing activities occur year round but with peaks in activity occurring in late winter and mid-summer. Discharge volumes from individual facilities range widely. Permit coverage requirements begin with facilities discharging more than 1,000 pounds per day and 30,000 pounds per calendar year while some facilities may discharge in excess of 500,000 pounds per day during peak production periods. In total, facilities operating under the AKG520000 permit discharged over one billion pounds of solid wastes in 2005.

Seafood processors discharge waste in two forms, solid and dissolved. Solid wastes consist of biological waste materials not used in final products and include fish heads, offal, scales, bones and shells. As noted above, estimates on the amount of solid waste discharged on both a daily and annual basis are readily available. Dissolved wastes are liquid based and consist of the dissolved and suspended materials that pass through processing operations. The vast majority of the dissolved wastes contain proteins, fats, nutrients, and ash. Small components of the effluent stream, such as wash-down water, may include disinfectants that could be toxic to marine life. Data on the volume of dissolved wastes discharged by seafood processors is not readily available.

Most wastes discharged from seafood processing facilities are not known to persist in the environment over long periods of time. However, seafood wastes composed of unground shells from high production facilities are known to not decompose and form piles that persist in the environment. This is especially evident from crab waste piles discharged in the 1980s (ADEC 2007, pers.

comm.). The soft tissue part of seafood waste is known to eventually disperse with tides and current in most topographic locations. Settleable solids in the discharges may locally cause accumulations of residues.

Historically, there have been only three facilities from seafood processing plants under the AKG520000 permit that have caused a waterbody to be listed under an impairment category for residue deposition or oxygen depletion. All three of these plants are located in Ketchikan, SE Alaska. Currently only one waterbody remains as listed for seafood waste discharges to the Tongass Narrows.

On a chemical basis, the composition of these organic wastes do not include constituents that would normally be suspected of accumulating or persisting in the environment. Likewise, the dissolved wastes could contribute to localized and short term changes in water chemistry (reduced dissolved oxygen) or reduced light transmission; however, the constituents are unlikely to accumulate or persist in the receiving waters.

Criterion #1 of the Ocean Discharge Criteria assesses “the quantities composition, and potential for bioaccumulation or persistence of pollutants in the discharge.” Seafood processing generates a significant volume of wastes, consisting mostly of organic material resulting from butchering and processing operations. The accumulation of toxic contaminants as a result of discharges covered by the permit is unlikely.

3.0 Transport, Persistence, and Fate of Materials Discharged

(NOTE: This chapter is carried forward from the 1993 ODCE developed in support of the initial NPDES general permit for seafood processing facilities. The modeling effort is still deemed to be accurate and applicable to this analysis.)

Alaskan seafood processing results in the discharge of wastewater consisting of solid and liquid wastes. These wastes consist primarily of dissolved and particulate organic matter and nutrients. Depending on the type and amount of waste discharged, and the physical, biological, and chemical characteristics of the receiving water, wastewater discharges from seafood processors have the potential to impair designated beneficial uses of the marine waters of Alaska. These potential adverse effects on the quality of marine waters of Alaska include reduction in water column dissolved oxygen due to the decay of particulate and soluble waste organic matter, the release of toxic levels of sulfide and ammonia from decaying waste, nutrient enrichment (eutrophication) and stimulation of phytoplankton growth and alteration of the phytoplankton community, and the accumulation of buoyant waste solids and fish oils on the water surface and shorelines.

Seafood waste discharges also have the potential to accumulate on the receiving water bottom in the vicinity of the discharge. The accumulation and decay of seafood waste solids results in the smothering of benthic marine organisms, and the release of carbon dioxide, methane, ammonia, soluble phosphorus, and hydrogen sulfide. The decay of the waste accumulation and the release of microbial decomposition by-products (e.g., sulfide and methane) also exerts a demand on the dissolved oxygen content of the overlying water column and within the sediments. These potential impacts on marine organisms are discussed in detail in Section 5.0 and the potential for exceedances of Alaska's marine water quality criteria are discussed in Section 9.0.

The following section describes a conceptual model of the transport, fate, and persistence of discharges from seafood processing facilities in Alaska and the potential adverse environmental impacts resulting from these discharges. The development of a computer model to predict the accumulation, persistence, and areal coverage of discharged seafood solid wastes is also described and the results of model case studies are summarized.

A number of Alaskan seafood waste discharges have resulted in the persistence of bottom accumulations of waste, and adverse effects on benthic organisms have been observed in the vicinity of the discharge (see Section 5.1). Therefore, the focus of this section is primarily on the transport, fate, and persistence of seafood waste solids. Since the permit includes the allowance of a persistent (i.e., year-round) bottom accumulation of seafood waste of no more than 1.0 acre, predicting the bottom area covered by seafood solid waste accumulations and the depth of the deposited solids on the bottom as a function of distance from the discharge point is also of interest.

This section begins with the description of a generalized conceptual model of the significant variables (biological, chemical, and physical) that affect the transport, fate, and persistence of seafood waste discharges (Section 3.1), followed by a description of the development of a computer model to predict the deposition of seafood solid waste and the selection of model input variables and modeling case scenarios (Section 3.2). A summary of the results of twelve modeling case scenarios based on the selected input variables to the computer model is also provided (Section 3.3).

3.1 Conceptual Model of Seafood Waste Discharges

The following is a description of a conceptual model of the most important factors that control the fate, transport, and persistence of seafood processing waste discharges, including the potential adverse environmental impacts associated with the discharge of seafood waste.

Seafood wastewater discharges consist of a combination of dissolved and solid waste particles (see Section 2.0). The dissolved portion of the waste consists of water soluble organic compounds and soluble nutrients. The liquid portion of the waste may also contain disinfectants used to clean the processing areas. The solid fraction of the waste should be ground to a particle size of 0.5 inch in diameter or less before discharge. The solid fraction consists of a variety of particles ranging from small bits of bone, shell, fat, or flesh to larger fragments of internal organs and fragments of flesh and fat attached to bone, shell, or connective tissue. Thus the solid fraction likely consists of a range of solid particle sizes with chemical compositions and densities that depend on the relative amount of protein, fat, bone, chitin, and connective tissue in each particle.

Once discharged to the receiving water, the rate at which the liquid and solid wastes are dispersed and advected away from the point of discharge will depend on the physical and chemical properties of the discharged waste discussed above, and the physical oceanographic characteristics of the receiving water. These oceanographic characteristics include the location of the discharge in the water column, the presence or absence of density stratification, water depth and bottom topography, and prevailing directions and speeds of wind- and tidally-forced currents. The solid waste particles will settle to the bottom at a rate that depends on the shape, density, and size of the individual particles. Once deposited on the bottom, periods of high currents or storm wave-induced bottom turbulence can result in the resuspension and transport of deposited seafood waste solids away from the point of discharge.

Following their discharge to the receiving water, the particulate and soluble wastes are subjected to chemical and biological transformations that result in the decomposition of the waste materials and the production of bacteria and chemical compounds. The decomposition of the soluble and particulate organic matter consumes dissolved oxygen and results in the production of varying quantities of soluble compounds including carbon dioxide, methane, ammonia, soluble phosphorus, and hydrogen sulfide. Scavenging organisms including fish, crabs,

and polychaete worms may also feed on the particulate waste that is suspended in the water column or fresh waste that has accumulated on the bottom.

The adverse environmental effects associated with the discharge include reduction of water column dissolved oxygen concentrations and reduction of oxygen in sediments affected by decaying waste accumulated on the bottom. Seafood wastes also have the potential to be toxic to marine organisms via the discharge of wastewater containing ammonia and residual chlorine compounds and the bacterially mediated production of ammonia and hydrogen sulfide from decaying waste accumulations. Direct smothering of benthic organisms may occur as a result of the accumulation of seafood waste on the bottom. If phytoplankton in the vicinity of the waste discharge are nitrogen or phosphorus limited, the additional nutrients supplied by the waste discharge may increase phytoplankton productivity and alter the species composition of the phytoplankton community.

The available information on the character and quantity of Alaskan seafood processing waste discharges has been summarized in Section 2.0. The most important variables that affect the transport, fate, and persistence of seafood processing wastes subsequent to their discharge to receiving waters are 1) the physical oceanographic characteristics of the receiving water, 2) the distribution and settling velocities of the waste particles, and 3) the loss processes and decay rates of the discharged organic matter. The available information on these variables that is relevant to predicting the transport, fate, and persistence of seafood processing waste discharges to marine waters of Alaska is summarized below.

3.1.1 Physical Oceanographic Characteristics of the Receiving Water

Significant physical oceanographic characteristics to consider include water temperature, density stratification, and water circulation in the vicinity of seafood processing discharges. Significant seasonal variation in water temperature and density structure occur in the Gulf of Alaska and the Bering Sea, especially in coastal waters in the vicinity of large freshwater inputs during winter and spring. Elevated surface water temperatures lower the saturation concentration of dissolved oxygen. Warmer surface waters overlying colder water also result in greater density stratification. Warmer surface waters occur in late summer. Density stratification of the water column can result in the trapping of waste discharges well below the water surface which may result in lowered dilution of the wastewater discharge, but prevent the appearance of the wastewater plume on the water surface.

Water circulation results in the advection or transport of discharged wastewater, and when bottom currents (or wind-induced waves) are strong enough, solid wastes that have settled on the bottom may be resuspended and transported away from the discharge. Water circulation occurs through wind- and tidally-driven currents. The amount of wind- and tidally-induced circulation will vary seasonally, and tidally-induced currents will vary over the course of the day in many coastal areas of Alaska which experience semidiurnal tides. Wind-driven circulation most strongly influences

circulation patterns during winter storms that frequent the Gulf of Alaska and Bering Sea.

Although it would be difficult to classify the marine waters of Alaska into regionally distinct oceanographic regimes, some generalizations were made from the available data on tide ranges and maximum tidal currents. Tide ranges and hence tidal currents are generally highest in the areas of Southeast Alaska, Prince William Sound. Cook Inlet, and Bristol Bay. Diurnal tides range between 10.1 and 28.8 feet at Yakutat and Anchorage, respectively. Maximum tidal current speeds in these areas range from 0.1 to 4.0 mi/hr at Juneau and Anchorage, respectively. The highest tide ranges and tidal currents occur in Cook Inlet, an estuary with one of the greatest tidal amplitudes and currents known.

In the area of the Alaska Peninsula and Aleutian Islands, including the Pribilof Islands and the island of Kodiak, and in the northern portion of the Bering Sea in the vicinity of Kuskokwim Bay, Norton and Kotzebue Sound, the tide range and tidal currents are generally lower. Diurnal tides in these areas range between 2.9 and 10.8 feet at Nome and Port Moller, respectively. The predicted maximum tidal current speed at Port Moller is 1.9 mi/hr.

It should be noted that seafood processing operations that occur at a fixed position (i.e., shore-based and anchored floating processors) generally choose to operate in locations that are relatively protected so that fishing and supply vessels can easily dock and transfer catch or load finished products. The locations of seafood processing operations in Alaska can be generally represented by four physical oceanographic environments:

Protected bays or harbors with reduced wave action, but possibly significant tidal currents.

Near-shore open coastal areas which are affected by wave action depending on the water depth and wind- and tidally driven currents.

Rivers or estuary mouths with some wave action and a predominant tidal and freshwater influence.

Open water which is affected primarily by wind-driven currents, although tidal currents may be important at some locations.

Because stationary operations are typically located in coastal environments with reduced currents and wave action, discharges from these facilities are most likely to result in the-accumulation of solid waste on the bottom in the vicinity of the discharge.

3.1.2 Seafood Waste Particle Settling and Resuspension Current Speeds

Seafood waste particle settling velocities and the current speeds required to resuspend deposited waste particles are important factors that affect the fate, transport, and persistence of the seafood waste solids that are

discharged. Estimates of these variables for seafood waste solids are summarized below.

Settling Velocities of Seafood Waste Particles. Ground seafood waste that is discharged is required to consist of solid particles that are no larger than 0.5 inch in any dimension. Currently, no studies have been identified that have adequately characterized the particle size distribution of ground seafood waste or the characteristic settling velocities of these particles. However, one study of the openwater disposal of ground seafood waste conducted in Chiniak Bay, Kodiak Island, Alaska, provides a first-approximation of the settling velocities of seafood waste particles (Stevens and Haaga 1994). Unground particles (primarily gills, skin, fins, and viscera 2-10 inches in diameter) required approximately 0.5 hr to settle to the bottom at depths of 400 to 500 feet (Stevens and Haaga 1994). Smaller particles (less than 0.5 inch diameter) required more than 1 hr to settle to the bottom. These ranges in settling times and water depths provide approximate bounds for the settling speeds of typical seafood waste particles of 0.098-0.262 foot/sec.

An approximation of the settling velocities of seafood waste particles can also be predicted using the method described by Sleath (1984). This method calculates the settling velocity of a smooth, non-rotating spherical particle of a specific diameter and density in a motionless fluid. The density of a seafood waste particle can be approximated assuming a density of 1.0, 1.5, 0.9, and 3.0 g/m^3 for water, protein, fat/carbohydrate, and bone/chitin, respectively, and a percent water, protein, fat/carbohydrate, bone/chitin content of 75, 15, 7, and 3, respectively (see Table 2.2). These assumptions result in an estimated particle density of 1.13 g/m^3. The calculated settling velocities of spherical particles with diameters ranging from 0.04-0.5 inch and a density of 1.13 g/m^3 are shown in Table 3.1.

These predicted settling velocities are generally much greater than those suggested by the observations of Stevens and Haaga (1994) described above. A spherical particle density that would result in settling velocities that were more consistent with the observations of Stevens and Haaga (1994) is 1.05 g/m^3 (see Table 3-1). The differences between the predicted and observed settling velocities may be due to 1) differences in particle sizes (the particle size distribution observed by-Stevens and Haaga may have been biased to larger particles), 2) overestimation of actual settling velocities for a given particle density using the method described in Sleath (1984) due to non-spherical particle shapes and greater drag forces of the actual particles, or 3) overestimation of the actual particle densities. The method described by Sleath (1984) has been developed for idealized particles and has been applied most successfully to predicting the settling velocities of fine mineral particles with relatively small diameters. This method may not be as reliable for the prediction of the settling velocities of relatively large, irregularly shaped organic waste particles.

Resuspension Current Speeds. The settling velocity of the solid waste particles (and the height of the discharge above the bottom) affects the initial areal extent of the deposit of solid waste on the bottom in the vicinity of the discharge. However, in regions that experience high currents it is important to consider the potential for the solid waste particles to be resuspended following deposition. If solid waste is resuspended and transported away from the vicinity of the discharge, the accumulation of solid waste would be less than that predicted based on the settling velocity and decay rate of the waste solids. The potential adverse impacts to benthic communities would also be reduced.

Resuspension and transport of deposited seafood waste solids is possible if the current speeds are sufficiently large. Periodically high current speeds can result from wind, tide, or wave action along the coast. Along the coast of Alaska, the currents in many areas are dominated by semidiurnal tidal currents. These can be approximately represented as a sine wave with amplitude equal to the maximum current speed. Assuming that the maximum current speed exceeds the critical resuspension current speed required to lift waste particles off the bottom, then resuspension and transport of material is possible during a portion of a tidal cycle. The amount of material transported depends on the duration and frequency of occurrence of the critical current speed. The critical current speed depends on the size and density of the waste particles, and the cohesiveness of the waste accumulation on the bottom.

The critical resuspension current speed [i.e., the critical current speed 3.3 feet above the seafloor (U_{100})] can be estimated for a particle of specified diameter and density in a non-cohesive sediment using Shield's diagram (Vanoni 1977) to compute the critical shear velocity u_* and the relation $u_* = (0.003)^{0.5} * U_{100}$ (Sternberg 1972). Critical resuspension current speeds calculated using this method are shown in Table 5 for the same particle sizes and diameters used to estimate settling velocities. These current speeds are necessarily first-approximations because the critical resuspension current velocities predicted using this method do not incorporate the effect of the cohesiveness of the waste solids accumulation which will necessarily resist resuspension and transport (Nowell et al. 1981). Diver observations of seafood waste piles have often noted a microbial mat over the surface of the pile which may increase the resistance to resuspension of decaying waste (e.g., USEPA 1991). The actual critical resuspension current speeds are therefore likely to be higher than those shown in Table 5.

Table 5 Estimated settling velocities and current speeds necessary to resuspend different sizes of seafood solid waste particles.

Seafood Waste Particle Diameter (cm)	Settling Velocity[a] (m/sec)		Resuspension Current Speed[b] (m/sec)		
	ρ = 1.13	ρ = 1.05	ρ = 1.05	ρ = 1.13	ρ = 1.4
For a given particle density in g/cm^2					
0.1	0.017	0.0057	0.07	0.11	0.20
0.2	0.036	0.014	0.08	0.15	0.28
0.3	0.055	0.021	0.09	0.18	0.37
0.318 (1/8 in)	0.058	0.022	0.09	0.19	0.38
0.4	0.072	0.029	0.10	0.22	0.44
0.5	0.089	0.036	0.12	0.25	0.51
0.6	0.105	0.042	0.13	0.28	0.58
0.635 (1/4 in)	0.111	0.045	0.14	0.29	0.60
0.7	0.122	0.049	0.14	0.31	0.64
0.8	0.138	0.055	0.16	0.34	0.70
0.9	0.154	0.062	0.17	0.37	0.76
1.0	0.165	0.068	0.18	0.40	0.82
1.1	0.174	0.075	0.19	0.42	0.86
1.2	0.181	0.081	0.20	0.45	0.90
1.27 (1/2 in)	0.186	0.085	0.21	0.47	0.93
1.3	0.189	0.087	0.22	0.47	0.95

[a] (Stokes fall velocity (Sleath 1984). Assumes a seawater density of 1.025 g/cm^3 and a kinematic viscosity of seawater at 5° C equal to 1.52×10^{-6} m^2/sec

[b] The calculation of the resuspension current speed [i.e., the current speed 1m (3.3 ft) above the seafloor (U_{100}) that is sufficient to cause resuspension of particles] is based on use of Shield's diagram (Vanoni 1977) to compute the critical shear velocity $u_* = (0.003)^{0..5}\ U_{100}$ (Sternberg 1972).

Although resuspension current speeds are likely to be higher near the bottom in shallow water than in deeper water, it should not be concluded that it would be more advantageous to locate seafood waste discharges in shallow waters. Shallow wastewater discharges will result in relatively lower initial dilution of the soluble portion of the waste due to the limited volume of dilution water available in shallow areas. Discharges in shallow near-shore waters also increase the potential for the surfacing of the waste plume and the accumulation of solids along the shoreline in the vicinity of the outfall.

3.1.3 Seafood Waste Decay and Loss Processes

Waste solid and liquid (i.e., particulate and dissolved) organic matter is decomposed by bacteria and eaten by scavenger organisms when released into the environment. The rate of decomposition or decay not only determines the persistence of the released organic matter, but the decay also results in the consumption of oxygen and the release of soluble compounds including nitrogen (e.g., ammonia), phosphorus (as soluble phosphorus), carbon dioxide, hydrogen sulfide, and methane.

Microorganisms mediate the chemical oxidation responsible for the degradation of organic matter. Microorganisms require an electron acceptor to accomplish this reaction, and different electron acceptors yield different

amounts of usable energy. In the environment, the degradation of organic matter involves a series of reactions, each successive reaction yielding less energy per unit of carbon oxidized than the previous reaction. Simplified forms of these reactions are presented in Table 6. It is also important to note that the stoichiometry of organic matter, here formulated as $(CH_2O)_x(NH_3)_y(HPO_4)_z$, is much more complex than represented. The organic matter is actually composed of various complex chemicals that may be generally grouped as proteins (amino acids) and soluble material (which contain nitrogen, phosphorus, and sulfur), fats and carbohydrates, and proteinaceous mineral matter that comprises skeletal and connective tissue (e.g., chitin which also contains nitrogen).

Table 6 Idealized chemical reactions of microbially medicated organic matter decomposition.

Microbially mediated processes:
Aerobic respiration $(CH_2O)_x(NH_3)_y(H_3PO_4)_z$[a] + $(x+2y)O_2$ --> $xCO_2 + (x+y)(H_2O) + yHNO_3 + zH_3PO_4$
Nitrate Reduction $5(CH_2O)_x(NH_3)_y(H_3PO_4)_z + 4xNO_3$ --> $xCO_2 + 3x(H_2O) + xHCO_3^- + 2xN_2 + 5yNH_3 + 5zH_3PO_4$
Manganese reduction $(CH_2O)_x(NH_3)_y(H_3PO_4)_z + 2xMnO_2 + 3xCO_2 + xH_2O$--> $xHCO_3^- + 2xMn^{2+} + yNH_3 + zH_3PO_4$
Iron reduction $(CH_2O)_x(NH_3)_y(H_3PO_4)_z + 4xFe(OH)_3 + 7xCO_2$ --> $8xHCO_3^- + 3xH_2O + 4xFe^{2+} + yNH_3 + zH_3PO_4$
Sulfate reduction $2(CH_2O)_x(NH_3)_y(H_3PO_4)_z + xSO_4^{2-}$ --> $8xHCO_3^- + xH_2S + yNH_3 + 2zH_3PO_4$
6. Methane production $2(CH_2O)_x(NH_3)_y(H_3PO_4)_z^-$ --> $xCO_2 + xCH_4 + 2yNH_3 + 2zH_3PO_4$
7. Fermentation (generalized) $12(CH_2O)_x(NH_3)_y(H_3PO_4)_z$ --> $xCH_3CH_3COOH + xCH_3COOH + 2xCH_3CH_2OH + 3xCO_2 + xH_2 + 12yNH_3 + 12xH_3PO$

[a] Theoretical chemical formula for organic matter.
Source: Aller 1982.

A more detailed organic matter composition can be approximated to better describe the amount of nitrogen, phosphorus, and sulfur that is liberated during the organic matter microbial decay process. The relative amount of these elements varies among the various types of organic matter. For

example, Vollenweider (1985) described the theoretical stoichiometry of protein, lipid, and chitin with the following chemical formulas:

Protein and soluble material: $C_{61}N_{16}H_{100}O_{24}SP$[1]

Chitin and connective tissue: $C_{32}N_4H_{56}O_{20}$

Fats and carbohydrates: $C_{15}H_{30}O$

All of the sulfur and phosphorus and most of the nitrogen is contained in the protein and soluble fraction of the organic matter.

The rate of decay of organic matter depends on several factors including the composition of the material (i.e., refractory or labile) and decomposition pathways which depend on the chemical (e.g., oxic vs. anoxic) and physical (e.g., temperature and currents) environment. Values of organic matter decay rate constants reported in the literature are extremely variable (see Table 3.3), ranging over five orders of magnitude ($1.6x10^{-6}$ to $1.4x10^{-1}day^{-1}$).

Only one study of the decomposition of discharged seafood waste solids has been identified. In this study Tetra Tech (1986, 1987) developed and calibrated a seafood waste pile decay model to predict the accumulation and decay of solid seafood waste disposed in Akutan Harbor, Alaska. The model assumed that: 1) all of the waste discharged accumulated at the point of discharge (i.e., no losses due to resuspension or slumping and transport) and 2) the decay of the pile was due only to microbial activity (i.e., scavenging by organism was not an important loss process). Decay rates were developed for the aerobic and anaerobic decay of fish and crab composed of protein, fats and carbohydrates, and bone or chitin. The first-order decay rate constants that provided a reasonable fit to the available data on the temporal variability of the waste pile volumes were 0.1, 0.01, and 0.001/day for aerobic decay and 0.01, 0.005, and 0.0005/day for anaerobic decay of protein, fats and carbohydrates, and bone/chitin, respectively (Tetra Tech 1986,1987).

The activity of scavenging organisms may also account for the reduction in the volume of accumulated waste in the vicinity of the discharge. However, no quantitative information regarding the consumption (i.e., loss) rate of seafood waste by organisms has been identified. However, marine organisms such as fish and invertebrates have been observed to feed on recently discharged solid waste particles (Hill, B., 8 June 1994, personal communication; Stevens and Haaga 1994). No quantitative studies regarding the importance of this activity have been identified.

The microbial decomposition process results in the liberation of a number of soluble compounds depending on the supply of electron acceptors (e.g., oxygen, nitrate, and sulfate) and the oxidation reduction state of the

[1] The elements of the chemical formula are designated by the following symbols: C = carbon, N = Nitrogen, H = hydrogen, O = oxygen, S = sulfur, and P = phosphorus.

environment and the amount liberated depends at least partly on the rate of decay of the organic matter (Froelich et al. 1979; Aller 1982) (See Table 7 for organic material decay rates). The microbially mediated reactions typically proceed in a predictable sequence based on the amount of energy released from the reaction beginning with the aerobic decomposition in the presence of oxygen, nitrate reduction of organic matter using nitrate as an electron acceptor and iron and manganese reduction in the near absence of oxygen, and sulfate reduction, methane production, and fermentation in the absence of oxygen. All of the microbial decay processes result in the liberation of soluble phosphate. Additional biological and chemical reactions can result in the assimilation of the released phosphate or the binding of phosphate to mineral particles. However, several studies have found that the amount of phosphorus actually released is typically greater than that predicted using stochiometric models due to the release of mineral-derived phosphates bound to sediments under the near anaerobic conditions typical of organic rich sediments (e.g., Almgren et al. 1975; Froelich et al. 1979). Nitrate and ammonia nitrogen compounds are also released from decaying organic matter, but additional microbial reactions such as assimilation and the transformation of ammonia to nitrate (i.e., nitrification), and nitrate to nitrogen (i.e., denitrification) serve to reduce the amount of ammonia and nitrate release to the overlying water column. The underestimation of the amount of nitrogen compounds released during organic matter decay using stochiometric models has been attributed to the loss of these compounds via nitrification-denitrification (e.g., Almgren et al. 1975). Hydrogen sulfide is also produced from the reduction of sulfate during anaerobic decay of organic matter in the presence of sulfate. However, additional chemical reactions complicate the prediction of the amount of sulfide released from decaying organic matter using simple stochiometric models. These reactions include the rapid oxidation of sulfide (Almgren and Hagstrijm 1974) and the binding of sulfide with mineral particles.

Table 7 Range of sediment decay constants (K) for organic material.

Day^{-1}	**Degraded Substrate**	**Measurement Method**	**Location**	**Reference**
$1.6x10^{-6}$ [a]	Refractory organic material	Benthic chamber, core incubator, pore water	Santa Monica Basin, CA	Jahnke 1990
$<8.2x10^{-5}$ [a]	Organic material	^{14}C	Resurrection Bay, AK	Henrichs and Doyle 1986
$>4.1x10^{-4}$ [a]	Labile organic material	Benthic chamber, core incubator, pore water	Santa Monica Basin, CA	Jahnke 1990
$1.2x10^{-3}$ [a]	Labile organic material	^{14}C	Long Island Sound, NY	Turekian et al. 1980
$1.7x10^{-3} – 6.0x10^{-3}$ [a]	Organic material	Pore water nitrogen	North Sea	Billen 1982
$2.3x10^{-3}$ [b]	Organic material	^{35}S	Long Island Sound, NY	Westrich and Berner 1984
$2.7x10^{-3}$ [b]	Refractory organic material	^{35}S	Long Island Sound, NY	Westrich and Berner 1984
$2.7x10^{-3}$ [a] $– 8.2x10^{-3}$ [a]	Refractory algal material	^{14}C	Resurrection Bay, AK	Henrichs and Doyle 1986
$1.0x10^{-2}$ [c]	--	--		EPA 1982
$2.0x10^{-2}$ [b]	Labile organic material	^{35}S	Long Island Sound, NY	Westrich and Berner 1984
$2.4x10^{-2}$ [a]	Labile algal material	^{35}S	Long Island Sound, NY	Westrich and Berner 1984
$1.4x10^{-1}$ [a]	Labile algal material	^{14}C	Resurrection Bay, AK	Henrichs and Doyle 1986
Range $1.6x10^{-6} – 1.4x10^{-1}$				

[a] Total degradation was measured.
[b] Only anoxic degradation was measured.
[c] No experiments were conducted

3.2 Development of a Numerical Model to Predict Deposition of Seafood Waste

Due to the diversity of Alaskan seafood processing operations and the variety of physical oceanographic conditions, a computer model of seafood processing waste discharges would provide a very useful tool to evaluate the transport, fate, and persistence of discharged seafood waste. The ideal computer model would simulate all of the relevant physical, chemical, and biological processes and provide predictions for all potential adverse impacts on marine and coastal communities including effects on fish, marine birds, and humans. However, due to limitations in the understanding of physical and chemical processes, interactions between chemical and physical processes and biological communities, and limitations in computing power, computer models are typically mathematical simplifications of the most relevant processes and interactions (Thomann and Mueller 1987). The following sections describe the selection and development of a computer model with the capabilities to predict the long-term accumulation of solid waste on the bottom in the vicinity of seafood processors discharging from a fixed location. The permit classifies Alaskan seafood processing operations into two categories:

Offshore floating seafood processors-operating and discharging between 0.5 and 1.0 nm from shore that discharge more than 1,000 pounds a day and 30,000 pounds per calendar year.

Offshore floating seafood processors-operating and discharging between 1.0 and 3.0 nm from shore or baseline that discharge more than 1,000 pounds per day and 30,000 pounds per calendar year.

It is predicted that significant accumulations of seafood solid waste will only occur in the vicinity of near-shore floating and shore-based seafood processing operations that discharge at a single fixed location. Offshore floating processors are not expected to remain in a single location, and therefore the solid wastes discharged by these facilities will be dispersed and will not result in a persistent accumulation of solid waste on the bottom. A study on the disposal of seafood solid wastes in the offshore waters of Chiniak Bay, Alaska, indicated the rapid disappearance of bottom deposits of seafood waste (Stevens and Haaga, 1994). Therefore, the modeling effort focused on the prediction of solid waste accumulations in the vicinity of near-shore and shore-based facilities that discharge from a single fixed location.

3.2.1 Model Selection

Two EPA-supported computer models were initially identified that could effectively model the deposition, decay, accumulation, and areal extent of seafood solid waste. The two EPA models identified were the Simplified Deposition Calculation (DECAL) (USEPA 1987) and the Water Quality Analysis Program Version 5.10 (WASP5) (Ambrose et al. 1988). Both models were considered suitable for modeling the deposition, decay, and accumulation of seafood solid waste. However, WASP5 is also capable of modeling water column dissolved oxygen and nutrient-phytoplankton

interactions. These additional capabilities of WASP5 as well as the potential to incorporate the influence of relatively complex shorelines and tidally-varying current speeds and directions resulted in the selection of the WASP5 model for use in predicting the areal extent of seafood waste solids accumulation. However, the additional complexity of the WASP5 model results in some sacrifice in ease of use and increases the amount of computing time required to run the model. The original WASP5 computer code also required some modifications to accommodate the prediction of organic solids decay and accumulation.

3.2.2 Description of the Modified WASP5 Model

The existing WASP5 and EUTROS (a sub-model component of WASP5) models (version 5.10) were modified by adding three state variables to represent three size classes of seafood waste solids particles. The proportion of solids in each of the three size classes and their settling velocities can be specified in the model. Seafood waste solids are modeled on a dry weight basis with decomposition accounted for in the oxygen balance through a 50 percent carbon:dry weight ratio and a stoichiometric factor of 2.67 g O_2/g C. Additional secondary output variables were added to the EUTROS sub-model to track the dry weight deposition flux of each size class of seafood waste as it passed from the water column to the bottom sediments. Also, additional kinetic constants were added to the EUTROS sub-model to account for the carbon:dry weight ratio and the first-order decomposition rates in the water column and sediment layers.

The current model uses a simple scheme of a steady along-shore net-drift current speed. This is the longterm net transport rate away from the point of discharge. Longitudinal, lateral, and vertical dispersion coefficients are used to approximate the spreading of the waste due to tidal actions. As currently modified, the model does not account for resuspension and transport of deposited waste solids. The potential for resuspension and transport can be assessed using estimates of the resuspension current speeds necessary to transport deposited solid wastes, and site specific information regarding average maximum current speeds, peak current speeds, and their duration.

The modeling grid system consists of a variably-spaced Cartesian grid system with two water column layers and one benthic layer. In the vicinity of the discharge there are 25 small segments each having a dimension of 60x60 feet which provides a 2.0 acre coverage of fine resolution computational cells (see Figure 3.1). As one moves away from the discharge, the segment sizes become progressively larger. The entire grid system consists of 300 water column segments and 150 benthic segments.

Because WASP5 does not explicitly model the initial dynamics of the buoyant wastewater plume, the waste discharge point source is located between the upper and lower water layers that are simulated in the model.

The effect of density stratification on mixing and dilution of the wastewater plume is not considered in the model.

The current version of the model provides predictions of the areal extent and the depth of the seafood waste deposit depending primarily on the horizontal dispersion coefficients, mass emission rate of seafood waste solids (in dry weight), the settling velocities and proportions of solids in each of the three particle classes, the first-order decay rate of waste solids, and the netdrift current speed.

3.2.3 Selection of Modeling Case Scenarios

Twelve modeling case scenarios were developed for application of the WASP5 model to assess the potential for accumulation of seafood solid waste under a variety of conditions (Table 8). These scenarios included six simulations for discharges from shore-based facilities with discharges located 6.6 feet above the bottom in 50 feet of water. Combinations of low and medium netdrift current speeds [5 and 15 cm/sec (0.10 and 0.29 mi/hr)] and three bottom slopes (0.0, 12.5, and 25 percent) resulted in the six case scenarios modeled for shore-based discharges. These scenarios were selected to evaluate the effect of varying slope and current velocities on the model-predicted accumulation of seafood waste solids from shore-based facilities.

Table 8 Summary of WASP5 modeling case scenarios of shore-based and off-shore near-surface seafood solid waste discharges.

Case #	Net velocity (cm/sec)	Total depth (m)	Surface layer thickness (m)	Bottom layer thickness (m)	Bottom slope (%)
Shore-based discharges					
1	5	15.24	11.24	4.00	0.0 %
2	15	15.24	11.24	4.00	0.0 %
3	5	15.24	11.24	4.00	12.5 %
4	15	15.24	11.24	4.00	12.5 %
5	5	15.24	11.24	4.00	25.0 %
6	15	15.24	11.24	4.00	25.0 %
Near-surface discharges in open ocean					
7	5	15.24	2.00	13.24	0.0 %
8	15	15.24	2.00	13.24	0.0 %
9	5	30.48	2.00	28.48	0.0 %
10	15	30.48	2.00	28.48	0.0 %
11	5	45.72	2.00	43.72	0.0 %
12	15	45.72	2.00	43.72	0.0 %

Six case scenarios were also selected to evaluate the effect of varying current speed and water depth on the model-predicted accumulation of seafood waste solids due to surface discharges from stationary floating processors. These simulations included a discharge 6.6 feet below the water surface in water depths of 50, 100, and 150 feet and a low and medium

current speed. The bottom slope in all of these cases was 0.0 percent (i.e., a flat bottom).

For each modeling case scenario, the model was run for varying steady mass emission rates to determine the waste solids mass emission rate that would result in the bottom accumulation 0.4 inch deep or more over a 1.0 acre area at steady-state (i.e., decay losses balanced by waste inputs). Although the WASP5 model has the capability to model time-varying solids mass emission rates, a steady (e.g., annual average) mass emission rate was used to simplify the estimation of the steady-state accumulation of waste solids.

3.2.4 Selection of Model Input Variables

Based on the information provided in Section 2.0 on the characteristics and quantity of Alaskan seafood waste and additional information provided above in Section 3.1 the values for several model input variables were selected for use in the modeling case scenarios. These values were considered to be reasonable estimates for a typical seafood processing waste discharge and receiving water characteristics. Because of the limited information for a number of the model variables (e.g., the first-order organic matter decay rate constant), the selection of input values for these variables was necessarily based somewhat on professional judgment. Due to the relative uncertainty of the values selected, the results of the modeling case scenarios should be considered a first-approximation. However, the modeling case scenarios do provide an indication of the relative sensitivity of the model to the factors that are varied in each case. Sensitivity of the model to particular variables will suggest which variables should be the focus of future laboratory or field investigations.

Table 9 shows the variables that were selected for use in the modeling case scenarios. The rationale for the selection of the values for the proportion of solids in the three size classes and their settling velocities and the first-order waste solids decay rate constant is described below.

Table 9 Seafood waste accumulation model input variables.

Solids distribution	**Settling velocities (m/sec)**
60 percent	0.085
20 percent	0.045
20 percent	0.022
Waste solids decay rate constant	0.02/day
Lateral and longitudinal coefficients	$D_x = D_y = m^2/sec$

Solids Distribution and Settling Velocities. The settling velocities of the three particle classes were selected from Table 3.1 and were chosen to approximate the range of settling velocities observed by Stevens and Haaga (1994). For lack of better information the distribution of solids in each of the three particle classes was selected as follows. Sixty percent of the waste

solids was assumed to be composed of particles with settling velocities of 0.28 feet/sec. Conceptually these are the waste particles with a diameter of 0.5 inch. Twenty percent of the waste solids were assumed to be composed of particles with settling velocities of 0.15 feet/sec. Conceptually these are particles with a diameter of 0.25 inch. Twenty percent of the waste solids were assumed to be composed of particles with settling velocities of 0.072 feet/sec. Conceptually these particles with a diameter of 0.125 inch.

Waste Solids Decay Rate Constant. Because of the wide range of possible organic matter decay rates, and because of the uncertainty regarding the significance of scavenging of the waste by organisms, the model waste solids decay rate constant was estimated by holding all model variables constant (the low current speed case was used) and comparing the model results to an actual Alaskan seafood waste discharge with a known annual discharge rate and a reasonably well surveyed waste accumulation in the vicinity of the discharge. It was assumed (although no data were available to verify the assumption) that the actual waste accumulation was not affected by resuspension and transport of the waste that had been deposited. The areal extent of the waste accumulation predicted by the model was compared to the observed areal extent of the actual waste accumulation. The model decay rate constant was adjusted until a reasonable agreement was obtained between the bottom coverage predicted by the model and the observed waste coverage.

This comparison process resulted in the estimation of a first-order waste decay rate constant of 0.02 day^{-1} which is within the range of values presented in Table 7.

If field data had been available for the netdrift current speed, waste solids particle distribution, and particle settling velocities for the actual discharge studied, the decay rate could have been estimated more precisely. Nonetheless, the method used to estimate the decay rate likely provided a reasonable estimate of a decay rate constant that has been shown to vary over five orders of magnitude depending on the environment and type of organic matter (see Table 7).

3.3 Modeling Case Scenario Results

The WASP5 seafood waste accumulation model was run iteratively to predict the steady-state solid waste discharge rate that would produce a bottom accumulation of seafood waste with a depth of 0.4 inch or greater over an area of 1.0 acre (Table 10). These results provide a first-approximation of the annual seafood solid waste discharge rate that would result in a bottom accumulation of seafood waste equal or exceeding the proposed ZOD of 1.0 acre. This iterative process was conducted for each of the twelve case scenarios. The model predictions are based on the assumption that resuspension and transport is negligible. Resuspension and transport of deposited solids may occur at individual facilities if bottom current speeds exceed the critical current speed required to resuspend bottom waste accumulations (see Section 3.1.2). Therefore, the model predictions may be

considered conservative estimates of the potential for waste accumulation under the conditions described in the model for the twelve case scenarios. The results for the near-bottom shore-based and near-surface floating discharges are summarized and discussed below.

Two estimates of the areal extent of the waste pile have been provided in Table 10. The first areal coverage estimate is based on interpolation of the WASP5 model-estimated waste deposit depths in each modeling cell using the computer program SURFER™. This program creates contour plots of the depth of the waste pile based on the model-estimated waste deposit depths in each WASP5 modeling cell and calculates the area covered by waste deposits 0.4 inch deep or greater (Figure 3-3). The second estimate of the areal extent of the waste pile is based on summing the areas of the WASP5 modeling cells that contain accumulations of seafood waste solids 0.4 inch deep or greater. For example, if the waste accumulation was greater than 0.4 inch in all of the smallest WASP5 modeling cells near the discharge point [i.e., 9, each with an area of 0.08 acre] in the vicinity of the discharge, then the estimated areal coverage of seafood waste solids greater than 0.4 inch deep would be 0.72 acre. For the nearbottom shore-based and near-surface modeling case scenarios the two rates are similar, generally within 20 percent.

Table 10 Summary of WASP5 modeling case scenarios of shore-based and off-shore near-surface seafood solid waste discharges.

Case #[a]	Net velocity (cm/sec)	Total depth (m)	Bottom slope (%)	Waste solids discharge rate (lb/yr wet weight)	Maximum waste accumulation depth (cm)	Aeral Coverage (acres)	
						S[b]	W[c]
Near-bottom shore-based discharges							
1	5	15.24	0.0	16,000,000	230	1.0	0.8
2	15	15.24	0.0	12,000,000	133	1.2	1.0
3	5	15.24	12.5	20,000,000	230	1.0	0.8
4	15	15.24	12.5	16,000,000	179	1.3	1.1
5	5	15.24	25.0	20,000,000	288	1.0	0.8
6	15	15.24	25.0	16,000,000	179	1.3	1.1
Near-surface discharges in open ocean							
7	5	15.24	0.0	8,000,000	63.4	1.0	0.8
8	15	15.24	0.0	4,000,000	19.2	1.2	0.6
9	5	30.48	0.0	4,000,000	24.2	1.1	0.9
10	15	30.48	0.0	4,000,000	12.3	1.3	1.0
11	5	45.72	0.0	4,000,000	18.5	1.2	1.2
12	15	45.72	0.0	4,000,000	8.0	1.3	1.0

[a] Case numbers correspond to the case scenarios outlined in Table 3.4

[b] Aeral coverage of solid waste estimated by SURFER™

[b] Aeral coverage of solid waste estimated using WASP5 output

3.3.1 Near-Bottom Shore-Based Discharges

The first-approximation of the annual near-bottom shore-based seafood waste solids discharge that would result in a waste accumulation greater than 1.0 acre in waters with a net-drift current speed of 0.16 feet/sec, a depth of 50 feet, and a flat bottom is 16 million pounds (wet weight) of waste solids. The maximum accumulated solids depth of this pile is predicted to be 7.5 feet. The first-approximation of the amount of seafood waste solids discharge that would result in the accumulation of greater than 1 acre of seafood waste on the bottom in waters with a net-drift current speed of 0.49 feet/sec, a depth of 50 feet, and a flat bottom is 12 million pounds of waste solids. The maximum accumulated solids depth of this pile is predicted to be 4.4 feet. The first-approximation of the amount of seafood waste solids discharge that would result in the accumulation of greater than 1 acre of seafood waste on the bottom in waters with a netdrift current speed of 0.16 feet/sec, a depth of 50 feet, and a sloping bottom (12.5 percent and 25 percent) is 20 million pounds of waste solids (see Cases 3 and 5, Table 10). The maximum accumulated solids depth of these piles are predicted to be 7.5 and 9.4 feet, respectively. The first-approximation of the amount of seafood waste solids discharge that would result in the accumulation of greater than 1 acre of seafood waste on the bottom in waters with a netdrift current speed of 0.49 feet/sec, a depth of 50 feet, and a sloping bottom (12.5 percent and 25 percent) is between 12 and 16 million pounds of waste solids (see Cases 4 and 6, Table 10). The maximum accumulated solids depths of these piles are predicted to be 5.9 feet.

The model predicts that less waste discharge is required to create a 1 acre pile 0.4 inch deep or greater when the current speed is higher because the higher current speed serves to spread the waste over a larger area. The model predicts that the waste accumulation will be relatively deep [i.e., greater than 3.3 feet] because the simulated discharge is 6.6 feet above the sea floor and the waste particles settle rapidly to the bottom in the vicinity of the discharge. The model also predicts that on sloping bottoms, more seafood waste can be discharged than on a flat bottom before a pile greater that 1 acre is created. The model-predicted estimates of the near-bottom shore-based waste discharges that would result in a 1 acre waste pile were consistent with the limited data on actual waste pile accumulations in the vicinity of several shore-based seafood processing facilities. For example, the maximum areal extent of a waste pile deposit of 0.7 acres, was associated with a 1993 annual solids discharge rate of approximately 11.1 million pounds of seafood waste.

3.3.2 Near-Surface Floating Discharges in Open Ocean

The first-approximation of the annual near-surface open water seafood waste solids discharge that would result in a waste accumulation greater than 1 acre in waters with a net-drift current speed of 0.16 feet/sec a depth

of 50 feet, and a flat bottom is 8 million pounds (wet weight) of waste solids. The maximum accumulated solids depth of this pile is predicted to be 2.1 feet. The first-approximation of the amount of seafood waste solids discharge that would result in the accumulation of greater than 1 acre of seafood waste on the bottom in waters with a net-drift current speed of 0.49 feet/sec, a depth of 50 feet, and a flat bottom is 4 million pounds of waste solids. The maximum accumulated solids depth of this pile is predicted to be 2.1 feet. The first-approximation of the annual near-surface open water seafood waste solids discharge that would result in a waste accumulation greater than l.0 acre in waters with a net-drift current speed of 0.16 or 0.49 feet/sec, depths of 100 or 150 feet, and a flat bottom is approximately 4 million pounds (wet weight) or less of waste solids. The maximum accumulated solids depth of these piles are predicted to be 0.3-0.8 feet.

The model predicts that discharges to near-surface waters will result in areal coverage of 1.0 acre of the bottom with significantly less seafood waste discharged than the near-bottom discharge model cases. These results can be explained by the fact that seafood waste discharges to the near-surface waters are exposed to the currents during settling for a longer time than the near-bottom discharges, and consequently, are dispersed over a larger area. As can be seen from the predictions of the maximum waste accumulation depths, the volume of material that accounts for the 1 acre coverage is much less than for the near-bottom discharges (see Table 10).

3.3.3 Modeling Case Scenarios Summary

The modeling results suggest the complexity of the regulation of seafood waste discharges. Tradeoffs are evident between the desire to minimize the appearance of wastewater and waste solids at the water surface, the transport of the waste onshore, and the accumulation of waste solids on the bottom, while also trying to maximize the dispersion and dilution of the waste. For shore-based facilities, the seafood waste accumulation model predicts that relatively deep [greater than 3.3 feet] waste deposits will occur when the end of the discharge pipe is 6.6 feet above the bottom. Increasing the net-drift current speed to 0.49 feet/sec spreads the waste over a larger area, increasing the areal coverage of the waste pile. At these current speeds the areal extent of the bottom waste accumulation appears to be controlled primarily by the current speed and not by the amount of the waste discharged. At higher current speeds greater areal coverage of the waste is predicted. On the other hand, the WASP5 seafood waste accumulation model of near-surface discharges from floating facilities predicts relatively shallow deposits [approximately 0.3-0.8 feet deep] for the low and medium (0.16 and 0.49 feet/sec respectively) current speeds modeled. Under these conditions the areal extent of the waste pile greater than 0.4 in deep is controlled primarily by the discharge rate. Greater areal coverage of the waste from near-surface discharges is predicted for lower discharge rates than from near-bottom discharges (see Table 10).

The model predictions discussed above are considered conservative estimates of bottom waste accumulation because the WASP5 model does not consider the resuspension and transport of deposited wastes. Therefore, actual bottom accumulations at facilities where current speeds sufficient to resuspend and transport significant amounts of deposited wastes will tend to be much less than those predicted by the model. A first-approximation of the likelihood that resuspension and transport of deposited seafood wastes may occur can be made by estimating or measuring current speeds in the vicinity of individual facilities and comparing them to the estimated resuspension current speeds in Table 5.

3.4 Summary

A conceptual model of the fate, transport, and persistence of seafood processing waste was developed that also identified the potential adverse biological effects caused by this discharge. A number of biological, chemical, and physical factors control the fate of the discharged wastes. Biological factors include microbial decay and scavenging of the waste by organisms. Chemical factors include the chemical composition of the waste, particularly the content of protein and soluble organic compounds, fats and carbohydrates, and skeletal and connective tissue. Each of these components has a characteristic chemical composition and decay rate. Physical factors that control the fate, transport, and persistence of the waste include density stratification, storm-, tidal-, and wind-induced currents, and water temperature. Current speed direction and duration strongly influences the transport and dispersion of the waste and critical current speeds can resuspend and transport waste solids deposited on the bottom. Although simple stoichiometric models of organic matter decay have been used by some researchers to predict the release of soluble compounds to the overlying water due to the microbial decay of organic matter, there are a complex of coupled reactions that complicate the reliability of these simple model predictions. These models typically under-predict the amount of soluble phosphorus released, due to the additional release of mineral-bound phosphorus, and these models over-predict the release of ammonia nitrogen and hydrogen sulfide because of additional microbial processes and chemical reactions that reduce the concentrations of these compounds in the overlying water.

A mathematical model was developed to simulate the discharge and accumulation of solid wastes from discharges near the bottom from shore-based facilities, and discharges near the surface from floating processing facilities in open water. Two current speeds (0.16 and 0.49 feet/sec) were simulated. For the simulations of shore-based facilities the bottom slope was varied resulting in six case scenarios, and for the floating facilities the water depth was varied which also resulted in six case scenarios. The model was used to provide a first-approximation of the amount of waste solids discharge that would result in an approximately 1 acre bottom deposit of seafood waste. The modeling results indicated that a steady annual discharge from a shore-based facility of approximately 12-20 million pounds (wet weight) of solid waste would be required to produce a 1 acre deposit in the absence of significant resuspension and transport of the deposited waste.

For a near-surface discharge in 50 feet water depth a steady annual discharge of approximately 8 million pounds would be required to produce a 1 acre deposit. In water depths greater than 50 feet, seafood waste discharges of 4 million pounds or less are predicted to create waste deposits of 1 acre.

4.0 Composition of Biological Communities

Section 4.0 provides an overview of the biological communities found within Alaskan coastal waters covered under the permit. The overview will identify key species that are important from an ecological and economic standpoint, or for subsistence harvesting. Significant interspecies relationships, essential environmental requirements, seasonal distribution and abundance, and prominent areas or habitats where these species occur are also discussed. The biological communities to be discussed in this section include plankton, benthic invertebrates, fishes, marine birds and waterfowl, and marine mammals.

4.1 Plankton

Planktonic organisms have limited or no ability for self-propulsion and generally are entrained along with water movements; therefore, the distribution, abundance, and seasonal variation of these organisms is strongly influenced by the physical environment. Plankton contain a diverse assemblage of plants (phytoplankton) and animals (zooplankton) that range from a maximum size (equivalent spherical diameter) of a few millimeters to less than 2 microns. These organisms are a vital component of the pelagic plankton community forming the bottom of the food chain for fish, shellfish, birds and some marine mammals within Alaskan coastal waters. Larval stages of many benthic and fish species are temporary members of the zooplankton community during their early developmental stages.

4.1.1 Phytoplankton

The seasonal cycle of phytoplankton productivity and standing stock throughout the area of coverage of the permit is typical of northern temperate waters. Both phytoplankton productivity and standing stock increase from April to early July with peaks in May and early July, respectively. Diatoms are the most important group of phytoplankton found in high latitude seas and dominate the phytoplankton during spring and summer. Phytoplankton assemblages are dominated by pennate and centric diatoms, with dinoflagellates, microflagellates, and other classes and families of phytoplankton also present. Phytoplankton biomass is controlled by light, nutrients, and the density structure of the water column. A variety of herbivores are dependent upon phytoplankton, including zooplankton, benthic invertebrates, and waterfowl.

Macroalgae communities (macrophytes) including eelgrass and kelp are distributed throughout coastal areas and serve as an important component of near-shore habitat for a number of species including juveniles of commercially important and forage fish species. Eelgrass (*Zostera marina*) grows in low intertidal and shallow subtidal areas in sand and mud while *Laminaria saccharina* and *L. solidungula*, the primary kelp species, occur in deeper water (to 30 meters) on rocky substrates (Johnson et al. 2003).

4.1.2 Zooplankton

Zooplankton include organisms which are planktonic throughout their entire life (holoplankton) and species that are planktonic only during a

portion of their lifecycle (meroplankton). The meroplankton consist mainly of the larval stages of benthic invertebrates, which may outnumber the holoplankton for brief periods in shallow water. More detailed accounts of species found in Shelikof Strait, Cook Inlet, and the southeastern Bering Sea are provided by Seifert and Incze (1991), Damkaer (1977), and Cooney (1987), respectively.

Zooplankton communities are similar in their composition and relative dominance structure in the southeastern Bering Sea, North Pacific, and the northern Gulf of Alaska (Cooney 1978). Copepods are the dominant zooplankton group, both in terms of numbers and biomass (Kendall et al. 1980). Zooplankton abundance varies seasonally with maximums generally occurring in the summer. Coyle and Pinchuk (2003) found calanoid copepods the most abundant zooplankton over a three-year period in the northern Gulf of Alaska with production peaking at approximately 35 mg C/m^3/day in May of each year. A considerable portion of the seasonal biomass variation that occurs in oceanic regions likely reflects the life histories of three large calanoid copepods: *Neocalanus cristatus*, *Neocalanus plumchrus*, and *Eucalanus bungii.* These copepods migrate vertically in the water column and various developmental stages occur in the upper 500 feet for a minimum of 10 months of the year (Cooney 1987). Smaller copepods, such as *Calanus pacifica* and *Metridia pacficus*, are also abundant at various times of the year. Decapod larvae are present primarily in spring and summer and are more prevalent in bays and near-shore waters (Kendall et al. 1980). Fish eggs and larvae are found throughout the year, although abundance and spatial distribution is highly variable due to seasonal spawning. Euphausiids are most abundant in the summer and display vertical distribution near the surface prior to and during spawning. Seasonal changes in zooplankton distribution are affected by biological factors such as vertical migration and physical factors such as local currents, wind, bathymetry, and fresh water input.

Zooplankton serve as forage for fish (copepod nauplii are critical in the diet of most larval fish), shellfish, marine birds, and mammals. Euphausiids are essential organisms in the diets of yellow Irish lord and yellowfin sole, and mysids are the principal prey of walleye pollock and halibut (SAIC 1979). Copepods and euphausiids are important prey items for blue, bowhead, fin, humpback, minke, northern right, and sei whales.

4.2 Benthic Invertebrates

Benthic organisms are generally sensitive to deposition of solids such as seafood waste, and can be considered indicators of the intensity of pollution. Benthic invertebrates are important as prey for higher trophic levels and are important mediators for nutrient recycling. Several benthic species are harvested commercially: Tanner crab, Dungeness crab, weathervane scallop, and shrimp. Razor clams are harvested from near-shore areas and bays. Benthic species frequently harvested for subsistence purposes include clams (razor, butter, steamer), crabs (Tanner, Dungeness, red king), cockles, and shrimp.

In general, polychaetes, bivalves, and small crustaceans, primarily amphipods, are the most abundant organisms, with polychaetes often constituting the majority of the infauna. Benthic infauna are not uniformly distributed, but many infauna have broadly overlapping ranges. Approximately 165 epifaunal species and 264 infaunal species were collected by Feder (1981) in lower Cook Inlet. Arthropods, molluscs, and echinoderms were the most frequent epifaunal species accounting for 60, 59, and 23 of the total species respectively, as well as dominating the total biomass. Molluscs, arthropods, and echinoderms were the most frequent infaunal species accounting for 128, 54, and 26 of the total species, respectively (Feder 1981).

In southeastern Alaska, polychaetes (*Nephthys cornuta*, *Owenia fusiformis*, *Mesochaetopterus*, and *Euclymene* sp.) and molluscs were found to be dominant taxa in two studies of the region (Meyers 1977; Hughes 1983). Other taxa found in this area included holothuroids, brachiopods, echiuroids, sipunculids, nemerteans, and epibenthic crustaceans. An average of 1,136 individuals/m^2, with an average biomass of 4,092 g/m^2 were documented in this area.

Stoker (1981) studied the benthic communities in the Bering and Chukchi Seas and recognized eight major faunal assemblages. The faunal composition for the Chukchi Sea area was noted as being similar to that found in the eastern Bering Sea. Two major faunal assemblages were identified in the Chukchi Sea that also occurred in the Bering Sea. One group was characterized by the polychaete *Maldae sarsi*, the echinoderm *Ophiura sarsi*, the sipunculid *Golfingia margaritacea*, and the bivalve *Astarte borealis*; the second group was characterized by the bivalves *Macoma calcarea, Nucula tenuis,* and *Yolida hyperborea,* and the amphipod *Pontoporeia femorata.* The Chukchi Sea fauna was dominated by detritus feeders. In examining the species distributions, sediment type was the environmental variable most directly correlated with the observed distributions (Stoker 1981).

Many benthic species are important prey items for higher trophic level consumers such as amphipods, molluscs (particularly *Spisula polynyma* and *Nuculana fossa)*, Tanner crabs, ophiuroids, shrimp, barnacles, and hermit crabs (EPA 1983). As well as being prey for Pacific cod, sculpin, and halibut, the Tanner crab is also a major predator on infaunal and epifaunal benthos. Post-larval red king crabs consume detritus, bryozoans, foraminiferans, copepods, and ostracods, while adults feed on barnacles, molluscs, and hermit crabs. Pandalid shrimp feed primarily on benthic crustaceans, polychaetes, molluscs, diatoms, foraminiferans, and small fish.

4.3 Fish

Fish assemblages are dominated by demersal species, with walleye pollock, Pacific cod, and arrowtooth flounder being the most abundant species in Alaskan waters (NMFS 2005e). Anadromous fish including Chinook, coho, sockeye, chum, and pink salmon are important commercial fish in terms of harvest volume and value. Other fish of commercial value include: yellowfin sole, sablefish, halibut, and herring. Halibut, the five species of salmon, and other anadromous

fish such as steelhead trout and Dolly Varden char are popular sport fish. Species important as prey for higher trophic levels include sand lance and capelin, as well as previously mentioned species (U.S.DOI/MMS 1992). Detailed life history information and distribution of the species discussed below can be found in the "Atlas to the Catalog of Waters Important to Spawning, Rearing, and Migration of Anadromous Fish" and "Alaska Habitat Management Guides" published by the Alaska Department of Fish and Game.

The following discussion is divided into commercially harvested fish, such as Pacific salmon and halibut, and other species that are not commercially harvested. Many of the species, such as sand lance and capelin, that are not commercially harvested are important as prey for higher trophic levels.

4.3.1 Commercially Harvested Fish

Five anadromous species (pink, sockeye, chum, coho, and Chinook salmon), three groundfish species (Pacific cod, sablefish, walleye pollock), and one pelagic species (Pacific herring) constitute the bulk of the fish harvested commercially. A brief description of each of these species is provided below.

Pacific salmon is the major pelagic finfish group of the Alaska region; all five American species occur throughout this region. Only a few occasional salmon are found in the Chukchi Sea. The Bering Sea – Bristol Bay sockeye run is the largest run of this salmon species in the world, although there are more pink salmon in the Alaska region than the other salmon species. Pink salmon are also more widely distributed in the region than other species. All pacific salmon are anadromous, returning to freshwater from the ocean to spawn and then die. The progeny enter the Bering Sea and North Pacific Ocean to mature. Most salmon rear in the North Pacific Ocean while only a few rear in the eastern Bering Sea. Pacific salmon may migrate over long distances during the course of their maturation before returning to their natal spawning areas. Bering Sea salmon migrate from the rivers of southwest Alaska along the coastline and through Unimak and the eastern Aleutian Island passes. Alaska region salmon remain in the ocean for one to three years before returning to spawn. Bering Sea spawning salmon, other than the Bristol Bay and North Alaska Peninsula runs, migrate in broad bands across the eastern Bering Sea to the major (Yukon and Kuskokwim) and smaller rivers of southwest Alaska.

Pink salmon. Pink salmon spawn annually with substantially larger returns in even-numbered years. Spawning fish migrate to their natal streams in early summer and runs may continue into early August. Fry emerge from the stream gravel in spring and school in estuarine waters for approximately a month before beginning a gradual, irregular movement to the ocean where they usually remain for two years. In late summer and early fall, the large schools move off-shore to deeper waters while still remaining relatively close to shore until December when they move further

off-shore. Copepods, amphipods, tunicates, and euphausiids are the dominate prey of pink salmon.

Sockeye salmon. Sockeye salmon spend two to three years in the ocean before migrating to their natal streams to spawn from early June until late August. Young sockeye remain in coastal waters during their first year of life. Juveniles feed on copepods, fish eggs and larvae, and shrimp larvae. Adult sockeye salmon prey consists of copepods, amphipods, tunicates and euphausiids.

Chum salmon. Chum salmon remain in the ocean for two to four years before migrating to their natal streams. They spawn from late July to late October and are the second most abundant species along the shoreline in lower Cook Inlet from May to September **(**KPB 1990). The fry spend several months in estuarine waters before beginning their off-shore migration in early fall. Juveniles feed on zooplankton (primarily copepods) and aquatic insects while adults feed on zooplankton, small fish, and squid (U.S. DOI/MMS 1984).

Coho salmon. Coho salmon spend one to two years in the ocean before migrating to their natal streams from late July to December. Young coho enter the ocean after one to four winters in freshwater and remain near-shore and near the surface where they feed on small fish and zooplankton crustaceans before moving further off-shore (EPA 1983). Adult coho feed on squid, euphausiids, and small fish in the open ocean.

Chinook salmon. Chinook salmon spawn from mid-May to early August. Young Chinook enter the ocean after spending one to two years in freshwater and remain near-shore for a short period before moving further off-shore. Juvenile Chinook feed primarily on fish larvae and aquatic insects whereas adults feed on herring. sand lance, squid, and crustaceans.

Pacific cod. Pacific cod is a benthic species that ranges throughout the North Pacific Ocean and eastern Bering Sea. Spawning occurs during winter and the eggs are demersal. Larval cod range from pelagic to benthic waters and they grow rapidly, reaching about 3 feet in length within 2 to 3 years. Adult cod feed on a variety of worms, crabs, mollusks, shrimps, and herring.

Sablefish. The sablefish or black cod is found in large numbers in the Gulf of Alaska. Sablefish occur in deeper waters (1,200-3,000 feet) where they prey on a variety of crustaceans, worms, and small fishes. The species spawns in winter and the eggs are pelagic with the larval stage occurring near the surface. Juveniles are sometimes found in large schools in near-shore waters. Sablefish migrate extensively over long distances, but without apparent timing or routing.

Walleye pollock. Walleye pollock predominates in the groundfish complex of the eastern Bering Sea and largely in the commercial harvest in the Gulf of Alaska. This demersal species is found in large schools. Annual

spawning begins in early spring and may continue into early summer. The larvae form dense aggregations that appear to be strongly dependent on ocean dynamics (e.g., the Alaska Coastal Current) for transport (Schumacher and Kendall 1989). Pollock migrate seasonally, moving from deeper waters in the winter to more shallow water in the summer. The fish also undergo diurnal, vertical migrations from deeper to shallow waters in the evenings (U.S. DOI/MMS 1984). Pollock feed on numerous species including mysids, euphausiids, and small fish. In addition to being of great commercial value, pollock serves as food for other marine fishes, birds, and mammals.

Pacific herring. Herring sac-roe is of high commercial value while adult herring are currently used mainly for bait in other fisheries. The Pacific herring populations in Alaska are generally on a downward trend. Bering Sea migrations are along the North Alaska Peninsula and out to the Aleutian Islands, then north toward the Pribilof Islands where herring overwinter in deeper waters. Pacific herring undergo annual spring migrations from pelagic waters to the coastal areas of southwest Alaska, lower Cook Inlet, Prince William Sound, and the islands and coast of southeast Alaska to spawn. The eggs are deposited on kelp, other seaweeds, rock substrate, and detritus in the shallower coastal zone. After spawning and hatching, both adult and larval herring remain in near-shore water until fall when the schools move to deeper and warmer waters to overwinter. Adults and larvae feed primarily on zooplankton (U.S. DOI/MMS 1992). Larvae and juveniles feed and grow in estuaries and embayments, thus making them vulnerable to changes in inshore habitats. Herring are important food fishes for other pelagic fishes, and marine birds and mammals. They are also important target species in the diets of communities participating in subsistence fishing.

4.3.2 Non-Commercially Harvested Species

Pacific sand lance and capelin are important as prey species for higher trophic levels. Dolly Varden char is an important sportfish species recreationally harvested in Cook Inlet. A brief description of each of these species is provided below.

Pacific sand lance. Pacific sand lance are abundant in near-shore areas and bays and generally inhabit water less than 330 feet deep. Sand lance lack a swim bladder and must actively swim, rest on the seafloor, or bury themselves in sand or fine gravel. They may form large pelagic schools during the day and return to the bottom at night. Sand lance spawn during winter in areas of strong currents. The larvae are planktonic and feed on diatoms, copepods, shrimp, and barnacle nauplii (Blackburn 1979). Pacific sand lance are prey items for salmon, Pacific cod, halibut, other demersal fishes, marine birds and mammals.

Capelin. Capelin is a pelagic species that forms large schools near the bottom. The species is distributed throughout the Bering and Chukchi seas

and south through the Aleutians. Spawning usually occurs from the end of May to about mid-July. Eggs are deposited on sandy beaches at night or on cloudy days following a high tide and are buried in the sand by wave action. Capelin consume copepods, amphipods, euphausiids, and shrimp and are important prey items for other fishes, marine birds and mammals (EPA 1983).

Dolly Varden char. Dolly Varden char occur throughout Alaska from southeast to the streams and rivers feeding the Beaufort Sea. They spawn mostly in the fall, with eggs incubating over winter. Many anadromous Dolly Varden char are capable of repeated spawning, although they suffer a high postspawning mortality and generally do not spawn in consecutive years.

4.4 Marine Birds and Waterfowl

Marine birds and waterfowl are significant components of the marine ecosystems in Alaskan waters and with some species being highly vulnerable to human impacts. NMFS (2005e) reports that 38 species of marine birds breed in Alaska in more that 1,600 colonies. Estimates of breeding populations reach 36 million individuals in the eastern Bering Sea and 12 million individuals in the Gulf of Alaska (NNMFS 2005e). Most of the discussions below reflect data that was collected between the 1970s and early 1990 although population updates based on current (2006) information are provided as available.

The short-tailed albatross may occasionally be found within Alaska and is listed as endangered under the ESA. The spectacled eider and Steller's eider are listed as threatened species. These species are discussed in greater detail in Section 6.0.

4.4.1 Important Species and Trophic Relationships

The following discussion addresses marine birds, which spend at least a portion of their lives in the open ocean, shorebirds, and waterfowl. The latter two are not typically found far from land. Discharges from offshore seafood processors would tend to have a greater affect on marine birds preferring open waters while nearshore and onshore discharges would be more likely to affect shorebirds and waterfowl. Accurate estimates of bird populations are difficult to obtain as a result of the large areas involved, migratory and life-history patterns, and funding limitations experienced by the agencies responsible for management. The discussion below is based on data presented in the 1994 ODCE with revisions to population numbers as they have been identified.

4.4.2 Marine Birds

The most prominent and numerous avian group found in the Alaska Region are the pelagic seabirds. This group consists of birds such as shearwater, petrels, murrelets, auklets, and gulls. These seabirds exhibit a wide array of body forms, life history patterns, and strategies for obtaining food, reproducing, and avoiding predation. These birds developed in an environment relatively free from predation but with a less predictable food

source. These factors have led to the development of long life spans, late attainment of sexual maturity, and small clutch sizes (U.S. DOI/MMS 1992).

Pelagic distribution of seabirds in the Bering Sea, as elsewhere in Alaskan marine waters, exhibits a patchy pattern of high and low densities (Piatt et al., 1988). Typically, greatest densities (e.g., 100-1,500 birds/mi^2) occur in spring, summer, and fall over the outer continental shelf (OCS) and shelfbreak (330- to 660-foot depth). Densities over the inner shelf, though generally lower, may reach high levels where shearwaters concentrate in huge flocks (ten of thousands to well over a million individuals) (U.S. DOI/MMS 1992). During the winter and early spring, most seabirds are widely dispersed over the southern Bering Sea, Aleutian Islands, and North Pacific Ocean south of the consolidated pack ice. Overwintering seabirds and spring migrants also tend to gather along the ice edge where prey may be concentrated. Bird densities of 1,300 to 2,600/mi^2 commonly occur in the ice front and up to 26,000/mi^2 have been observed (Divoky 1983).

Black-legged kittiwakes are abundant in most Bering Sea colonies, with Alaska populations estimated at 1.3 million individuals (USFWS 2006). Thick billed and common murres often occur together in the Bering Sea and Aleutian Islands with populations of each species in excess of 2.0 million. Annual declines of common murres of approximately 3.6 percent on Saint Paul Island, 9.0 percent on Chisik/Duck Island (Cook Inlet) and 4.5 percent in Bristol Bay have been observed, while populations have been shown to be increasing on Gull Island in Kachemak Bay (USFWS 2006). In addition, fulmars are abundant on the Pribilofs and on St. Matthews Island with Alaskan populations estimated at 1.4 million (USFWS 2006). Red-legged kittiwakes nest on the Pribilofs although declines averaging 2.6 percent per year have been observed on Saint Paul Island (USFWS 2006). Large numbers of auklets inhabit St. Matthews Island, St. Lawrence Island, Little Diomede Island, King Island, and Fairway Rock with a positive population trend observed for crested auklets on Kasatochi Islands in the Aleutians (U.S. DOI/MMS 1992; USFWS 2006). Burrow-nesting species such as storm-petrels and tufted puffins are abundant in the Aleutian Islands. At least 9 to 10 million nonbreeding shearwaters occupy the Bering Sea and Gulf of Alaska annually in the summer and fall.

Fifteen species of marine birds constitute 90 percent of the total seabird population in the Gulf of Alaska. Six of these species have populations over one million (fork-tailed storm petrel, tufted puffin, Leach's storm petrel, common murre, black-legged kittiwake, and homed puffin) (Baird and Gould 1983). Other common seabirds include shearwaters, fulmars, cormorants, gulls, tern, guillemots, murrelets, and auklets. Many birds such as shearwaters rarely come to land except to breed while others such as arctic tern and mew gulls may breed hundreds of miles inland. Most seabirds return to breeding colonies in April and lay eggs in May, June, and

July. While seabirds are rearing young, foraging is limited to near-shore waters. Most seabirds leave their breeding colonies by October.

Seabirds feed primarily on marine invertebrates and fishes, although their diet varies according to body and bill size, age, season, prey size and availability. The major food source during spring and summer months include capelin, sand lance, euphausiids, squid, and pollock. Various benthic invertebrates and demersal fish are the main winter food sources (U.S. DOI/MMS 1984). Studies that have measured the food fed to seabird chicks have indicated that capelin and sand lance comprise 48 to 84 percent of their diets (Baird and Gould 1983). Most foraging of breeding birds occurs within 30 miles of their colony and usually within 3 miles of land.

More than 60 seabird colonies are located in the lower Cook Inlet region and approximately 120 bird colonies have been identified in the Shelikof Strait region (U.S. DOI/MMS 1984). Many seabirds winter in off-shore waters while others remain in Alaskan near-shore waters, particularly Kachemak Bay. In Cook Inlet, Shelikof Strait, and the Barren Islands, there are over one million nesting seabirds with the largest aggregation found in the Barren Islands (U.S. DOI/MMS 1984). Afognak Strait and Kodiak Island also provide important winter congregation areas for murres and auklets in particular, as well as other species.

4.4.3 Shorebirds

Shorebird refers to those birds generally restricted to coastline margins (beaches, mudflats, salt marshes, bays, and estuaries). Shorebirds encompass members of the plover, sandpiper, and avocet families. An important characteristic of almost all shorebird species is their migratory behavior, which is strongly developed. The vast majority of shorebirds that occur along the Pacific coast of North America breed in Alaska where important nesting concentrations are found on moist tundra and marshlands of the Arctic north slope and the west coast (e.g., Yukon-Kuskokwim River Delta). From May through September each year, millions of shorebirds may be found in these areas. Species occurring along the shores of the Bering Sea include Pacific golden-plover, bristle-thighed curlew, black turnstone, and western sandpiper. Shorebirds common in the Bering Sea islands and Aleutian Islands include black oystercatcher, dunlin, ruddy turnstone, and rock sandpiper (Alaska Shorebird Working Group 2000).

Limited numbers of mudflats occur within the migratory flyway between the Washington coast and the Alaska Peninsula. Critical habitats for migrating shorebirds include the Copper/Bering River deltas (near Valdez, Alaska), Fox River Flats, Mud Bay, and Kamishak Bay. As noted above, the Yukon-Kuskokwim River Delta is an important nesting concentration area. A breeding colony of the rare Aleutian terns and more common Arctic terns nest along the mud flats in the Homer area.

4.4.4 Waterfowl

Waterfowl in Alaska include ducks and geese. During the fall migration, the numbers of ducks in saltwater marshes and tideflats increase dramatically as local populations are supplemented by ducks from the north and west. Eighteen species of diving ducks breed in Alaska.

Areas of major importance to waterfowl populations occupying the Bering Sea include the Yukon-Kuskokwim River Delta and lagoons along the north side of the Alaska Peninsula, particularly Izembek and Nelson. The eastern Aleutian Islands area, polynyas near major islands (e.g., St. Lawrence, St. Matthew, and Nunivak), and the ice front also provide important overwintering habitat for some waterfowl species.

Waterfowl breeding on the Yukon-Kuskokwim Delta include tundra swan, white-fronted goose, Taverner's Canada goose, cackling Canada goose, emperor goose, and Pacific black brant, and at least 13 species of ducks and loons. Ten to 50 percent of the population of these species nests in this region. Several of the goose and duck species nest in high densities throughout the coastal Bristol Bay area, on Nunivak Island, and along the north side of the Alaska Peninsula.

Dabbling ducks (mainly American widgeon, mallard, northern pintail, and green-winged teal) comprise approximately 60 percent of the breeding waterfowl in Trading Bay, Redoubt Bay, and the Fox River Flats (KPB 1990). The initial nesting period for dabbling ducks usually begins in mid-April and extends through June. The molt and brood-rearing period occurring from late June to early August is a stressful period and demands considerable energy. Consequently, waterfowl are sensitive and vulnerable during this time. In Cook Inlet, dabbling ducks have two population peaks in the fall. The first is in mid-to-late August and the second is late September to early October. By November, most dabbling ducks have departed for wintering grounds. Dabbling ducks feed primarily on invertebrates and plant matter.

Most diving ducks arrive on their breeding grounds by late May, with the nesting period generally extending through June. Brood rearing and molting occurs throughout July and August. The majority of the diving ducks that breed in Alaska are residents of Alaskan coastal areas in winter. Preferred marine habitats of diving ducks include protected estuaries, and other marine waters within the 60-foot depth contour.

The largest concentrations of geese are found in their preferred habitats; estuaries, lagoons, river deltas, marshes, and tidelands. High concentrations occur on the tidal salt marshes and the extensive mud flats of Cook Inlet during the spring and fall migrations. The only known nesting area of the tule white-fronted goose is on the west shore of Cook Inlet, primarily in Trading and Redoubt Bays. Snow geese congregate on the Kenai flats from mid-April to mid-May to feed and rest en route to their breeding grounds in Siberia. In 1988, 25,000 snow geese were observed using the Kenai flats (KPB 1990). Along the Alaska Peninsula, king and Steller's eiders molt in

Nelson Lagoon in August and September with the majority of the females molting in Izembek Lagoon (U.S. DOI/MMS 1992).

Canada geese nest on lakes and ponds, and marshes. Nests are usually initiated in early May, dependent upon weather conditions. Molting flocks typically use large lakes and protected coastal waters away from nesting areas. On coastal marshes and tideflats, geese feed on molluscs, crustaceans, and other invertebrates as well as plants.

Areas of major importance to waterfowl include the Yukon-Kuskokwim Delta, Nunivak Island, bays and inlets along the Alaska Peninsula, Aleutian Islands, Kodiak Island, and the eastern side of the Alaska Peninsula. In the Gulf of Alaska, important areas include the Copper River Delta, Prince William Sound, and several bays in upper and lower Cook Inlet.

4.5 Marine Mammals

Several species of marine mammals occur in Alaskan coastal waters. These species include cetaceans, pinnipeds, and sea otters. All marine mammals are protected under the Marine Mammal Protection Act (MMPA) of 1972. The MMPA also incorporates regulations and restrictions regarding the harvests of marine mammals. Additional protection is provided under the ESA for blue, bowhead, fin, gray, humpback, right, sei, and sperm whales, and the Steller sea lion (northern sea lion). Additional regulations associated with the northern fur seal are provided by a 1957 treaty, the Interim Convention on Conservation of northern fur seals. The endangered or threatened species occurring in Alaskan waters are discussed in Section 6.0.

Marine mammals in the Gulf of Alaska are important constituents of the Alaskan food web, annually consuming 7.55 million metric tons of euphausiids, copepods, fish, cephalopods, and crustaceans (Calkins 1987). The most frequent prey for marine mammals in this region are: copepods, euphausiids, herring, cod, walleye pollock, capelin, salmon, cephalopods, and crustaceans. Fin and sei whales have the highest annual consumption rates followed by the Dall's porpoise and Steller sea lion.

Most of the marine mammals occurring in Alaskan waters can be grouped into two categories: 1) pinnipeds (seals, sea lions, and walrus) that are ice associated during the winter and also reproduce during that time, and 2) whales that use Alaskan waters as summer feeding grounds. The only other marine mammal, the northern sea otter, does not fit with either of these groups.

4.5.1 Pinnipeds

Pinnipeds in Alaskan waters include the northern fur seal, ice seals (spotted, ribbon, bearded, and ringed), harbor seal, and Pacific walrus.

Northern fur seal. The northern fur seal has a range extending from the Bering Sea south to San Diego, California. These seals are migratory and widely dispersed in pelagic waters throughout this range during the non-breeding season (November to May). During the summer breeding season, much of the population is found on the Pribilof Islands. While most fur

seals migrate southward from Alaskan waters, a portion of the population, principally young non-breeding males, remain in the Gulf of Alaska year-round. The most recent population estimates for the Eastern Pacific stock of northern fur seals is 709,881. This number has dropped significantly since the late 1950s, resulting in the population being designated as depleted under the MMPA in 1988 (NMFS 2007).

Ice Seals. Four seal species in Alaska (spotted, ringed, bearded, ribbon) are ice-associated for much or all of the year. Their association with near-shore pack ice, off-shore pack ice and shorefast ice varies with species and season with the general range of all four species extending from the Beaufort Sea to the southeastern Bering Sea. Spotted and ribbon seals are concentrated in the Bering Sea, while the majority of bearded and ringed seals occupy areas farther north. Population estimates for these seals are generally dated and based on limited surveys; the most current population estimates for ice seals in the Bering-Chukchi-Beaufort area are 225,000 spotted, 95,000 ribbon, 275,000 bearded, and 250,000 ringed (NMFS 2007). Winter/spring spotted seal densities are greatest east of the Pribilof Islands, while ribbon seals are most numerous west of the Pribilof and St. Matthew Islands. Ringed seals are abundant in shorefast ice areas of the Chukchi and northern Bering Seas. All four species breed and give birth in the spring and are associated with the ice pack in some way.

Harbor seal. Harbor seals tend to frequent near-shore waters and haul out on off-shore rocks, sandbars, and beaches of remote islands. These seals often move considerable distances between various haul out sites, although they tend to have a limited number of preferred sites which they return to repeatedly. The breeding and pupping season occurs from late May through July (KPB 1990). The diet of harbor seals is highly varied with prey primarily consisting of herring, eulachon, walleye pollock, octopus, salmon, shrimp, and flounder.

The harbor seal has an extensive range extending from the Bering Sea southward to Baja California. The Bering Sea and Gulf of Alaska stocks have been in decline since the early 1980s with the status of the southeast stock undetermined. The current population estimate is 180,000 state wide. Although the population has been in decline with no clear reason, none of the stocks has been identified as depleted under the MMPA or considered for listing under the ESA (NMFS 2007).

Pacific walrus. In Alaska, the Pacific walrus ranges from the Beaufort Sea to the southeastern Bering Sea migrating north and south with the seasonal pack ice (U.S. DOI/MMS 1992). During the winter months (January-March), most walruses occur in the drifting pack ice west and southwest of St. Lawrence Island and in the Bristol Bay area. Beginning in April, nearly all the pregnant females and those with young move north with the receding pack ice. By late June, the migrants have passed through the Bering Strait to occupy the area north in the northeastern Bering Sea and western Beaufort Sea. Adult and subadult males that remain in the Bering

Sea in summer most consistently haul out at several sites in the northern Bristol Bay (Walrus Islands State Game Sanctuary) and St. Matthew Island (Alaska Maritime National Wildlife Refuge) areas. Current population estimates are not available and variability in survey methods make previous estimates unreliable (USFWS 2002a).

4.5.2 Cetaceans

Several non-endangered cetaceans occur within Alaskan waters. They include beluga, minke, and killer whales, and Dall's and harbor porpoises. It should be noted that in 2000, NMFS designated the Cook Inlet stock of beluga whales as depleted under the MMPA and on October 22, 2008 a final determination to list the Cook Inlet beluga whale as endangered was made.

Dall's porpoise. The Dall's porpoise is present year-round throughout the Gulf of Alaska, with the largest numbers occurring over the continental shelf in spring and summer from Kodiak Island east to Icy Strait. Surveys conducted in 1999 and 2000 consistently showed Dall's porpoise in deeper water than harbor porpoise. Alaska populations were estimated to contain approximately 417,000 individuals based on observations collected in 1993; the estimate was revised downward to an estimated 83,400 based on inflated counts resulting from vessel attraction behavior (NMFS 2007). This species usually travels in groups of 2 to 20 animals, although concentrations of over 1,000 porpoises may occur infrequently. The majority of breeding and calving takes place from June to August. Dall's porpoises feed on walleye pollock, sablefish, capelin, Pacific herring, sand lance, eulachon, and squid (Crawford 1981).

Harbor porpoise. The harbor porpoise ranges from Point Barrow south to Point Conception, California. In Alaska they occur in coastal waters less than 100 feet deep from the Gulf of Alaska through southeast Alaska, including Glacier Bay, Yakutat Bay, the Copper River Delta and Sitkalidak Strait. Population surveys were conducted in Bristol Bay in summer 1999 resulting in population estimates of over 66,000 individuals; population estimates for other parts of Alaska were not provided (NMFS, 2007). Although they are assumed to be year-round residents where they occur, sightings are much less frequent in fall and winter. They are generally observed in harbors, bays, and river mouths. Breeding occurs from June or July to October with peak calving in May and June (MMS 1984).

Killer whale. Killer whales prefer shallow areas of the continental shelf and are considered surface feeders preying mostly upon large fishes when available and marine mammals. Killer whales form groups called pods with resident and transient pods occurring in Alaskan waters. Transient pods are known to have ranges from the Puget Sound north through Prince William Sound and Kodiak Island while other residents are more localized (e.g. Gulf of Alaska). Killer whales have been observed in the Bering and Beaufort seas. The population estimate for killer whales in Alaskan waters

on a permanent or temporary basis is approximately 320 individuals based on surveys conducted between 1994 and 2004 (NMFS 2007).

Beluga whale. Two separate stocks of beluga whales occur in Alaska: the western Arctic stock and the Cook Inlet stock. The Cook Inlet stock experienced a rapid decline in numbers in the mid-to-late 1990s and was designated as depleted under the MMPA. On October 22, 2008 the Cook Inlet stock was listed as endangered under the ESA (73 FR 62919). The Cook Inlet stock is discussed in greater detail below in Section 6.2.

The western Arctic stock numbers about 47,000 individuals distributed from Bristol Bay to the eastern Beaufort Sea. Major concentrations of belugas occur in Bristol Bay, Yukon River-Norton Sound, Kotzebue Sound, and Kasegaluk Lagoon in the Bering, Chukchi, and Beaufort Seas. Northern waters are used during migration and throughout the summer while winter pushes the northern stock of belugas to the southern portions of their range and areas with open leads and polynas (NMFS 2007). Belugas feed on salmon, smelt, flounder, sole, sculpin, cephalopods, and shrimp. Calving takes place during the summer from July to August (Calkins 1989; MMS 1992).

Minke whale. The minke whale is the smallest of the baleen whales. It is a coastal species, usually occurring within the 660-foot depth contour. In spring, most minke whales are located over the continental shelf, especially in shallow near-shore waters. Their highest concentrations in summer are around Kodiak Island, and in the northeast Gulf of Alaska, although they are also common in the Bering and Chukchi seas (NMFS 2007). Most whales are thought to leave the region by October as they are seldom observed in the fall or winter. It is likely that they migrate northward in early spring and southward in the fall. Breeding occurs throughout the year with peaks in January and June. Their prey consists mainly of euphausiids and copepods (MMS 1992).

4.5.3 Northern Sea Otters

Three distinct populations have been identified within Alaska. The USFWS issued a final rule listing the southwest Alaska population segment of the northern sea otter as threatened under the ESA on August 9, 2005 (USFWS 2005). The listed population is located between the Aleutian Islands and Cook Inlet, including the Alaska Peninsula and the Kodiak archipelago and is discussed in more detail in the Threatened and Endangered Species section below (Section 6.2.3).

Sea otters (*Enhydra lutris*) occur from northern Japan to southern California. The northern sea otter that occurs in Alaska, *E. lutri kenyoni* is one of three recognized subspecies of *E. lutris*. Their range extends from the Aleutian Islands in southwestern Alaska to the coast of the state of Washington (USFWS 2005). Once exploited to near extinction, northern sea otters in Alaska have reoccupied most of their known range since coming under protection under the International Fur Seal Treaty in 1911.

They are at or near their carrying capacity throughout the Aleutian Islands and east to Prince William Sound. Few sea otters survive in the Pribilof Islands (USFWS 2005). Recent estimates place the Alaskan population between 56,000 and 70,000 individuals. Approximately 6,000 sea otters are located in the Kodiak Island area and an estimated 2,100 are found in the Kenai Peninsula and Cook Inlet area. Otters tend to be non-migratory, moving relatively short distances between breeding and foraging areas. Sea otters are extremely susceptible to marine pollution as their fur must remain clean to maintain its insulative qualities, and they seldom leave the water.

Sea otters generally occur in shallow water areas near the shoreline where they consume large quantities of benthic invertebrates, including sea urchins, mussels, clams, chitons, and crabs. Visual observation of 1,251 dives by sea otters in southeast Alaska indicate that foraging activities typically occur in water depths ranging from 6 to 100 feet, although foraging at depths up to 328 feet was observed (Bodkin et al 2004). In Nanwalek and Port Graham, the sea otter population has expanded to the extent that otters have severely depleted some of the benthic invertebrate resources used by these two subsistence communities (KPB 1990). Sea otter interactions with fisheries are limited to theft of bait from crab pots set in near-shore waters where commercial Tanner crab activities and sea otters overlap. Occasional drownings occur as a result (MMC 1989).

4.6 Important Habitat or Areas

The following discussion identifies key habitats or concentrations for marine mammals. The section is divided into pinnipeds (seals and sea lions), cetaceans (whales), and sea otters.

4.6.1 Pinnipeds

Pinnipeds are found throughout Alaskan waters with the distribution of several species overlapping. Fur seals occur from the Bering Sea to southern California but concentrate in the Pribilof Islands and on Bogoslof Island in the summer (NMFS 2007). Harbor seals usually inhabit marine, estuarine, and freshwater environments from the coast to a few miles off-shore. They prefer gently sloping or tidally exposed habitats including reefs, off-shore rocks and islets, mud and sand bars, and sand and gravel beaches and are typically found in water depths less than 180 feet (EPA 1984a). Populations of harbor seals occur in the Bering Sea, Gulf of Alaska, and southeast Alaska. Ice seals are concentrated from the Bering Sea north associated with sea and pack ice. These species (bearded, spotted and ring seals) spend most of their time on ice rather than land although concentrations of bearded seals have been observed south of Kivalina (NMFS 2007). Walrus concentrate in Bering and Chukchi seas in continental shelf waters. A group of mostly males also use coastal haulouts in Bristol Bay in the summer (USFWS 2002a).

4.6.2 Cetaceans

Cook Inlet supports killer whales, Dall's porpoises, and harbor porpoises with beluga whales concentrated in the northern portions of the Inlet for most of the spring and summer. Recent surveys show concentrations of Dall's porpoises around the shelf break in the central-eastern Bering Sea (NMFS 2007). Minke whales are relatively common in the inshore waters of the Gulf of Alaska and in the Bering Sea, on the north side of the Alaska Peninsula and around the 330 foot (100 meter) contour near the Pribilof Islands (NMFS 2007). Unimak Pass is a known route for gray whales migrating to and from the Bering Sea in spring and fall (ADF&G 1994a). Humpback whales are known to concentrate in certain areas including southeast Alaska, Prince William Sound, Kodiak and the Barren Islands, between Semidi and Shumagin islands, around the eastern Aleutian Islands and in the southern Bering Sea (ADF&G 1994b). This area is also a possible migratory route for fin and humpback whales.

4.6.3 Northern Sea Otters

Sea otters are found in bays, lagoons, and estuaries and most commonly inhabit waters of less than 300 feet deep along the coast. The highest densities are found within the 130-foot isobath where young animals and females with pups forage. When otters haul out, they rest on land and in kelp beds (Calkins and Schneider 1985). Sea otter populations occur in the Barren Islands, northern and southern Kodiak Island, southwestern Kenai Peninsula, Kamishak Bay, along the shoreline of lower Cook Inlet, and the Trinity Islands (MMS 1984).

4.7 Summary

Phytoplankton communities form the basis of the marine food chain and are dominated by diatoms, with dinoflagellates, microflagellates, and other classes and families of phytoplankton also being present. Phytoplankton occurs throughout Alaskan seas particularly the Bering Sea and southern portions of Cook Inlet. Several herbivores, including zooplankton, benthic invertebrates, and waterfowl, are dependent upon phytoplankton.

Zooplankton including copepods, euphausiids and mysids occur throughout marine waters and provide an important part of the food chain. Zooplankton communities are similar in composition and relative dominance structure in the southeastern Bering Sea, North Pacific, and the northern Gulf of Alaska. Zooplankton are prey for fish, shellfish, marine birds and mammals. Copepods are the dominant zooplankton species providing forage to a number of species including the larvae of walleye pollock. Euphausiids are essential prey in the diets of yellowfin sole and minke whales, and mysids are the principal prey of adult walleye pollock and halibut.

Several benthic species are harvested commercially: Tanner crab, Dungeness crab, weathervane scallop, and shrimp. Species frequently harvested for subsistence purposes include clams, crabs, cockles, and shrimp. Kamishak Bay, Kachemak Bay, and areas of Shelikof Strait are important habitats for Tanner, Dungeness, and king crabs. Five species of shrimp are commercially harvested

from Kachemak Bay, although populations of shrimp and king crab have been declining in recent years. Amphipods, molluscs, crabs, ophiuroids, shrimp, and other benthic species are important prey items for higher trophic levels as well as mediators for nutrient recycling.

The fish assemblages are dominated by demersal species, with walleye pollock, yellowfin sole, and halibut being the most abundant species. Commercially harvested fish include Chinook salmon, coho salmon, chum salmon, sockeye salmon, pink salmon, walleye pollock, Pacific cod, halibut, and Pacific herring. Salmon, steelhead trout, and Dolly Varden char are important sport fish. Species important as prey for higher trophic levels include sand lance and capelin, as well as previously mentioned species.

Pelagic seabirds are the most prominent and numerous avian group found in the Alaska region. The most abundant species are fork-tailed storm petrel, tufted puffin, Leach's storm petrel, common murre, blacklegged kittiwake, and horned puffin. Other common seabirds in the eastern Bering Sea and Gulf of Alaska areas include shearwaters, fulmars, cormorants, gulls, tern, guillemots, murrelets, and auklets (NMFS 2005e).

Waterfowl in the area include ducks and geese. Eighteen species of diving ducks breed in Alaska. Many diving ducks overwinter in Kachemak Bay. Other areas of importance to waterfowl include the Yukon-Kuskokwim Delta, Izembek, and Nelson lagoons in the Bering Sea; eastern Aleutian Islands; lower and upper Cook Inlet; Kodiak Island; the eastern side of the Alaska Peninsula; and the Copper River Delta and Prince William Sound in the Gulf of Alaska. Waterfowl feed primarily on crustaceans, molluscs, aquatic insects, and fish.

Several non-listed species of marine mammals occur in Alaskan coastal waters including cetaceans (beluga, minke, killer whales, Dall and harbor porpoises), pinnipeds (northern fur seals, ice seals, harbor seals, walrus), and northern sea otters. Many are found year round in the coastal areas, or use these areas as potential migratory routes. Frequent prey for marine mammals in the Gulf of Alaska include copepods, euphausiids, herring, cod, walleye pollock, capelin, salmon, cephalopods, and crustaceans. Important habitats or areas include the Pribilof Islands for northern fur seals and the Walrus Islands for Pacific walrus.

5.0 Potential Impacts of Discharges on Marine Organisms

This section of the ODCE addresses three of the ten criteria listed in Section 1.0 that must be considered in determining whether there is potential for "unreasonable degradation" of the marine environment related to a point-source discharge. As discussed earlier and for the purposes of this section, "unreasonable degradation" is defined as:

1. "Significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities;
2. "Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms."

The three criteria to be considered in this section are:

Criterion # 1: "The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged"

Criterion # 2: "The potential transport of such pollutants by biological, physical, or chemical processes"

Criterion # 6: "The potential impacts on human health through direct or indirect pathways"

The potential adverse effects of seafood processing waste include direct and indirect impacts of the solid and liquid waste discharges to marine organisms. Solid wastes consist of unused portions of the fish and shellfish that have been processed and may include heads, skin, scales, viscera, fins, and shells discarded during cleaning and butchering. Liquid wastes include soluble organic matter and nutrients leached from fish and shellfish during processing. The liquid wastes may also include waste from process disinfectants, sanitary wastes, and other wastewaters (i.e., cooling water, boiler water, gray water, freshwater pressure relief water, refrigeration condensate, water used to transfer seafood to the facility, and live tank water). Both solid and liquid wastes are authorized discharges under the permit.

Potential direct impacts of solid waste discharges include alterations in the benthic community due to burial, alteration of the sediment texture, and chemical changes effected within the sediments due to the decay of organic matter accumulations. The decay of accumulations of solid waste may also result in depletion of dissolved oxygen in the overlying water column and releases of potentially toxic decay byproducts like unionized ammonia and undissociated hydrogen sulfide. Nutrients (particularly nitrogen and phosphorus) are also released during the decay of solid waste which may result in eutrophic conditions and subsequent shifts in both phytoplankton community abundance and structure. The solid waste discharge may also result in water column turbidity which has the potential to decrease photosynthetic production by phytoplankton. Potential direct impacts of liquid wastes include depletion of dissolved oxygen in the water column due to the decay of soluble oxygen demanding substances in the

wastewater. Residual concentrations of chlorine disinfectants in the liquid wastestream, and additional oxidants produced by the reactions of chlorine with other compounds, also potentially impact marine organisms.

Potential indirect impacts of seafood waste discharges involve effects on marine mammals and birds due to their attraction to seafood waste discharges. The attraction of marine mammals to seafood waste discharges may make them easier prey for predators. Birds that are attracted to surface plumes of seafood waste may become oiled due to accumulation of waste fish oils on the water surface. Another potential indirect impact involves the development of dependence on an anthropogenic food supply that may result in concentration and growth of marine mammal and bird populations that could be adversely affected if this food supply was reduced or eliminated. Eutrophication of marine waters may also indirectly result in enhancement of phytoplankton species that are toxic to marine organisms and humans. Bacteria associated with the decaying seafood waste may also adversely impact marine mammals and birds.

Although a number of potential impacts to marine organisms are outlined above, few studies specific to seafood processing waste discharges have been conducted to assess the importance of the direct and indirect impacts. Most studies conducted to date have focused on the direct effects of solid waste accumulations on benthic organisms, the effect of decaying waste on water column dissolved oxygen concentrations, and the potential toxic effect of waste decay byproducts (i.e., unionized ammonia and undissociated sulfide) on marine organisms. The potential direct and indirect impacts of seafood waste discharges are discussed in more detail below. Information specific to seafood processing waste discharges is reviewed and summarized where possible. Literature relevant to potential impacts associated with eutrophication and residual chlorine are necessarily from studies conducted on other types of waste discharges (e.g., municipal wastewater facilities). Most of the discussion of the potential indirect impacts of seafood processing discharges relies on personal communications from scientists and regulatory agency personnel familiar with seafood processing activity in Alaska.

5.1 Impacts Associated with Solid Seafood Process Wastes

During discharge of seafood processing waste, biological impacts are most likely to occur as a result of the discharge of seafood waste particulates (both direct and indirect effects). The following discussion briefly presents the different potential effects of discharges on biota including burial and habitat modification, the alteration of sediment composition, and the chemistry associated with the decomposition of the waste solids.

5.1.1 Burial and Habitat Modification

Disposal of seafood waste solids will have the greatest impact on less mobile benthic organisms such as polychaetes and bivalves, and on demersal fish eggs that cannot move away from the accumulating waste. The following section discusses the nature of the solid waste deposition and potential impacts to benthos and demersal eggs.

Settling of seafood discharges on the seafloor occurs at varying rates according to the size of the particles. Once settled, these particles can form organic mats or thick waste piles that can smother the underlying substrate and benthic communities within it. Some waste piles have been recorded to rise 40 feet or more above the seafloor (ADEC, 1998). The degradation of this organic material occurs at varying rates according to different characteristics of the discharge area (i.e. biological, physical, and chemical factors). In one study where salmon waste was widely distributed, the waste was completely absent within 33 days following discharge and no adverse effects on dissolved oxygen concentrations noted (Stevens and Haaga 1994). The accumulation of these deposits in some areas indicates that the rate of discharge exceeds the assimilation capacity of some water bodies and more specifically, the assimilation capacity of the benthic community and other aquatic life that metabolize this material. The permit requires that mobile offshore processors discharge seafood waste in areas with high tidal activity that will ensure dispersion and dilution of the seafood wastes and minimize accumulation of these deposits in one area. If discharge limits are adhered to, the effects on aquatic biota in areas of seafood processing waste discharge should be minimal.

Seafood processing industry representatives met with ADEC and EPA and questioned the environmental benefit of the permit effluent limit requiring grind size of 0.5 inches in all dimensions. The effluent limit was established based on the EPA's national effluent limitation guidelines and is highly unlikely to be changed. However, since the scientific validity of it was questioned, ADEC initiated a research project. One component of this research was to evaluate seafood solid waste impacts on the benthos (Germano and Associates, 2004).

The intent of this study was to see what the impacts are to the surrounding benthos and benthic community from seafood solid wastes deposited in a ZOD. The impacts were evaluated using a Sediment Profile Imaging (SPI) camera. The SPI camera takes an image of the top few inches of sediment. Aquatic life within the sediments was also collected for analysis using a Van Veen grab device. The SPI camera showed where seafood wastes made the sediments anoxic and methane producing with the presence of sulfur-producing bacteria, *Beggiatoa,* indicating anoxic conditions.

For two adjacent processors with relatively small, active discharges located approximately 600 feet apart, the visual ZODs were 0.34 and 0.21 acres. However, the area of *Beggiatoa* was approximately 6.0 to 7.4 acres. The presence of *Beggiatoa* indicates reduced oxygen in the sediments and an adverse effect to the benthos and benthic community outside of the ZOD. Other measures for adverse effects include numbers and kinds of species present.

Immediately adjacent to the smaller active piles both fish and crab forage. The diversity of benthic species was less within the first 200 feet of the periphery of the ZOD compared to the diversity observed in a distant

control site. However, the few opportunistic species that existed in the vicinity of the ZOD occurred in great numbers. At approximately 500 feet or more from the periphery of the active piles more of the normal resident species were recorded and the overall abundance of the opportunistic species was less. The study determined that normal resident species population levels and diversity did not occur until 1,500 feet or more down-current of the periphery of the waste piles.

Two other seafood processors evaluated had larger discharges and inactive waste piles greater than 1 acre in size. Very little to no solid waste discharges had occurred for the 2 years preceeding the study. These discharges occurred approximately 1,000 feet apart. In this case, the *Beggiatoa* were observed in 2.8 and 0.5 acres around each waste pile respectively. The areas of reduced oxygen due to *Beggiatoa* were significantly smaller for the inactive waste piles than for the active waste piles. From these results, the authors of the study conclude that biota in sediments will revert to natural conditions within 5-10 years after the cessation of seafood waste disposal (Germano and Associates, 2004).

As stated above, seafood processing wastes can form organic mats within the ZOD, depending on the amount discharged and the biological, chemical, and physical factors affecting decomposition and dispersion of the waste. Depending on the depth of burial, deposits can make the substrate inhospitable, or influence the species composition favoring opportunistic organisms that may out-compete the normal fauna. Algal blooms caused by high nitrogen concentrations can also alter habitat by smothering benthic substrates when they die, and by reducing the available water column or surface aquatic habitat for visual predators, including birds.

5.1.2 Effects of Deposited Solids

Many benthic invertebrates are relatively sedentary and sensitive to environmental disturbance and pollutants. Short- and long-term effects of seafood waste on benthic invertebrates within a ZOD are expected to include smothering of biota, especially by ground particulates in the area near the discharge. Deposition is likely to reduce and possibly eliminate abundances of infaunal benthos such as polychaetes, mollusks, and crustaceans, and may affect demersal eggs of various benthic species and fish. The greatest impact within the ZOD would be expected down current along the plume’s median axis.

Little information is presently available concerning the direct effects of various deposition depths on benthic communities. Most studies that have investigated deposition impacts on benthos have examined deposition of dredged materials (Hale 1972; Kranz 1974; Mauer et al. 1978; Oliver and Slattery 1973; Saila et al. 1972; Schafer 1972; Wilber 1992). These studies indicate that the response to deposition and survival following such an event is species-specific. Of the species examined, burial depths from

which organisms were able to migrate to the surface ranged from 0.4 to 12.6 in (1 to 32 cm). If it is assumed that most benthos are not adversely affected by deposition of seafood waste less than 0.4 in (1 cm), benthos in the vicinity of the discharge receiving deposition in excess of this amount are likely to be adversely impacted. Seafood solids are highly organic material and the decomposition of this material may lead to other impacts on benthos related to localized depression of dissolved oxygen. As noted in Section 5.1.1, these effects have been observed in the water column beyond the boundaries of the ZOD. If it is assumed that solids deposition of greater than 0.4 in (1 cm) depth could have a potential impact on benthos, solids deposition outside the ZOD should be less than 1 cm (0.4 in) to avoid potential impacts to benthic organisms.

A number of important species including, walleye pollock, Pacific cod, rock sole, and sand lance release demersal eggs. As with other types of fish eggs, demersal eggs require oxygen for development. Seafood waste discharges resulting in waste piles are typically anoxic due to decay and decomposition of the waste. Thus, demersal eggs could be smothered if located beneath a discharge. Such smothering of demersal eggs could have a substantial adverse impact on these demersal species and other aquatic organisms that prey upon these fish. Seafood wastes that are discharged during spawning and egg production periods have the most potential to adversely affect these species. Near-shore seafood operations in Alaskan coastal waters have a greater likelihood to adversely impact demersal fish spawning activities than off-shore operations because spawning grounds are more commonly found in these waters. A number of studies have been conducted regarding effects of suspended solids on egg mortality, but the effect of waste deposition on egg mortality is not well documented (USEPA 1984b). In particular, it is not known at what depth of deposition egg survival would be impaired. However, it is reasonable to conclude that impairment may occur at fairly shallow waste depths (e.g., 0.4 in) if that depth of waste was sufficient to impair oxygen transfer to the egg or if anoxic conditions were present such as those commonly observed in and around the ZOD (e.g., Germano & Associates, 2004).

5.1.3 Alteration of Sediment

Alteration of sediment characteristics is expected to impact the benthic community structure more subtly, but at greater distances from the point of discharge, than smothering. Benthos would be the group of organisms most affected by changes in the sediment, but other organisms may be affected as well; impacts to benthic communities could also conceivably affect epibenthic and pelagic invertebrates, fish, birds, and mammals that rely on benthic invertebrates for food.

The general changes in benthic community structure and function that occur under conditions of increasing organic enrichment of the sediments (such as occurs as a result of seafood waste discharges or municipal sewage effluent discharges) have been well documented (see Pearson and

Rosenberg 1978 and Germano & Associates 2004). Slight to moderate enrichment results in slight increases in numbers of individuals and biomass of benthic communities, while species composition remains essentially unchanged. As enrichment increases, the overall abundance of benthic organisms increases. However, there is a corresponding decrease in the number of species as the less tolerant species are eliminated. In more extreme cases and areas associated with active seafood processing waste discharges, only a relatively small number of species adapted to disturbed environments and/or high organic content become very abundant. When the enrichment levels are optimal for those few species, they become extremely abundant, and overwhelmingly dominate the benthic community. Biomass generally decreases as many of these opportunistic species are very small.

These changes in benthic community variables are accompanied by a progressive reduction in the depth of the oxygenated surficial sediment layer, and changes in the predominant trophic groups of benthic organisms. Mixed assemblages, or assemblages dominated by suspension feeders, are first replaced by assemblages dominated by surface deposit feeders, and then replaced by assemblages dominated by subsurface deposit feeders. Under very highly enriched conditions, such as those that exist within active waste piles generated by seafood waste discharges, the sediments become anoxic and macrobenthic organisms may be entirely absent.

The absence of benthic organisms has been documented by divers on several seafood waste piles in Alaskan coastal waters during compliance dive surveys conducted by USEPA and other commercial divers. In a study of a major seafood processor in Akutan, Alaska, USEPA (1984b) documented anoxic conditions in the sediments produced severe impacts to benthic infaunal communities that were confined to areas under seafood waste piles. These results were mirrored in later studies conducted by Germano & Associates (2004). It is typical for areas extending outward around the actual waste pile deposits ranging from approximately five to a few hundred meters from the edge of the pile to experience lesser impacts. These results were based on sediment chemical composition, visual inspection, and sampling of the benthic infauna communities. Characteristics of the benthic community in a ZOD around the pile included low species richness, and dominance by polychaetes typically associated with high organic inputs and bottom disturbance (USEPA 1984b and Germano & Associates, 2004).

5.1.4 Decay of Solid Wastes

As noted above, the decay of organic matter accumulations can effect chemical changes within the sediments and may lead to anoxic conditions within the waste pile. The decay of solid waste accumulations may also result in depletion of dissolved oxygen in the overlying water column and releases of potentially toxic decay byproducts like unionized ammonia and undissociated hydrogen sulfide. Again, benthic communities and demersal

eggs would be directly adversely affected by anoxic conditions within the waste pile. Most infauna would either migrate out of the area or be killed as a result of the lack of oxygen. Anoxic conditions are expected to destroy any demersal eggs that might be present. A few species may be able to survive within the thin upper sediment layer of the waste pile (e.g., *Capirella* spp.). Since ambient waters containing abundant dissolved oxygen rapidly mix with the affected waters, reductions of dissolved oxygen concentrations throughout the overlaying water column are not expected, nor are significant impacts to mobile marine organisms. Any areas of reduced dissolved oxygen above a waste pile would be expected to be small and would be avoided or quickly passed through by mobile organisms.

Releases of potentially toxic decay byproducts like hydrogen sulfide and methane also have the potential to impact marine organisms in the vicinity of the waste pile. However, as with impacts related to depressed oxygen conditions, the potential for impacts in the water column is very slight due to the rapid mixing.

Judging from impacts observed in other areas, the magnitude of the observed impact from decaying organic wastes depends on the total area receiving organic waste deposits, the depth of deposition, the difference between native sediments and deposited waste, the degree to which the deposits are anaerobic, and the length of time during which detectable changes in sediment composition occur. Existing data summarized from other areas indicate that impacts may occur, but are likely to be localized. The greatest effect is expected in the area under the waste pile. It is unlikely that sediment alteration from seafood processors in offshore and nearshore areas will significantly impact populations of benthos since these areas are unlikely to become covered by waste piles.

Indirect impacts could also occur with respect to ecosystem interrelationships resulting from behavioral changes, but these would be difficult to observe and correlate with seafood waste disposal. For example, altered sediment composition may inhibit larval recruitment or feeding and survival of individual benthic species in some areas, resulting in subtle changes in species composition.

5.1.5 Cumulative Impacts of Solids Deposition

Impacts from any individual seafood processing facility discharging in compliance with the requirements of the permit are likely to be localized. Although benthic organisms may be smothered or community composition altered in localized areas, the benthic communities in Alaskan coastal waters would not be expected to decline significantly. However, as evidenced by a number of impaired waters (waters occurring on the State's 303(d) list), multiple facilities discharging into the same receiving water, and even a single discharger operating outside the terms of the permit, have the potential to cause water quality impacts attributed to settleable solids

deposition and dissolved oxygen (EPA 1995a, EPA 1995b, EPA 1995c, EPA 1995d, EPA 1998a, EPA 1998b). Wastes in these areas covered a wider area than the 1 acre ZOD allowed under Alaska Water Quality Standards. Areas where total maximum daily loads (TMDLs) have been implemented include Akutan Harbor, South Unalaska Bay, King Cove and Udagak Bay. The permit excludes coverage for facilities discharging into waters listed as impaired or covered by other general or individual permits.

Impacts from toxicity due to anoxic conditions and changes in community structure could be cumulative spatially and over time. Although more complete knowledge would be of value in assessing the magnitude and significance of cumulative environmental impact, available data indicate that unreasonable degradation is not likely to occur in areas of adequate dispersion and dilution (e.g., USEPA 1984a and Germano & Associates, 2004).

5.1.6 Indirect Effects Through Food Supply Reduction

The quantity of benthic organisms preyed upon by other species could be reduced in the area of the discharge if benthos migrate from the area, or experience increased mortality or decreased recruitment, through smothering, toxicity, or alteration of sediment grain size characteristics. Issues affecting temporal or spatial extent of such impacts are discussed by USEPA (1984a). The degree of food supply reduction caused by discharges of seafood waste is unknown, as the size of the affected area and severity of impacts are by necessity speculative.

5.2 Exposure to Suspended Solids

As discussed in Section 3.0, deposition of the majority of discharged solids is expected to be rapid and localized. Therefore, adverse physical effects to biota from ground seafood discharge should be limited to the nearfield vicinity of the outfall. Within this region, zooplankton and fish larvae near the discharge may experience altered respiratory or feeding ability due to stress, or clogging of gills and feeding apparatus. Phytoplankton entrained in the discharge plume may have reduced productivity due to decreased light availability. However, such potential impacts may be offset in the farfield by increases in nutrient concentrations. These impacts should result in negligible impacts to populations in the region, as impacts should be restricted to the immediate vicinity of the discharge. Mobile invertebrates, fish, birds, and mammals presumably will avoid the discharge plume if conditions become stressful. However, biota may also be attracted to the discharge plume to feed on the discharged particulates. Secondary impacts associated with attraction are discussed in Section 5.3. Infaunal or sessile organisms near the discharge are not likely to be impacted by the suspended solids.

In addition to potential chemical and physical alterations of the water column and benthos, seafood processing residues can cause some aesthetic and physical effects on the water surface and shorelines that could impair existing or designated uses. For example, depending on water currents, presence and severity

of storms, and other factors, residue material, may wash up on nearby shorelines impairing aesthetic quality as well as creating an undesirable attraction of nuisance species and predators. In addition, seafood processing residues can form a surface layer of scum, foam, or fine particles that could present a physical barrier preventing dissolved oxygen re-aeration, block light to the water column, deter avian feeding, and create an aesthetically undesirable condition. Such effects could also attract nuisance species and unwanted predators that would impair beneficial uses. The permit requires facilities to comply with WQS at the boundary of the mixing zone and zone of deposit.

5.3 Impacts Associated with Liquid Seafood Process Wastes

Liquid seafood processing discharges includes two waste streams, one directly associated with the seafood waste and the other associated with ancillary operations whose wastewaters do not come in contact with seafood waste. Liquid seafood processing wastes contain soluble materials that include soluble oxygen demanding substances (i.e., BOD), nutrients and oil and grease. These discharges may also contain disinfectants, including ammonia and chlorine which may produce direct toxic effects. Liquid discharges that are not directly associated with seafood processing activity and that do not come into direct contact with seafood waste (e.g., bailwater, cooling water, boiler water, etc.) are generally not expected to impact marine organisms because they are considered to be non-toxic, do not contain significant amounts of oxygen demanding substances and nutrients, or in the case of soluble sanitary wastes, are treated prior to discharge. The potential impacts to marine organisms due to the discharge of substances with elevated BOD, nutrients, and disinfectants are discussed below.

5.3.1 Biochemical Oxygen Demand/Dissolved Oxygen

Soluble wastes discharged from seafood processing facilities include relatively high concentrations of BOD. Bacterial oxidation of the soluble organic matter in these wastes results in the consumption of water column dissolved oxygen. Relatively low dissolved oxygen (DO) concentrations or the complete absence of DO is lethal to a number of marine organisms, with the exception of obligate and facultative anaerobic bacteria. The State of Alaska has established marine water quality criteria for the protection of marine life. The state standard for DO in surface coastal waters for a depth of one meter is 6.0 mg/L, dissolved oxygen may not be reduced below 4 mg/l at any point beneath the surface, and dissolved oxygen concentrations in estuaries and tidal tributaries may not be less than 5.0 mg/l except where natural conditions cause this value to be depressed. The potential for exceedence of the Alaska marine dissolved oxygen standards is evaluated in detail in Section 9.0

In general, the coastal waters of Alaska are well oxygenated and provide a considerable buffer for the assimilation of soluble organic wastes. In areas of restricted circulation or relatively low ambient dissolved oxygen concentrations resulting from natural processes, the potential for adverse effects on marine organisms from depletion of dissolved oxygen is

increased. Nonetheless, modeling studies presented in Section 9.5 indicate that typical seafood discharges to well-oxygenated open coastal waters or semi-enclosed embayments will not likely result in exceedences of state dissolved oxygen standards excepted as noted above at the interface of the sediment and the water column.

5.3.2 Nutrients and Dissolved Oxygen

Excessive nutrients can cause a multitude of problems in coastal areas including eutrophication, harmful algal blooms, fish kills, shellfish poisonings, loss of seagrass and kelp beds, coral reef destruction, and reduced DO. As stated above, nitrogen is a common pollutant found in seafood processing waste. Nitrogen is known to be particularly damaging to bays and coastal seas by boosting primary production (the production of algae). With excessive amounts of nitrogen, the growth of algae and denitrifying bacteria increases making the water more turbid. As the algae die and decompose, dissolved oxygen is depleted from the surrounding water if there is insufficient mixing or other re-aeration mechanisms present (Howarth et al., 2000; Novatec, 1994). High levels of living algae can also lead to depletions in oxygen over the nighttime hours due to their oxygen consumption during this time period. Low dissolved oxygen levels can cause direct mortality of organisms, or reduced efficiency of physiological processes (e.g. food processing, growth). These changes in nutrients, light, and oxygen, favor some species over others causing shifts in phytoplankton, zooplankton, and benthic communities (Howarth et al. 2000). In particular, animals that rely directly or indirectly on seagrass beds could be affected by algal blooms caused by excessive nutrients.

Unlike solid residues, nutrients are water soluble and can therefore be transported beyond areas of heavy deposition unless assimilated by aquatic life, sorbed to sediments, or released to the atmosphere (denitrification and volatilization of nitrogen). Insufficient dilution or mixing of transported nutrients could conceivably affect other locations.

There have been no analyses of nutrient enrichment impacts in Alaska and it is unknown what nutrient-related effects have occurred from seafood processing discharges. The State’s dissolved oxygen standards may protect against many of the deleterious effects from nutrients. The permit, however, does not include dissolved oxygen monitoring.

5.3.3 Enhanced Productivity

Because phytoplankton form the base of the food chain, impacts to the phytoplankton community could have significant effects on the marine ecosystem as a whole (Legendre 1990). Although enhanced phytoplankton growth would not necessarily be an adverse effect since phytoplankton form the base of the marine food chain, a large increase in phytoplankton standing crop or changes in species composition, particularly to toxic species, could have adverse effects on dissolved oxygen concentrations, aesthetic water quality, other marine organisms, and humans.

Several factors control the rate of phytoplankton productivity and the accumulation of algal biomass. These include temperature, light intensity, mixing depth, and the supply of other nutrients such as nitrogen, phosphorus, silica, and a number of other essential elements (e.g., iron, manganese, zinc, copper, and cobalt). Other factors influencing phytoplankton productivity and biomass that are still poorly understood include inhibitory and stimulatory substances such as vitamin B12 and chelating agents (Aubert 1990; United Nations 1990). Factors influencing changes in phytoplankton community composition are also poorly understood, but are generally related to adaptations of certain species to specific combinations of the factors identified above. For example, diatoms (a group of marine and freshwater algae) appear to be favored when available nutrient concentrations (especially silica) are high and turbulent water column mixing is adequate to maintain these algae in the upper water column layer where light is available. An additional factor that controls the biomass and species composition of phytoplankton is the grazing activity of zooplankton that may feed selectively on certain species of phytoplankton.

The potential for adverse impacts of nutrient discharges from seafood processing facilities would necessarily depend on whether the amount of nitrogen or phosphorus available limit phytoplankton growth in the vicinity of the discharge or if other influencing factors contained in the waste discharge could significantly influence phytoplankton production. Other relevant factors to consider include water exchange, mixing depth, zooplankton grazing activity, and the depth of light penetration in the water column. These variables make it difficult to predict the potential impact of nutrient rich waste discharges from seafood processors on Alaskan marine phytoplankton communities. However, impacts are most likely to occur in relatively shallow areas of restricted water circulation where nitrogen or phosphorus limitation of phytoplankton growth occurs. Therefore, discharges to relatively well-flushed coastal and off-shore areas have a lower potential to cause enhanced phytoplankton growth and biomass.

5.3.4 Alterations in Phytoplankton Species Composition/Toxic Phytoplankton

Alterations in phytoplankton species composition is another potential impact of nutrient rich discharges on marine phytoplankton. Concerns regarding alterations in phytoplankton community composition are related to indirect effects resulting from increasing the populations of phytoplankton species that may produce adverse effects on marine organisms and humans. Effects produced by some phytoplankton species include physical damage to marine organisms (e.g., diatom species of *Chaetoceros* that have caused mortality of penned salmon), toxic effects to marine organisms (e.g., a raphidophyte flagellate species of *Hererosigma*), and toxic effects to humans due to the concentration of algal toxins in marine fish and shellfish [e.g., Paralytic Shellfish Poisoning (PSP), Diarrheic Shellfish Poisoning (DSP), Neurotoxic Shellfish Poisoning

(NSP), Amnesic Shellfish Poisoning (ASP), and ciguatera] (Taylor 1990; Haigh and Taylor 1990). Concerns regarding toxic phytoplankton have been heightened in recent years due to suspicions that the frequency of toxic phytoplankton blooms has increased due to human activities, especially due to agricultural runoff and the discharge of municipal and industrial wastewater to marine coastal areas (Smayda 1990; Smayda and White 1990; United Nations 1990; Anderson 1989).

Although there have been several reports linking mortalities of relatively large numbers of marine mammals (e.g., O'Shea et al. 1991; Anderson and White 1989; Geraci 1989; Geraci et al. 1989; Gilmartin et al. 1980), fish and shellfish (e.g., Cosper et al. 1990; Harper and Guillen 1989; Smayda and Fofonoff 1989), and aquatic plants (e.g., Cosper et al. 1990) to the occurrence of toxic phytoplankton in other parts of the U.S., no such episodes have been reported for the coastal waters of Alaska. The occurrence of human intoxication due to PSP has been recorded at locations in southeast Alaska (Sundstrom et al. 1990). PSP is caused by the consumption of shellfish that have concentrated toxins from an algae of the species *Protogonyaulax* (Shimizu 1989); however, direct links between the occurrence of PSP and eutrophication have not been established (Anderson 1989). Therefore, the linkage between PSP and seafood processing discharges, while possible, is tenuous.

Although there is a potential for the discharge of seafood processing waste to cause localized changes in phytoplankton species composition, there are no known studies to verify that discharges of seafood processing wastes have produced toxic or harmful phytoplankton blooms. Similarly, while Paralytic Shellfish Poisoning has been documented in Southeast Alaska, there is currently no evidence suggesting a linkage with seafood processing discharges.

5.3.5 Disinfectants/Residual Chlorine

Soluble wastes from seafood processing discharges may contain residual concentrations of chlorine-based disinfectants. Residual chlorine and chlorine-produced oxidants have been shown to be toxic to marine organisms at relatively low concentrations (USEPA 2002; Thatcher 1980). Thatcher (1980) conducted 96-hr LC_{50} continuous-flow bioassays on a number of species of fishes and invertebrates typical of the Pacific Northwest and determined that juvenile species of salmon were particularly sensitive. The lowest LC_{50} was determined for coho salmon **(**32 μg/L). The State of Alaska has adopted chlorine standards for marine waters of 7.5 μg/L (chronic) and 13 μg/L (acute) (ADEC, 2003).

The permit has the requirement to “not violate the Alaska Water Quality Standards at the boundary of the mixing zone or outside the zone of deposit,” which includes the total residual chlorine standard of 7.5 μg/L for salmonids. The permit does not require residual chlorine monitoring at the edge of the mixing zone or end-of-pipe. The permit requires development a

best management practice (BMP) plan that includes a specific requirement to minimize the use of chlorine-based or other toxic disinfectants or otherwise limit potential contamination of the discharge.

5.4 Secondary Impacts Due To Seafood Processing Wastes

Although a number of potential secondary impacts to marine organisms are outlined below, limited studies have been conducted to determine whether the potential impacts of seafood processing waste discharges occur. Most of the discussion of the potential secondary impacts of seafood processing discharges relies on personal communications from scientists and regulatory agency personnel familiar with seafood processing activity in Alaska.

Potential secondary impacts of seafood waste discharges involve effects on marine mammals and birds due to their attraction to seafood waste discharges. Bacteria associated with the decaying seafood waste may also adversely impact marine mammals and birds. The potential indirect impacts resulting from eutrophication of marine waters have been previously discussed in Section 5.3.4.

Seafood processing wastes that are commingled with sanitary wastewater also present a potential risk to aquatic species that forage the waste piles and seagulls and other birds that land on the plume and consume the waste. The permit does not prohibit commingling of seafood waste and sanitary wastewater that has been treated only using an MSD. The permit does not require monitoring to verify proper operation and performance of the MSDs and ensure that bacteria loadings from human sources are minimized in the discharges, however the permit does require that BMPs be developed for the proper operation of the MSD to meet the bacteria requirements of the US Coast Guard pollution control standards for a Type II MSD.

5.4.1 Attraction of Organisms to the Discharge

The attraction of marine mammals to seafood waste discharges may make them easier prey for predators. There is anecdotal information from NMFS indicating a very strong attraction to seafood processors by sea lions at sea. As seafood processing moved onshore, observations of sea lions were made in Kodiak Harbor. Occasional observations of killer whales feeding on sea lions in Kodiak were also made. NMFS personnel observed a possible linkage of sea lion observations with fishing activity and fish processing (Loefflad, M., 1 April 1994, personal communication). Linkages were also indicated by Thorne et al. (2006). Loughlin and York (2000) further cited that discharges from off-shore seafood processing facilities attract both steller sea lions and killer whales. These authors indicate that this results in increased predation above natural levels, although actual increases in mortality cannot be accurately quantified.

Another potential secondary impact involves the development of dependence on an anthropogenic food supply that may result in the concentration and growth of populations of marine mammal and birds that could be adversely affected with a reduction or elimination of this food

supply. It is evident that a large number of birds (e.g., gulls) are attracted to seafood processing waste discharges to feed on floating particulates in the discharge (ADEC 2007 pers. comm).

Artificial food sources such as seafood process wastes may increase the gull populations in Alaska by providing food throughout winter months when food is less abundant and survival is the most difficult. Large gulls (herring, glaucous, and glaucous-winged) and parasitic birds (jaegers and skuas) interfere with the reproductive success in waterfowl and in seabirds by preying on ducklings and chicks, displacing other species from nests, and harassing adult birds (Giger, M., 6 April 1994, personal communication). Several studies have documented gulls and other parasitic birds preying on waterfowl and seabirds (Anderson 1974; Tyler 1975; Nettleship 1977; Munro and Bedard 1977; Martin and Barry 1978; Mendenhall and Milne 1985; Barry and Barry 1990; Lloyd et al. 1991; Mendenhall 1993). Seafood waste discharges typically increase localized populations of gulls and parasitic birds which may adversely affect the breeding success of some bird species. Similarly, Reed and Flint (2007) cite the correlation of eiders attracted to an area with both seafood processing and municipal wastewater discharges with increased predation by eagles. The permit contains a narrative standard that processing wastes "not create an attractive nuisance where fish or wildlife species are attracted to waste disposal or storage areas," which could be applied on a case by case basis if discharges were deemed to be creating a problem. Other than the anecdotal information described above, there is no conclusive information on potential marine mammal impacts.

Birds that are attracted to surface plumes of seafood waste (especially floating particulates) may potentially become oiled or their feathers fouled due to accumulation of waste fish oils on the water surface. While studies on the effects of oil spills have shown that birds may be adversely affected, fish oils are different in composition from petroleum products and the potential impacts may or may not be similar. Unless the volume of floating oils was significant and the birds were constantly diving through it, it is unlikely that fouling of the feathers would occur.

5.4.2 Bacteria from Decaying Onshore Waste Accumulations

Bacteria associated with the decaying seafood waste may potentially adversely impact marine mammals and birds. The potential for impact is hypothesized to be from animals eating, rubbing, or rolling in decaying seafood that has accumulated on the shoreline and has a strain of bacteria that may be harmful to the organism. There are no studies or known anecdotal information to suggest that this is a potential problem and again the permit prohibits the accumulation of seafood waste on shore. In addition, the permit requires processors to discharge seafood wastes in areas with high tidal activity which should allow for dispersion and dilution of discharges and minimize the potential for accumulation of seafood waste on shore.

5.5 Summary

The potential adverse effects of seafood processing waste include direct and indirect impacts of the solid and liquid waste discharges to marine organisms. Potential direct impacts of solid waste discharges, including burial of benthic communities, alteration of the sediment texture, and chemical changes within the sediments as a result of decaying organic matter accumulations, are expected to be minimal. The permit requirement of discharges located in areas of high tidal activity should minimize the potential of accumulation of seafood wastes. The decay of accumulated solid waste may reduce concentrations of dissolved oxygen in the overlying water column and release potentially toxic decay byproducts like unionized ammonia and undissociated hydrogen sulfide. Permitted discharges of seafood waste to oxygenated well-flushed areas at rates consistent with permit limitations are not generally expected to cause levels of dissolved oxygen or toxic substances that could have an adverse effect on marine organisms.

Eutrophication of coastal marine waters is not expected to occur in locations where water exchange is adequate to dilute nutrient inputs from seafood processing waste discharges. However, the degree of eutrophication is not known in areas where there is low flushing. Residual concentrations of chlorine disinfectants in the liquid waste stream, and additional oxidants produced by the reactions of chlorine with other compounds, are not known since no monitoring has been required by past general permits.

The attraction of marine mammals and birds to seafood processing waste discharges has the potential to create indirect impacts. At present the data regarding these effects are mostly circumstantial and anecdotal. While prohibitions in the permit are intended to reduce or eliminate these types of potential impacts, a thorough assessment cannot be made at this time. Whether or not birds feeding on seafood waste that has commingled with sanitary waste discharges may result in an impact is unknown.

Eutrophication of marine waters may also indirectly result in enhancement of phytoplankton species that are toxic to marine organisms and humans. Although toxic phytoplankton species occur in marine waters of Alaska, there is no known evidence to date to establish a link between the occurrence of toxic phytoplankton and seafood processing waste discharges.

6.0 Threatened and Endangered Species

6.1 Introduction

The determination of "unreasonable degradation" of the marine environment is to be made based upon consideration of the ten criteria listed in Section 1.0. This section provides information pertinent to consideration of the criterion listed below:

Criterion #3: "The composition and vulnerability of the biological communities which may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain"

The ESA defines an "endangered species" as a species that is in danger of extinction throughout all or a significant portion of its range. A "threatened species" is defined as a species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

6.2 Abundance and Distribution of Threatened and Endangered Species

The threatened and endangered species listed below and subsequently discussed in detail are included because of their potential presence with portions of the area covered by the permit.

- Chinook salmon (Oncorhynchus tshawytscha)
- Sockeye salmon (Onchorhynchus nerka)
- Short-tailed albatross (*Phoebastrai albatrus*)
- Steller's eider (Polysticta stelleri)
- Spectacled Eider (*Somateria fischeri*).
- Blue whale (Baleaptera musculus)
- Bowhead whale (Balaena mysteicetus)
- Fin whale (Balaenoptera physalus)
- Humpback whale (Megaptera novaengliae)
- Northern Pacific right whale (*Eubalaena japonica*)
- Sei whale (Balaenoptera borealis)
- Sperm whale (Physeter macrocephalus)
- Steller sea lion (*Eumetopias jabatus*)
- Northern sea otter (Enhydra lutris kenyoni)

The Cook Inlet stock of beluga whales (*Delphinapterus leucas*) has been designated as depleted under the Marine Mammal Protection Act (MMPA) and have recently been listed as endangered under ESA; therefore, beluga whales are also addressed in this section (73 FR 62919). Kittlitz's murrelet was proposed as a candidate for listing under ESA in May 2004 (69 FR 24876) and Pacific herring

was proposed as a candidate for listing under ESA on April 11, 2008 (73 FR 19824). Therefore, Kittlitz's murrelet and the southeast Alaska DPS of Pacific herring will be addressed in this section as well.

6.2.1 Fish

Snake River Fall Chinook Salmon *(Oncorhynchus tshawytscha)*.

Chinook salmon are anadromous meaning that as adults, they migrate from a marine environment into the fresh water streams and rivers of their birth (anadromous) where they spawn and die. Seasonal *runs* (i.e., spring, summer, fall, or winter) have been identified on the basis of when adult Chinook salmon enter fresh water to begin their spawning migration (Tetra Tech 2006). Because genetic analyses indicate that fall-run Chinook salmon in the Snake River are a distinct evolutionarily significant unit (ESU) from the spring/summer-run in the Snake River Basin (Waples et al. 1991), Snake River fall-run Chinook salmon are considered separately.

Two distinct races have evolved among Chinook salmon. The *stream-type* race of Chinook salmon is found most commonly in headwater streams. Steam-type Chinook salmon have a longer fresh water residency, and demonstrate extensive off-shore migrations into the North Pacific before returning to their natal streams in the spring or summer months (NMFS 1998; Healy 1991). The *ocean-type* Chinook, including the Snake River fall-run Chinook salmon ESU are commonly found in coastal streams in North America. Ocean-type Chinook migrate to sea where they tend to spend their ocean life in coastal waters within about 1,000 kilometers (621 miles) from their natal river (NMFS 1998; Healy 1991). Ocean-type Chinook salmon return to their natal streams or rivers in spring, winter, fall, summer, and late-fall runs, but summer and fall runs predominate (Tetra Tech 2006). The difference between these life history types is also physical, with both genetic and morphological foundations (NMFS 1998).

The historical population of Snake River fall-run Chinook salmon is difficult to estimate. Irving and Bjornn (1981) estimated a population of 72,000 for the period of 1938 to 1949 that declined to 29,000 during the 1950s. Numbers declined further following completion of the Hells Canyon Dam complex. The Snake River component of the fall-run Chinook has been increasing during the past few years as a result of hatchery and supplementation efforts in the Snake and Clearwater River Basins.

The critical habitat for the Snake River fall Cinook salmon was listed on December 28, 1993 (NMFS 1993a) and modified on March 9, 1998, (NMFS 1998) to include the Deschutes River in Oregon. The designated critical habitat does not include any waters within the state of Alaska.

Snake River Spring/Summer Chinook Salmon *(Oncorhynchus tshawytscha)*. Recent trends in redd counts in major tributaries of the Snake River indicate that many subpopulations could be at critically low levels. Subpopulations in the Grande Ronde River, Middle Fork Salmon

River, and Upper Salmon River Basins are at especially high risk. Both demographic and genetic risks would be of concern for such subpopulations, and in some cases, habitat may be so sparsely populated that adults have difficulty finding mates. NOAA Fisheries estimates that the median population growth rate over a base period from 1980 through 1998 ranges from 0.96 to 0.80, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared with the effectiveness of fish of wild origin (McClure et al. 2000). In 2002, the fish count at Lower Granite Dam was 75,025, more than double the 10-year average. Estimated hatchery Chinook at Lower Granite Dam accounted for a minimum of 69.7 percent of the run (Tetra Tech 2006). The spring Chinook count in the Snake River was at the all-time low of about 1,500 as recently as 1995, but in 2001 and 2002, both hatchery and wild/natural returns to the Snake River increased (FPC 2003).

The critical habitat for the Snake River spring/summer Chinook salmon was listed in 1993 (NMFS 1993a). The designated habitat consists of river reaches of the Columbia, Snake, and Salmon Rivers, and all tributaries of the Snake and Salmon Rivers (except the Clearwater River) presently or historically accessible to Snake River spring/summer Chinook salmon (except reaches above impassable natural falls and Hells Canyon Dam) (Tetra Tech 2006).

Snake River Sockeye Salmon (*Onchorhynchus nerka*). Snake River sockeye salmon returns to Redfish Lake since at least 1985, when the Idaho Department of Fish and Game began operating a temporary weir below the lake, have been extremely small (1 to 29 adults counted per year). Snake River sockeye salmon have a very limited distribution relative to critical spawning and rearing habitat. Redfish Lake represents one of the five Stanley Basin lakes historically occupied by Snake River sockeye salmon. NMFS proposed an interim recovery level of 2,000 adult Snake River sockeye salmon in Redfish Lake and two other lakes in the Snake River Basin (NMFS 1995). Because only 16 wild and 264 hatchery-produced adult sockeye returned to the Stanley River Basin between 1990 and 2000, NMFS considers the risk of extinction of this ESU to be very high (Tetra Tech 2006). In 2002, 52 adult sockeye were counted at Lower Granite Dam on the Snake River (FPC 2003); 12 sockeye salmon had been counted at Lower Granite Dam through September 2003 (USACE 2003).

The critical habitat for the Snake River sockeye salmon was designated on December 28, 1993 (NMFS 1993a). The designated habitat consists of river reaches of the Columbia, Snake, and Salmon Rivers, Alturas Lake Creek, Valley Creek, and Stanley, Redfish, Yellow Belly, Pettit, and Alturas Lakes (including their inlet and outlet creeks) (Tetra Tech 2006).

Southeast Alaska DPS Pacific herring. The Southeast Alaska DPS of Pacific herring extends from Dixon Entrance northward to Cape Fairweather and Icy Point and includes all Pacific herring stocks in Southeast Alaska. Pacific herring are located in distinctly varying

environments during different times of the year. The Southeast Alaska DPS of Pacific herring is currently undergoing a status review to determine if this species warrants listing under the Endangered Species Act. While the Pacific herring fisheries have undergone decline in the 1980's and 1990's, specific trends and risks of this species are still under investigation.

6.2.2 Birds

Short-tailed Albatross (*Phoebastrai albatross*). The short-tailed albatross was listed as endangered under the ESA in waters of the United States on July 30, 2000 (USFWS 2000a). This species once ranged throughout most of the North Pacific Ocean and Bering Sea with known nesting colonies on several islands within the territorial waters of Japan and Taiwan (Tetra Tech 2006). Other undocumented nesting colonies may also have existed in areas under U.S. jurisdiction on Midway Atoll in the Aleutian Islands; however, the evidence for breeding on the Alaskan Aleutian Islands is based on scant evidence considered highly unlikely (USFWS 2000a).

The marine range within U.S. territorial waters includes Alaska's coastal shelf break areas and the marine waters of Hawaii for foraging. The extent to which the birds use open ocean areas of the Gulf of Alaska, North Pacific Ocean, and Bering Sea is unknown (USFWS 2000a). Observations by the USFWS (USFWS 2000a) suggest that short-tailed albatross frequent near-shore and coastal waters, with "many" birds being sighted within 10 kilometers (6 miles) of shore, and fewer birds ("several") observed within 5 kilometers (3 miles) of shore.

Currently, breeding colonies are limited to two Japanese Islands of Torishima and Minami-kojima (USFWS 2000a). Birds arrive at the Torishima breeding colony in October and initiate breeding and egg-laying, which continue through late November. The chicks hatch in late December and January and are close to being full grown by late May or early June at which time the adults begin to abandon the breeding colony and return to sea. The chicks fledge after the departure of the breeding adults and depart the colony by mid-July (USFWS 2000). The specific geographical and seasonal distribution patterns of the birds, once they depart from the breeding colony, are not well understood (Tetra Tech 2006). The birds are reported to be long-lived and slow to mature, with an average age at first breeding of 6 years old (USFWS 2000).

The total population of short-tailed albatross was estimated to be 1,200 birds in 2000 (USFWS 2000). Demographic information provided by USFWS (2000) indicates that the breeding population on the island of Torishima is growing at a "fairly rapid rate," with an annual population growth rate of 7.8 percent. No information is available for the other breeding colony located on the island of Minamikojima (Tetra Tech 2006).

No critical habitat has been designated for short-tailed albatross. The USFWS has determined that the designation of critical habitat for this species is not prudent because it would "not be beneficial to the species"

(65 FR 46643, July 31, 2000). USFWS concluded that the designation of critical habitat for potential and actual breeding areas within the U.S. areas of jurisdiction on the Midway Atoll National Wildlife Refuge would not provide additional benefit or protection over that conferred through the jeopardy standard of Section 7 of the ESA. With regard to the designation of critical habitat for foraging in the waters of the United States, USFWS concluded there is no information available to support a conclusion that any specific marine habitat areas are uniquely important (USFWS 2000).

Steller's Eider (*Polysticta stelleri*). The Alaskan breeding populations of Steller's eider were listed as threatened under the ESA on June 11, 1997 (Tetra Tech 2006). Two breeding populations in Arctic Russia are not part of the ESA listing in the United States and are not addressed in this section. The historical breeding range of the Alaskan breeding population of Steller's eider is unclear; it may have extended discontinuously from the eastern Aleutian Islands to the western and northern Alaska coasts, possibly as far east as the Canadian border (USFWS 2001). In western Alaska, historical (pre-1970) data suggests that the birds formerly nested on the Yukon-Kuskokwim River Delta (Y-K Delta) and at least occasionally at other western Alaska sites, including the Seward Peninsula, St. Lawrence Island, and possibly the eastern Aleutian Islands and Alaska Peninsula (USFWS 2002b).

In recent times, breeding has occurred in two general areas, the Arctic Coastal Plain on the Alaskan North Slope and on the Y-K Delta in western Alaska (USFWS 2001). The Arctic Coastal Plain area, particularly the area surrounding Barrow, is extremely important to nesting Steller's eiders (USFWS 2002b). Aerial surveys conducted 1999–2002 in a 2,757 km^2 area from Barrow south to Meade River recorded between 2 to over 100 breeding pairs for a maximum density of 0.08 birds per square kilometer (Tetra Tech 2006). The Y-K Delta is currently of much lesser importance; only seven nests were found on the Y-K Delta from 1994 to 2002 (USFWS 2002b).

After breeding, Steller's eiders move to marine waters where they molt, and individuals remain flightless for about 3 weeks. The birds, which presumably consist of members of both Alaskan and Russian populations, primarily molt along the north side of the Alaska Peninsula, in Izembek Lagoon, Nelson Lagoon, Port Heiden, and Seal Islands (USFWS 2002b). After molting, many Steller's eiders disperse to the Aleutian Islands, the south side of the Alaska Peninsula, Kodiak Island, and as far east as Cook Inlet (Tetra Tech 2006). Wintering birds usually occur in waters less than 33 feet deep and are, therefore, usually found within 400 meters (400 yards) of shore except where shallows extend further off-shore in bays and lagoons (USFWS 2002b).

Birds from Alaska and Russian breeding populations intermix on the wintering grounds. It is not known what percentage of the wintering birds that overwinter in Alaska are members of the ESA-listed population

(Alaskan breeding population) versus the non-ESA-listed Russian breeding population (Tetra Tech 2006). According to the USFWS, about 4.2 percent of the Steller's eider in or near the Cook Inlet area are assumed to be from the Alaskan breeding population (MMS 2003).

Determining the population trends for Steller's eider is difficult (USFWS 2000c). Counts conducted in 1992 indicated that at least 138,000 birds wintered in southwest Alaska. It appears that the breeding range in Alaska has substantially contracted, with the species disappearing from much of its historical range in western Alaska (USFWS 2000c). The size of the breeding population on the Alaskan North Slope varies considerably among years and it is not known whether the population is currently declining, stable, or improving (USFWS 2000b).

The designated critical habitat for the Steller's eider includes five units along the Bering Sea and north side of the Alaskan Peninsula. These are the Y-K Delta, Kuskokwim Shoals, Seal Islands, Nelson Lagoon, and Izembek Lagoon (USFWS 2001). Within these areas, the primary habitat components that are essential include areas to fulfill the biological needs of feeding, roosting, molting, and wintering. Important habitats include the vegetated intertidal zone and marine waters up to 9 meters (30 feet) and the underlying substrate and benthic community, associated interbrate fauna, and where present, eelgrass beds and associated biota (USFWS 2001).

The recovery plan for Steller's eider identifies a potential for exposure to contaminants by feeding on seafood processing wastes. The contaminants of concern include petroleum products and detergents (USFWS 2002b). The USFWS proposed to study how seafood processing wastes could affect the quality and quantity of the diet of Steller's eider (USFWS 2002b).

Spectacled Eider (*Somateria fischeri*). The spectacled eider was listed as a threatened species under the ESA on May 10, 1993 (USFWS 1993a). It nests near islands, ponds, meadows, or along the coast, with one breeding population occurring primarily across the North Slope from Demarcation Point to Point Hope. A second population is located on the shore of the Bering Sea from the southern portion of Norton Sound to the northwestern corner of Bristol Bay. After breeding, the eiders leave to molt and winter in unknown locations, possibly in the Chukchi or Bering Seas (USFWS 1993). The coastal fringe of the Yukon-Kuskokwim Delta is the primary location of the spectacled eider in Alaska (Daw and Kistchinski 1977. Could et al. 1982). An estimated 1,721 spectacled eider pairs were observed nesting on the Yukon-Kuskokwim Delta in 1992. Also observed is a population decline of 14 percent per year, although the causes are unknown (USFWS 1993). While the causes of the decline are not known, possibilities include increased predation by species such as glaucous-winged gulls (Larus glaucescens). The USFWS has indicated that the numbers of glacucous-winged gulls have increased in southwestern Alaska as a result of the availability of fish processing wastes (USFWS 1996).

Critical Habitat has been identified for spectacled eiders for overwintering, molting and breeding (USFWS 2001). Breeding habitat is located within the Yukon Delta within the Yukon Delta National Wildlife Refuge. Critical habitat for molting is identified in Norton Sound and Ledyard Bay. Wintering critical habitat is located south of St. Lawrence Island. The proposed permit does not include exclusions for critical habitat for molting in Norton Sound or overwintering critical habitat.

Kittlitz's murrelet. The Kittlitz's murrelet ranges in Alaska from Point Lay in the north to Glacier Bay and nearby southeast Alaska. Its centers of abundance appear to be Prince William Sound and Glacier Bay. The Kittlitz's murrelet is generally found in association with marine tidewater glaciers and glacially influenced waters, often in protected fjords or among islands. When within the range of tidewater glaciers, the species is associated with waters containing icebergs and brash ice (i.e. ice cover of 5-15%) and avoids areas that contain heavy ice cover (Day et al. 1999, Day et al. 2000). Elsewhere, Kittlitz's murrelets are found along coasts with waters influenced by glacial outwash (USFWS 2005b).

During the breeding season, Kittlitz's murrelets appear to favor waters less than 200m from shore (Day et al. 2000). During non-breeding season, the marine distribution is farther offshore. However, in winter, Kittlitz's murrelets occur in the protected waters of Prince William Sound, Kenai Fjords, Kachemak Bay, and Sitka Sound (Day et al. 1999).

The Alaska population of Kittlitz's murrelets currently is approximately 17,000 (USFWS 2004), but is declining at a rate of up to 18% per year (Kuletz et al. 2003, USFWS 2004). Significant downward trends have been reported from Prince William Sound, where the Kittlitz's murrelet population has declined 84% over 11 years. At this rate, extirpation of Kittlitz's murrelets in Prince William Sound is predicted to take approximately 30 years (Kuletz et al. 2005). Populations have also declined along the coast of Kenai Fjords (Van Pelt and Piatt 2003), Lower Cook Inlet (Speckman et al. 2005), Glacier Bay (Robards et al. 2003) and the Malasping Forelands (Kissling et al. 2005).

Threats include exposure to oil contaminants, entanglement in gillnets, disturbance from commercial and recreational cruise ships, and the effect of climate change on the stability of tidewater glaciers (USFWS 2005b).

6.2.3 Marine Mammals

Blue Whale (*Baleaptera musculus*). The blue whale was listed as endangered under the ESA on June 2, 1970. Blue whales are found in all of the world's oceans from the Arctic to the Antarctic. In the North Pacific, they rarely enter the Bering Sea and are only seldom seen as far north as the Chukchi Sea (ADFG 1994a). In the eastern North Pacific, they winter off southern and Baja California; during the spring and summer, they are found from central California northward through the Gulf of Alaska (Tetra

Tech 2006). Historical areas of concentration in Alaska include the eastern Gulf of Alaska and the eastern and far western Aleutians (ADFG 1994a).

Blue whales are believed to migrate away from coastlines and feed preferentially in deeper off-shore waters (Gregr and Trites 2001; Mizroch et al. 1984). They are seldom seen in near-shore Alaska waters (ADFG 1994a). No critical habitat has been designated for the blue whale (Tetra Tech 2006).

Blue whales are estimated to reach sexual maturity between 5 and 10 years of age, and may live as long as 70 to 80 years (Environment Canada 2004b). Upon reaching sexual maturity, females bear a single calf every 2 to 3 years (ADFG 1994a). Like many other species of baleen whales, blue whales migrate from low-latitude wintering areas to high-latitude summer feeding grounds (Tetra Tech 2006).

Blue whales appear to practice more selective behavior in feeding than other rorquals (those baleen whales that possess external throat grooves during gulp-feeding) and specialize in plankton feeding, particularly swarming euphausids (krill) in the Antarctic (Tetra Tech 2006). In the North Pacific, the species *Euphausia pacifica* and *Thysanoessa spinifera* are the main foods of blue whales (ADFG 1994a).

The pre-whaling abundance of blue whales in the North Pacific has been estimated at 4,900 to 6,000 animals and is now 1,200 to 1,700 animals (ADFG 1994a). There have been very few sighting of blue whales in Alaskan waters (Tetra Tech 2006). The first confirmed blue whale sighting in 30 years was observed by NOAA scientists on July 15, 2004, 100 nautical miles southeast of Prince William Sound (Joling 2004).

Bowhead whale (Balaena mysteicetus). The majority of these whales inhabit areas around Alaska as part of the Western Arctic stock. Five populations existed historically. Today, one population might be extinct and three others exist in low numbers. Bowhead whales live only in Arctic or subarctic waters and have adapted to living along the pack ice and do not travel to temperate waters to calve (Sheldon and Rugh 1995).

The western Arctic or Bering Sea stock, which is the only stock found in United States waters, follows a 3,600 mile (5800km) migration route. They winter in the Bering Sea in polynyas (areas of consistently open water within pack ice) and at the edge of the pack ice. From late March through April, bowheads move north through the Bering Strait as the pack ice retreats. Most bowheads follow leads or cracks in the ice through the Chukchi Sea along the Alaska coast to Point Barrow. They travel offshore across the Beaufort Sea and arrive in Canadian waters from mid-May through June. The bowhead whale spends the summer in the Canadian Beaufort Sea, then migrate west along the continental shelf of the Beaufort Sea to Point Barrow from August through October. Next, the whales cross the Chukchi Sea and travel south along the Russian coast passing through the Bering Strait by November (Carroll 1994). Studies of stable isotope

ratios in bowhead baleen suggest that the Bering and Chukchi Seas are the preferred feeding habitats rather than Beaufort Sea (Lee and Schell 1999).

Before commercial whaling, there were over 50,000 bowhead whales worldwide. Between the 1600s and 1800s, the eastern arctic stocks of bowheads were reduced from over 50,000 animals to less than 1,000. The Bering Sea stock originally numbered about 18,000 whales and was reduced significantly in the 1800s and early 1900s. They remain severely depleted. However, the population had increased from 6,400 to 9,200 in 1992(Carroll 1994).

Fin Whale (*Balaenoptera physalus*). The fin whale was listed as endangered under the ESA on June 2, 1970. In the North Pacific, fin whales can be found from above the Arctic Circle to lower latitudes of approximately 20ºN (Leatherwood et al. 1982). Fin whales along the Pacific coast of North America have been reported during the summer months from the Bering Sea to as far south as central Baja California (Tetra Tech 2006); three stocks are recognized: Alaska (Northeast Pacific), California/Washington/Oregon, and Hawaii (NMFS 2007).

Fin whales are believed to feed preferentially mainly in off-shore waters, with preferred habitat encompassing a large area that includes the continental shelf break and off-shore waters (Gregr and Trites 2001). They are seldom seen in inshore coastal waters. Fin whales could inhabit areas included within the permit coverage including the Gulf of Alaska. No critical habitat has been designated for the fin whale (Tetra Tech 2006).

Fin whales tend to be more social than other rorquals, gathering in pods of 2-7 whales or more. Sexual maturity occurs at ages of 6 to10 years in males and 7 to 10 years in females and both sexes may live as long as 90 years (OBIS 2005). Reproductive activity occurs in winter, when whales have migrated to warmer waters. Females can mate every 2 to 3 years (Tetra Tech 2006). Fin whales eat a variety of fish and zooplankton species including capelin, sand lance, herring, and euphausids (krill) (OBIS 2005).

The pre-whaling abundance of fin whales in the North Pacific has been estimated at 42,000 to 45,000 animals while early 1970s population estimates ranged from 14,620 to 18,630 whales (Ohsumi and Wada 1974). Very few sightings of fin whales have occurred in Alaska waters (Tetra Tech 2006). A survey conducted in August 1994 covering 2,050 nautical miles of track line south of the Aleutian Islands encountered only 4 fin whale groups (NMFS 2003b).

Humpback Whale (*Megaptera novaengliae*). The humpback whale was listed as endangered under the ESA on June 2, 1970. The humpback whale is distributed worldwide in all ocean basins, although it is less common in Arctic waters. Currently there are four recognized stocks of humpback whales in U.S. waters based on geographically distinct winter ranges (NMFS 2007): Gulf of Maine stock, eastern North Pacific stock, central North Pacific stock, and the western North Pacific stock. The central North

Pacific stock includes animals found in Alaskan waters. In Alaskan waters, most humpbacks tend to concentrate in southeast waters, Prince William Sound, the area near Kodiak and Barren Islands, the area between the Semidi and Shumagin Islands, eastern Aleutian Islands, and the southern Bering Sea (ADFG 1994b). In Southeast Alaska (i.e., Glacier Bay and Frederick Sound) photo identification studies summarized by Perry et al. (1999) appear to show that humpback whales use discrete, geographically isolated feeding areas that individual whales return to year after year. These studies find little documented exchange in individual animals between Prince William Sound areas and the Kodiak Island area, and between the Kodiak Island area and Southeast Alaska feeding areas, suggesting that while movement among these areas may occur, it is reasonably uncommon (Tetra Tech 2006). Although humpback whales can be observed year-round in Alaska, most animals are thought to migrate to winter in waters near Hawaii (ADFG 1994b; Perry et al. 1999). No critical habitat has been designated for the humpback whale anywhere throughout its range (Tetra Tech 2006).

Humpback whales feed preferentially over continental shelf waters (Gregr and Trites 2001) and are often observed relatively close to shore, including major coastal embayments and channels (NMFS 2005b). Sexual maturity occurs at age 4–6 years, with mature females giving birth every 2–3 years (ADFG 1994b).

Humpback whales use a variety of feeding behaviors to catch food including underwater exhalation of columns of bubbles that concentrate prey, feeding in formation, herding of prey, and lunge feeding (ADFG 1994b). On the basis of their diet, humpbacks have been classified as generalists (Perry et al. 1999). They have been known to prey upon euphausids (krill), copepods, juvenile salmonids, Arctic cod, capelin, Pacific herring, sand lance, walleye pollock, pteropods; and some cephalopods (Tetra Tech 2006). On Alaska feeding grounds, humpback whales feed primarily on capelin, juvenile walleye pollock, sand lance, Pacific herring, and krill (NMFS 2003c; Perry et al. 1999).

The pre-whaling abundance of humpback whales in the North Pacific has been estimated to be approximately 15,000 animals (ADFG 1994b). The current total estimated abundance of the Central North Pacific stock of humpback whales is 4,005 individuals (NMFS 2005b). NMFS (2005b) reports abundance within known feeding areas in Alaska as southeast Alaska (961 whales), Kodiak Island area (651 whales), and Prince William Sound (149 whales). At least some portions of this stock have increased in abundance between the early 1800s and 2000 (Tetra Tech 2006). The rate of population increase in southeast Alaska may have recently declined, which may indicate the stock is approaching its carrying capacity (NMFS 2005b).

North Pacific Right Whale (*Eubalaena japonica*). The northern right whale was listed as endangered under the ESA on June 2, 1970. On April

10, 2003, NMFS published a final rule (NMFS 2003a) that split the endangered northern right whale into two endangered species: North Atlantic right whale (*Eubalaena glacialis*) and North Pacific right whale (*Eubalaena japonica*) (Tetra Tech 2006). This section discusses the North Pacific right whale.

The North Pacific stock of northern right whale has historically occurred across the North Pacific, north of 35º N latitude, with concentrations of whales occurring in the Gulf of Alaska, eastern Aleutian Islands, south-central Bering Sea, Sea of Okhotsk, and the Sea of Japan (NMFS 2001).

Two populations of North Pacific right whale are thought to exist, one in the western North Pacific off Russia and the other in the eastern North Pacific off Alaska (MMC 2002). The distribution and status of neither population is well understood. The eastern population is more severely depleted than the western population, with the population thought to number in the tens of individuals versus hundreds for the western population (MMC 2002; NMFS 2007). Between 1900 and 1994, there have been only 29 reliable sightings of right whales in the eastern North Pacific (Tetra Tech 2006). Since that time, between 4 and 13 individuals have been sighted each year; all these sightings have occurred in a 60 by 100 nautical mile area about 200 nautical miles north of Unimak Pass in the southeastern Bering Sea (CBD 2000; MMC 2002; NMFS 2002a).

Because the North Pacific eastern population is so small and infrequently sighted, little is known about their range and movements (Tetra Tech 2006). The whales are thought to move northward to high latitudes in the spring, summer in the Bering Sea and Gulf of Alaska, and move southward in the fall and winter possibly as far south as Baja, California (CBD 2000; NMFS 2002a).

Historically, right whales often were observed in coastal waters where their slow speed and tendency to float after death resulted in their near-decimation by whalers in the 1800s. Recent whale sightings have all occurred within the shallower waters of the continental shelf (CBD 2000). The feeding preferences of North Pacific right whales have not been determined; however, NMFS has noted that these whales probably feed almost exclusively on calanoid copepods, a component of zooplankton (NMFS 2002b).

The pre-exploitation size of the population of North Pacific right whales has been estimated as likely exceeding 10,000 animals (67 FR 7660, February 20. 2002) to 19,000 animals (CBD 2000). The current population is thought to be very small, perhaps in the tens of animals and no sightings of a cow with a calf have been confirmed since 1900 (NMFS 2002b).

On June 3, 1994, NMFS designated critical habitat for the species of northern right whale (NMFS 1994a), which as of April 10, 2003, became referred to as the North Atlantic right whale (NMFS 2003a). The three areas designated as critical habitat are in the North Atlantic Ocean off the

eastern United States. NMFS determined at the time that insufficient information was available to consider critical habitat designation for other stocks of northern right whale, including whales residing in the North Pacific (Tetra Tech 2006).

On October 4, 2000, the Center for Biological Diversity petitioned the NMFS to designate a portion of the southeastern Bering Sea as critical habitat for the North Pacific right whale on the basis of annual sightings of whales in the area that suggest the area is a summer feeding ground for this severely depleted population (CBD 2000). On July 11, 2001, the Marine Mammal Commission responded to this request by recommending that NMFS proceed with designating the area as critical habitat and modify the boundaries as future data about future population distribution becomes available (MMC 2002). However, on February 20, 2002, NMFS published notice that it had determined that the petitioned action to designate critical habitat was not warranted (NMFS 2002b). NMFS noted that because the essential biological requirements of the population in the North Pacific Ocean are not sufficiently understood, the extent of critical habitat cannot be determined. No critical habitat has been designated for the Northern Pacific right whale (Tetra Tech 2006).

Sei Whale (*Balaenoptera borealis*). The sei whale was listed as endangered under the ESA on June 2, 1970. Sei whales have historically occurred in all oceans of the world, migrating from low-latitude wintering areas to high-latitude summer feeding grounds (Fisheries and Oceans Canada 2005). In the eastern North Pacific, sei whales are common in the southwest Bering Sea to the Gulf of Alaska (Tetra Tech 2006), and off-shore in a broad arc between 40ºN and 55ºN (Environment Canada 2004a).

The sei whale prefers deeper off-shore waters, with preferred habitat tending to occur in off-shore areas that encompass the continental shelf break (Gregr and Trites 2001). Commercial whaling catch records off British Columbia indicate that less than 0.5 percent of sei whales were caught in waters over the continental shelf (Environment Canada 2004a). No critical habitat has been designated for the sei whale (Tetra Tech 2006).

Sei whales reach sexual maturity between 5 and 15 years of age and may live as long as 60 years. Sei whales feed primarily on copepods, followed by squid, euphasids, and small pelagic fish (Trites and Heise 2005).

The pre-whaling abundance of sei whales in the North Pacific has been estimated to range from 42,000-62,000 animals (Ohsumi and Wada 1974). There are no current data on trends in sei whale abundance in the eastern North Pacific waters. A fact sheet prepared by NMFS (2000b) on the eastern North Pacific stock of sei whale suggests that the population is expected to have grown since being given protected status under the Marine Mammal Protection Act in 1976; however, continued unauthorized take, incidental ship strikes, and fill net mortality makes this uncertain (Tetra Tech 2006).

Sperm Whale (*Physeter macrocephalus*). The sperm whale was listed as endangered under the ESA on June 2, 1970. Sperm whales inhabit all ocean basins, from equatorial to polar waters. Their distribution generally varies by gender and the age composition of groups, and is influenced by prey availability and oceanic conditions (Perry et al. 1999). In the North Pacific, sperm whales are distributed widely, with the northernmost boundary extending from Cape Navarin (62º N) to the Pribilof Islands (NMFS 2007). Mature females, calves and immature whales of both sexes in the North Pacific are found in social groups, and remain in tropical and temperate waters year round from the equator to approximately 45º N latitude (NMFS 2007; Perry et al 1999). Males lead a mostly solitary life after reaching sexual maturity between 9 and 20 years of age, and are thought to move north in the summer to feed in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands (Tetra Tech 2006). Research has revealed considerable east-west movement between Alaska and the western North Pacific (Japan and Bonin Islands), with little evidence of north-south movement in the eastern Pacific (NMFS 2007; Perry et al 1999).

The habitat preferred by sperm whales differs among the sexes and age composition of individual whales (Tetra Tech 2006). The social groups composed of females, calves, and immature whales have a broader habitat distribution than males; they are generally restricted to waters with surface temperatures greater than 15º C and are rarely found in areas with water depths less than 650 to 3,300 feet (Gregr and Trites 2001; Reeves and Whitehead 1997). Males exhibit a tighter distribution over deeper waters along the continental shelf break, and are often found near steep drop-offs or other oceanographic features (e.g., off-shore banks, submarine trenches and canyons, continental shelf edge), presumably because these areas have higher foraging potential (AKNHP 2005; Gregr and Trites 2001).

The distribution of sperm whales indicates that male sperm whales are the only sex that frequent Alaskan waters. Available evidence indicates that males are present off-shore in the Gulf of Alaska during the summer (Tetra Tech 2006). No critical habitat has been designated for the sperm whale.

Sperm whales feed primarily on medium-sized deep water squid, with the remaining portion of their diet composed of octopus, demersal and mesopelagic sharks, skates, and fish; feeding occurs all year-round, usually at depths below 400 feet (AKNHP 2005; NMFS 2005c).

Pre-whaling abundance estimates of sperm whale in the North Pacific are considered unreliable and range from 472,000 to 1,260,000 animals (NMFS 2007; Perry et al 1999; NMFS 2005c). The abundance of whales in the North Pacific in the 1970s was estimated to be 930,000 animals (Rice 1989). The current abundance of the North Pacific stock (Alaska) of sperm whale is unknown (NMFS 2005c).

Steller Sea Lion (*Eumetopias jubatus*). The NMFS listed the Steller sea lion as threatened, by emergency interim rule, on April 5, 1990 (NMFS

1990a). The emergency rule listing, which had duration of 240 days, was followed by a final listing of the Steller sea lion as threatened on November 26, 1990 (NMFS 1990b). On May 5, 1997, the NMFS issued a final rule reclassifying Steller sea lions into two distinct population segments (NMFS 1997). The Steller sea lion population west of 144º W longitude (a line intersecting the Alaskan coastline near Cape Suckling) was reclassified as endangered; the sea lion population to the east of this line retained its ESA-listing status as threatened.

The Steller sea lion is distributed around the North Pacific Ocean rim from northern Hokka, Japan along the western North Pacific northward through the Kuril Islands and Okhotsk Sea, then eastward through the Aleutian Islands and central Bering Sea, and southward along the eastern North Pacific to the Channel Islands, California (NMFS 2007). Designated critical habitat for the Steller sea lion by NMFS includes rookeries, haulouts, and marine foraging areas. Critical habitat consists of a terrestrial zone that extends 3,000 feet landward from the baseline or base point of each major rookery and major haulout and includes an air zone that extends 3,000 feet above the terrestrial zone measured vertically from sea level. Critical habitat within the aquatic zone in the area east of 144º W longitude (ESA endangered population) extends 20 nautical miles seaward in state and federally managed waters from the baseline or base point of each rookery or major haulout (NMFS 1994b). Critical habitat is defined in 55 CFR 226.202 and is presented in Appendix B.

The breeding season for the Steller sea lion is from May to July, where the animals congregate at rookeries, the males defend territories, mating occurs, and the pups are born (Tetra Tech 2006). Non-reproductive animals congregate to rest at more than 200 haulout sites where little or no breeding occurs. Sea lions continue to gather at both rookeries and haulout sites throughout the year, outside of the breeding season (NMML 2004b). Habitat types that typically serve as rookeries or haulouts include rock shelves, ledges, and slopes and boulder, cobble, gravel, and sand beaches. Seasonal movements occur generally from exposed areas in summer to protected areas in winter (ADFG 1994c).

In 1980, the world population of Steller sea lions was estimated to be between 245,000 and 290,000 (Loughlin et al. 1992). The western population of Steller sea lions has declined at about 5.0 percent per year over the period of 1991-2000, while the eastern population has increased at about 1.7 percent per year (Loughlin and York 2000). Survey data collected in 2003-2004 suggest that the decline of the western population within Alaskan territory may have abated in recent years, with an annual rate of increase estimated at 2.4 to 4.2 percent (NMFS 2005a).

Northern Sea Otter (*Enhydra lutris kenyoni*). The USFWS issued a final rule listing the southwest Alaska distinct population segment of the northern sea otter as threatened under the ESA on August 9, 2005 (USFWS 2005). The overall range of the sea otter extends from northern Japan to

southern California. There are three recognized subspecies of *Enhydra lutris*, *E. lutris kenyoni*, referred to as the northern sea otter, with a range that extends from the Aleutian Islands in southwestern Alaska to the coast of the state of Washington (USFWS 2005).

Sea otters generally occur in shallow water areas near the shoreline where they forage in shallow water (Tetra Tech 2006). Visual observation of 1,251 dives by sea otters in Southeast Alaska, indicates that foraging activities typically occur in water depths ranging from 6 to 100 feet), although foraging at depths over 300 feet was observed (Bodkin et al 2004).

Sea otter movements are influenced by local climatic conditions such as storm events, prevailing winds, and in some areas, tidal conditions (Tetra Tech 2006). They tend to move to protected or sheltered waters during storm events or high winds (USFWS 2005). The home ranges of sea otters in established populations are relatively small and animals usually do not migrate or travel unless an area has become overpopulated or food is scarce (ADFG 1994d). Sexually mature females have home ranges of 5 to10 miles. Breeding males remain for all or part of the year within the bounds of their territory which ranges from 300 feet to 0.6 mile. Male sea otters that do not hold territories may move greater distances between resting and foraging areas than territorial males (USFWS 2005). Critical habitat designation was finalized on October 8, 2009. The critical habitat is designated in five discrete units considered important to the recovery of the northern sea otter. From west to east, these are: (1) Western Aleutian Unit; (2) Eastern Aleutian Unit; (3) South Alaska Peninsula Unit; (4) Bristol Bay Unit, and (5) Kodiak, Kamishak, Alaska Peninsula Unit. Within these five discrete units, critical habitat occurs in nearshore marine waters ranging from the mean high tide line seaward for a distance of 100 meters, or to a water depth of 20 meters. See http://alaska.fws.gov/fisheries/mmm/seaotters/pdf/SeaOtterCriticalHabitatMaps.pdf for maps of the critical habitat.

Sea otters mate at all times of the year, and young may be born in any season; however, in Alaska, most pups are born in late spring (ADFG 1994d). Females typically give birth in the water, although they have been observed giving birth on shore (USFWS 2005). Male sea otters appear to reach sexual maturity at 5 to 6 years of age and have a lifespan of about 10 to 15 years (Tetra Tech 2006). Female sea otters reach sexual maturity at 3 to 4 years of age and have a lifespan of about 15 to 20 years (USFWS 2005). Sea otters are gregarious and may become concentrated in an area, sometimes resting in pods of fewer than 10 to more than 1,000 animals (ADFG 1994d).

The search for food is one of the most important daily activities of sea otters, as large amounts are required to sustain the animal in healthy condition. Sea urchins, crabs, clams, mussels, octopus, other marine

invertebrates, and fishes make up the normal diet of sea otters (ADFG 1994d).

Prior to commercial exploitation, the world population of sea otter in the North Pacific Ocean was estimated to be between 150,000–300,000 individuals (USFWS 2005). Over the next 170 years, sea otters were hunted to the brink of extinction first by Russian and later by American fur hunters (Tetra Tech 2006). Sea otters became protected under the International Fur Seal Treaty of 1911; at that time the entire population may have been reduced to 1,000 to 2,000 animals (USFWS 2005).

By the 1980s, sea otters in Southwest Alaska increased in abundance and recolonized much of their former range. The population in Southwest Alaska is currently estimated at 41,865 animals (USFWS 2005).

Beluga Whale (*Delphinapterus leucas*). Beluga whales are one of the two members of the family Monodontidae and are divided into five stocks on the basis of mitochondrial DNA analyses: Cook Inlet, Bristol Bay, eastern Bearing Sea, eastern Chukchi Sea, and Beaufort Sea (NMFS 2007). Beluga whales are circumpolar in distribution, inhabiting subarctic and Arctic waters. In Alaska, their range extends from Yakutat to the Alaska-Canada Border in the Beaufort Sea. Some of the northern populations undertake seasonal migrations spending winters in the Bering Sea and following the receding sea ice to the Beaufort Sea in summer (NMFS 2007). Beluga whales tend to spend winters in offshore areas associated with pack ice or open leads and polynyas in ice-covered areas; in spring they move shoreward to estuaries, bays, and rivers.

NMFS stock assessment reports estimate the combined population of the five beluga whale stocks in U.S. waters at nearly 60,000 individuals (NMFS 2007). NMFS reports that the population trends for the Beaufort Sea and Eastern Bering Sea stocks are unknown; these two stocks account for over 90 percent of the estimated population of beluga whales in U.S. waters. The population of the Eastern Chukchi stock, consisting of 3,710 individuals, shows no evidence of decline, and NMFS considers the population of the Bristol Bay stock (1,619) to be stable to increasing (NMFS 2007).

Population trend analyses conducted on the Cook Inlet stock between June 1994 and June 1998 were constrained by the limited data available but showed a high probability that a 40 percent decline in the population had occurred during the time period (NMFS 2000a; NMFS 2005d). The Cook Inlet stock of beluga whales was placed on the ESA candidate list in 1991 (NMFS 1991). The stock was more recently determined to be depleted under the Marine Mammal Protection Act (NMFS 2000a).

Little information is available on the winter distribution of the Cook Inlet stock although some tracking data places individuals in the southern portions of the inlet in winter months. In summer, beluga whales

concentrate near the mouths of the sediment-laden rivers in the northern portion of the Cook Inlet.

NMFS investigated the potential sources of the decline of the Cook Inlet stock, identifying natural and human-induced sources of potential impacts that included:

- Habitat capacity and environmental change
- Strandings events
- Predation
- Subsistence harvest
- Commercial fishing
- Oil and gas development

Despite the imposition of mandatory and voluntary restrictions on subsistence harvests beginning in 1999, there has been no clear trend or indication that the population is increasing (NMFS 2005d). On October 22, 2008, the final determination to list a Distinct Population Segment of the beluga whale, *Delphinapterus leucas*, found in Cook Inlet as endangered was made. In January 2010, NMFS announced a notice of public hearings on the proposal to designate critical habitat for the endangered Cook Inlet beluga whale (75 FR 3191).

6.3 Effects of Permitted Discharges on Threatened and Endangered Species

This section summarizes potential impacts on threatened and endangered species from discharges from near-shore, and off-shore seafood processing operations covered under the permit. The primary concern is the volume of solid wastes discharged. Some of the dissolved constituents of the discharge, such as disinfectants, could produce toxicity at high concentrations. Further, chemical reactions, including reductions in dissolved oxygen, could result directly from constituents in the discharge as well as byproducts formed during the decomposition of seafood wastes. The potential effects of discharges therefore, could occur as direct or indirect impacts including burial, acute toxicity, reductions in prey availability, bioaccumulation, nutrient enrichment, habitat alternation and increased predation.

6.3.1 Fish

Assuming that that Snake River fall-run Chinook salmon, Snake River spring/summer run Chinook salmon, and Snake River sockeye salmon were to swim within the vicinity of a seafood processing waste discharge covered by the general permit, the potential for impacts is low. The fish are mobile and can transit out of the location of seafood processor waste discharge.

6.3.2 Birds

The short-tailed albatross is a pelagic seabird, although it has been observed within three miles of shore. Since they typically do not make use

of near-shore habitats, these birds would be more likely to be exposed to discharges from offshore facilities than those nearshore operations. Short-tailed albatross are surface feeders and the primary concern would be related to solid waste discharges and floating wastes, including offal as a food source.

Steller's and spectacled eiders are more likely to be present along the shorelines where they would be exposed to the discharges from nearshore facilities rather than the floating, offshore dischargers. Reed and Flint (2007) describe studies conducted in Dutch Harbor on the movement and foraging of Steller's eiders (and harlequin ducks). They found that eiders are attracted to an area around a seafood processing discharge and municipal wastewater discharge likely due to eutrophication and associated enrichment of prey species. As a result of this attraction, the eiders may be at greater risk of impacts due to increased predation by bald eagles and other avian species (Reed and Flint, 2007). Other effects of waste discharges on eiders have not been documented to date. The Alaska Sealife Center, however, is currently completing research on the eider health, including the occurrence of diseases.

Spectacled eiders may molt and overwinter in areas outside of the excluded areas. The reasons for their decline are not well understood but possibilities include increased predation by species such as glaucous-winged gulls, whose populations have been increasing in part as a result of the availability of fish processing wastes (USFWS 1996).

The permit lists protected areas excluded from coverage by the permit within 1 nautical mile of critical habitat for Steller's or spectacled eiders from May 1 through September 30, and within 1 nautical mile of a state game sanctuary, refuge, critical habitat area, national park, preserve, or wildlife refuge. These exclusions to areas that are areas in which Steller's and spectacled eiders spend the majority of their time should minimize potential effects to these species.

6.3.3 Marine Mammals

It is unknown if Steller sea lions are impacted directly by seafood processing plant discharges in Alaska, however due to their ability to swim, they can avoid both seafood waste and sanitary waste discharges. Designated critical habitat for Steller sea lions, within the aquatic zone in the area east of 144º W longitude (representing the endangered population), extends 20 nautical miles seaward in state and federally managed waters from the baseline or base point of each rookery or major haulout (NMFS 1994b). In the permit, excluded areas for discharges are located out to 3 nautical miles from a sea lion rookery or major haul-out.

The potential exists for indirect effects as a result of a decrease of prey abundance if the discharges have the potential to affect prey species (e.g., benthic organisms or demersal fish species). Because of the localized areas of effects, however, the effects due to loss of prey are likely to be limited.

Indirect effects further include the sea lions attraction to seafood processing waste discharges as well as to piles (to prey on the species foraging on the piles). In off-shore locations, killer whales are also attracted to the discharges and pose a threat of predation to the sea lions (Loughlin and York, 2000). For off-shore facilities, the attraction to seafood processing discharges places them at increased risk of human contact. The habituation to humans can be a danger to the animals if they become a nuisance and humans take action against them. Most of the offshore seafood discharges will occur in high tidal areas which allow for dispersion and dilution of the seafood wastes which should minimize the potential for sea lions or killer whales to be attracted to the discharge therefore minimizing predation from killer whales and contact with humans.

It has been documented that seafood processing wastes discharged from fish plants in the City of Cordova provided an easily accessible food source for sea otters and contributed to their morbidity and mortality. Sea otters were observed feeding at the fish processing outfalls and a large number of sea otter carcasses were being reported along the beaches around Cordova. During the winter months, the seafood plants were processing Alaskan pollock and Pacific cod. Sea otters did not suffer the same symptoms from consuming salmon waste during the summers. Therefore, the permits excludes coverage for the discharge of uncooked fish processing wastes during the months of November, December, January, February and March in Orca Inlet. The waste is cooked to kill parasites and soften the bones. Since this provision has been in the permit, there have been no more reports of sea otters dying around Cordova from these symptoms (ADEC, pers. comm.).

While deaths occurred in sea otters in Cordova located near Prince William Sound, Alaska, from consuming seafood processing wastes, it is unknown if seafood processing activities are affecting the threatened population in Southwestern Alaska (USFWS 2005). Sea otters in Southwestern Alaska have smaller population numbers, so natural food resources are more abundant and sea otters may be less likely to use the seafood waste discharge as a food source.

The potential also exists for sea otters to experience indirect effects that include a reduction in food sources in the form of burial of food or changes to the benthic community. Most of the offshore seafood processors will be in areas of high tidal activity allowing for dispersion of the wastes and less potential for waste piles to occur resulting in burial of prey resources. Because of the localized areas of effects and dispersion of wastes, the effects due to loss of prey are likely to be limited.

While the Cook Inlet stock of beluga whales feed within shallow waters on prey species that include benthic organisms the general location of their feeding activity in northern Cook Inlet would generally preclude them from direct interactions with fish processing vessels.

6.4 Summary

Species listed under the ESA that are likely to occur in waters that are included in the permit include fish, marine birds, and marine mammals. Specifically, spring/summer and fall run Snake River Chinook salmon (threatened), Snake River sockeye salmon (threatened), short-tailed albatross(endangered), Steller's eider (threatened), spectacled eider (threatened), blue whale (endangered), bowhead whale (endangered), fin whale (endangered), humpback whale (endangered), Northern Pacific right whale (endangered), sei whale (endangered), sperm whale (endangered), Steller sea lion (threatened and endangered populations), and northern sea otter (threatened) are all considered in this evaluation. There have been limited studies directed at evaluating the impacts of seafood processing waste discharges or other discharges from a seafood processing operation on these species, so the impacts are generally unknown. A potential advantage that the salmon, whales, sea lions and sea otters all share is their ability to swim out of harms way. However, seafood processing discharges can present a food source or can change the dynamic of the presence of other species foraging on the waste that may influence the endangered or threatened species.

Indirect effects include the loss of prey (including the alteration of prey habitat), the attraction of nuisance species and contamination from the discharges. Studies are being undertaken in the case of spectacled eiders to establish if the morbidity/disease rate has increased due to eider's feeding around seafood processing waste outfalls. Additional concerns have been raised that due to attraction to seafood processing waste discharges, there may be increased predation by larger birds.

7.0 Commercial, Recreational, and Subsistence Harvest

The determination of "unreasonable degradation" of the marine environment is to be made based upon consideration of the ten criteria listed in Section 1.0. This section provides information pertinent to consideration of the two ocean discharge criteria shown below:

- **Criterion #7:** "Existing or potential recreational and commercial fishing, including finfishing and shellfishing"
- **Criterion #8:** "Any applicable requirements of an approved Coastal Zone Management Plan."

This section will assist in evaluating criterion #7 by briefly describing the commercial, recreational, and subsistence fisheries in Alaskan waters, and discussing the potential impacts seafood waste discharges may impose on these activities.

Several district Coastal Zone Management Plans include provisions for the continuance of subsistence resources and harvesting within their jurisdiction. Therefore, discussions on subsistence harvests in this chapter are applicable to considerations of criterion #8.

7.1 Commercial Harvests

Alaskan waters sustain several commercially important fisheries. Major fisheries exist for salmon, groundfish, crab, herring, and shrimp. Other minor fisheries include invertebrates, such as scallops, clams, sea cucumbers, and abalone.

Activities covered under the permit result directly from commercial harvest of seafood from Alaskan waters. Section 2.1 discusses the location of commercial fisheries along with the characterization of the fish processing industry. Information on commercial harvests is presented briefly below.

7.1.1 Groundfish

The commercial groundfish fishery is the largest fishery in terms of pounds landed and value. The fishery consists chiefly of walleye pollock, Pacific cod, Pacific halibut, rockfish, flounder, and sablefish with walleye pollock and Pacific cod being the primary target species. The majority of groundfish harvested in Alaskan waters are taken in the Gulf of Alaska, Bering Sea, and off-shore waters of the Aleutian Islands.

Walleye pollock comprise the largest proportion of the catch for the Gulf of Alaska and Bering Sea fisheries. In these two areas, commercial fishing is concentrated along the outer continental shelf and upper slope.

The groundfish fishery is managed by imposing catch limits on target and bycatch species for specific management regions and by restricting fishing activities from specified areas (which may include important spawning and marine mammal habitats). The groundfish commercial fishery commences on the first of January and continues throughout the year until the fishery in a particular management region is closed due to catch or bycatch quotas

having been reached. A regulatory closure of the Bering Sea fishery for the protection of marine mammals from April through September results in a fishery that is concentrated in the first and last three months of the year in the Bering Sea.

Walleye pollock is the most abundant groundfish species in the Bering Sea and Aleutian Islands and constitutes the majority of the total groundfish harvested. Over 2.2 billion pounds are harvested annually from the Bering Sea and Aleutian Islands.

Pacific cod are harvested by foreign and domestic fisheries in the Bering Sea. The 1989 catch of this species was 376,896,240 pounds. Extremely large year classes in 1977 and 1984 resulted in high harvests for the past several years, however, as these year classes are removed from the fishery, harvests are expected to decline (U.S. DOI/MMS 1990).

The Pacific halibut fishery in the Gulf of Alaska has been an important fishery since the 1910s and the Bering Sea halibut fishery began in 1928. Halibut were traditionally harvested by Canadian and U.S. fishermen and Japanese and Soviet fishermen were allowed to fish in the Bering Sea from 1962 to 1976. In 1981, however, the fishery was restricted to domestic vessels only, although significant quantities continue to be taken by foreign fisheries as bycatch (Aleutians East CRSA 1984).

7.1.2 Salmon

The State of Alaska manages the salmon fishery which includes five harvested species: pink (*Oncorhynchus gorbuscha*), sockeye (*O. nerka*), Chinook (*O. tshawytscha*), coho (*O. kisutch*), and chum (*O. keta*). This fishery is separated into four management regions: Southeastern, Central, Arctic-Yukon-Kuskokwim, and the Westward Management Region.

The most abundant salmon species harvested in Alaskan waters is the pink salmon. In 2005, the highest volume of salmon harvested was in Prince William Sound at 208 million pounds with Southeast Alaska next at 124 million pounds. Sixty-two million pounds were harvested in Bristol Bay and the Naknek River. Other areas received lower harvest amounts.

The Bering Sea-Bristol Bay sockeye run is the largest run of this species in the world. Major salmon runs for this area occur in the Togiak, Nushagak, Kvichak, Egegik, Ugashik, Meshik, and Chignik river drainages (Bristol Bay Coastal Resource Service Area 1992).

The five salmon species are located in several different habitats in any given location. Cook Inlet may be used as an example of salmon habitat utilization. Adult salmon are present in near-shore and estuarine waters adjacent to the Kenai Peninsula from late April to early November and begin migration to freshwater from May to November. Juvenile salmon emerge from bottom substrates in freshwater from April to June. Pink and chum salmon move immediately downstream to estuarine areas while Chinook, coho, and sockeye remain in freshwater for one to four years

before moving to marine waters. Chum salmon remain within 30 miles of the shore during July through September and young Chinook remain in near-shore waters during their first year at sea.

7.1.3 Herring

The Pacific herring fishery is managed by the Alaska Department of Fish & Game. Pacific herring stocks occur from southeast Alaska to Norton Sound. The majority of the commercial harvest occurs in the form of sac roe with significantly smaller production for food and bait. The sac roe fishery occurs during the spawning season (from late March in southeast to July in the north) while the food and bait fishery occurs in the winter (southeast) and summer (Dutch Harbor). Fisheries are monitored and closed as necessary to maintain sustainable population numbers. The fishery in Prince William Sound, for example, has been closed since 1998 and fisheries in Cook Inlet have been limited to certain areas. Herring spawning grounds are located in the intertidal and shallow subtidal waters where they typically spawn on eelgrass, kelp, rockweed, and other marine vegetation (Pelican Coastal Management Program 1994).

7.1.4 Shellfish

Shellfish fisheries are composed chiefly of crab (Tanner, Dungeness, and king), shrimp, scallops, clams, sea cucumbers, and abalone. These fisheries are managed by the Alaska Department of Fish & Game in state waters and the North Pacific Fisheries Management Council in the Fisheries Conservation Zone. The crab fishery is the largest shellfish fishery and the fishing season varies with location, species harvested, and allowable catch. Large crab fisheries are located in the Bering Sea and Bristol Bay. Since the early 1980s, harvests of king and Tanner crab have been in decline (ADF&G 2005). Many of the king, Dungeness, Tanner, hair, and snow crab fisheries have been closed intermittently (and in some cases for multiple years) in different locations since 1998. Potential reasons for the depressed numbers include overharvest, decline in recruitment due to adverse climatic conditions, and unintentional bycatch of broodstock (ADF&G 2005).

Shrimp populations crashed in the western and central portions of the Gulf of Alaska in the late 1970s through the early 1980s. The crash coincided with a warming of the waters in these areas and increases in the populations of pollock, Pacific cod, and flatfish. As a result of the crash, fisheries in these portions of the Gulf of Alaska have been closed to trawling, Cook Inlet is closed to all shrimp harvests, and Prince William Sound is closed to commercial shrimp pot fishing. Shrimp production therefore is currently concentrated in Southeast Alaska where production levels have dropped since the mid-1990s although the fisheries are considered stable (ADF&G 2005).

Fisheries for scallops, clams, sea cucumbers, and abalone are generally on a much smaller scale than for other harvested invertebrates. Fisheries occur

throughout most of the year in various locations, depending upon species harvested, and are generally concentrated near coastal areas.

7.2 Recreational Harvests

Alaskan residents and non-residents participate in Alaskan recreational fisheries in all areas of Alaska. Since the early 1990s, a shift has occurred in the percentage of resident to non-resident participants in recreational fishing with continued increases in the number of non-residents purchasing sport fishing licenses. In 2003, over 477,000 non-residents purchased fishing licenses along with 188,000 residents (ADF&G 2006). While residents accounted for only 40 percent of the fishing licenses sold, they accounted for 60 percent of the days fished in 2003 (ADF&G 2006). The majority of the fishing effort has consistently occurred in the southcentral region (including Cook Inlet, Kenai Peninsula, Prince William Sound, and Kodiak), followed by the southeast region (the area from Ketchikan to Yakutat), and to a much lesser extent, the Arctic-Yukon-Kuskokwim region. Since 1993, the Kenai Peninsula has annually received the greatest number of angler-days fished (30 to 35 percent of the state total) with the Upper Copper/Upper Susitna Drainages and North Gulf Coast/Prince William Sound receiving the second-most number of angler-days (ADF&G 2006). The predominant species harvested are salmon, trout, Dolly Varden char, and Pacific halibut. Other species commonly harvested include herring, cod, clams (razor and steamer), crab, and shrimp. The 2003 marine fish harvested in all areas of Alaska included 177,102 Chinook salmon, 783,328 coho salmon, 447,492 sockeye salmon, 136,495 pink salmon, 34,110 chum salmon, 67,330 Dolly Varden char, 402,232 halibut, and 590,018 razor clams (ADF&G 2006).

7.3 Subsistence Harvests

Subsistence, as defined by state and federal law, is the customary and traditional non-commercial use of wild resources for a variety of purposes such as food, clothing, fuel, arts, crafts, sharing, and customary trade. Under State law, rural residents qualified for subsistence between 1978 and 1989; court rulings resulted in changes to qualifications for subsistence in 1990 where all Alaska residents may qualify as subsistence users (ADF&G 2000). Subsistence resources are important to the economy and culture of many Alaskan communities, especially for the residents of rural areas with limited road access. Subsistence harvests in many of these communities constitute a major proportion of the daily diets for these residents. Over 123,000 people in about 270 communities lived in rural areas in 1999 with 51 percent being Alaska Natives. Statewide, 95 percent of households in rural areas used fish gathered as part of subsistence activities and 86 percent used game (ADF&G 2000). Subsistence harvesting occurs in all regions of the state with the largest annual harvest occurring in the western and Arctic regions of the state, from the tip of southern Norton Sound to Kuskokwim Bay and from southern Norton Sound to the North Slope, respectively (Wolfe and Bosworth 1990).

Subsistence harvesting generally occurs in rivers and near-shore waters on a year round basis for shellfish and other marine invertebrates, and seasonally for salmon

and halibut. Species harvested include salmon, halibut, herring, whitefish (pollock), various shellfish and other invertebrates, marine mammals, and terrestrial mammals. Fish constitute the majority of the subsistence harvest, accounting for approximately 60 percent by weight of the total harvest (ADF&G 2000). The proportion of each species harvested varies among households and between communities. Marine mammals are allowed to be used as a subsistence resource by regulation and the numbers taken vary substantially among communities.

Waterfowl, particularly year round residents such as white-winged scoters, mallards, and goldeneyes, are harvested in winter months in coastal areas. Other ducks and geese are taken in the spring and fall when they are in coastal areas, rivers, and lakes.

7.4 Effects of Seafood Waste Discharges on Harvest Quantity

Commercial, recreational, and subsistence fisheries have the potential to be adversely impacted by seafood waste discharges either directly by the discharged processing wastes or indirectly through effects such as alteration of habitat and increased predation. Potential direct and indirect effects to these fisheries are discussed below.

7.4.1 Commercial Fisheries

Seafood waste discharges may adversely impact commercial groundfish fisheries in areas proximal to the discharges by decreasing fish stocks of walleye pollock and Pacific cod.

For example, walleye pollock form dense aggregations, particularly on the Alaska Peninsula side of Shelikof Strait and in the western Gulf of Alaska, during a spawning period from mid-March to early-May (Picquelle and Megrey 1993). Spawning produces a large concentration of eggs (ranging from 3,004 to 23,171/m^2) that generally remain below 492 feet for two weeks until hatching. Once hatched, the larvae tend to concentrate in the upper 164 feet and drift southwestward (Incze et al. 1989). Eggs have the potential to be smothered by the deposition of solids and larvae may be affected by increased predation from the attraction of fish and waterfowl to the discharges. The extent to which impacts could occur is dependent upon the type of wastes, the amount of wastes generated, and the location of the discharge.

The permit retains the prohibition of discharges within 1 nautical mile of designated critical habitat. All of Shelikof Strait has been designated as Steller sea lion critical habitat. Discharges to spawning grounds in the western Gulf of Alaska and eastern Aleutian Islands may potentially impact walleye pollock abundance.

Pacific cod produce large concentrations of demersal eggs which hatch after a 10 to 20 day incubation period. They are believed to spawn during the winter mainly in coastal areas with rocky bottoms. Although it is not likely, discharges during this time could adversely affect both egg and

larvae survival for the reasons listed above for walleye pollock. These effects are discussed further in Section 5.0.

7.4.2 Recreational and Subsistence Fisheries

The presence of near-shore and shore-based seafood processing plants, tenders, fishing vessels, and all the associated activities can impact recreational activities of anyone wishing to use that shoreline or waters near and around the seafood plant/vessel for other purposes. In some small rural, Alaskan communities, the locals are willing to accept the presence of a seafood processing plant for the economic gains of having a place to sell and process their fish. In other instances, the presence of seafood waste discharges increases the presence of species that are then harvested readily by recreational and subsistence fishers.

7.5 Summary

Alaskan waters sustain several commercially important fisheries. Major fisheries exist for salmon, groundfish, herring, and crab. Other minor fisheries include invertebrates, such as shrimp, clams, and scallops.

The groundfish fishery is the largest fishery in Alaska in terms of pounds harvested and employment. The commercial groundfish fishery consists chiefly of walleye pollock, Pacific cod, Pacific halibut, rockfish, flounder, and sablefish with walleye pollock and Pacific cod being the primary target species. The majority of groundfish harvested in Alaskan waters are taken in the Gulf of Alaska. Bering Sea, and off-shore waters of the Aleutian Islands. Five species of salmon are commercially harvested in Alaskan waters: pink, sockeye, Chinook, coho, and chum, with pink salmon being the most frequently harvested species. The Bering Sea Bristol Bay sockeye salmon run is the largest run of this species in the world.

Alaskan residents as well as non-residents participate in Alaskan recreational fisheries in all areas of Alaska. The majority of the fishing effort occurs in the southcentral region (includes Cook Inlet, Kenai Peninsula, Prince William Sound, and Kodiak), followed by the southeast region (includes area from Ketchikan to Yakutat), and to a much lesser extent, the Arctic-Yukon-Kuskokwim region. The primary species harvested are salmon, trout, Dolly Varden char, and Pacific halibut. Other species commonly harvested include herring, cod, clams (razor and steamer), crab, and shrimp.

Subsistence, as defined by state and federal law, is the customary and traditional non-commercial use of wild resources for a variety of purposes such as food, clothing, fuel, arts, crafts, sharing, and customary trade. Subsistence resources are important to the economy and culture of many Alaskan communities especially for the residents of rural areas with limited road access. Subsistence harvests in many of these communities constitute a major proportion of the daily diets for these residents. Subsistence statistics released by ADF&G indicate that approximately 123,000 people living in 270 communities qualified for subsistence within Alaska. Specific production figures are not available; however, 83 percent

of households reported harvesting fish and 95 percent reported using fish within the context of subsistence (ADF&G 2000).

Seafood waste discharges may potentially adversely impact commercial groundfish fisheries in areas proximal to the discharges by decreasing fish stocks of walleye pollock and Pacific cod. Walleye pollock and Pacific cod eggs have the potential to be smothered by the deposition of solids and larvae may be affected by increased predation from the attraction of fish and waterfowl to the discharges. The extent of potential impacts is dependent upon the type of wastes, the amount of waste generated, and the location of the discharge.

Near-shore habitats used for recreational and subsistence fisheries can be impacted by seafood process waste discharges. For example, in some instances, the presence of a fish plant, its associated vessel activity and dominance of the shoreline displaces recreational and subsistence fishers. However, in other instances, the presence of seafood waste discharges attracts fish that are then harvested by subsistence and recreational fishers. The positive or negative benefits vary on a case by case basis.

8.0 Alaska Coastal Management Program

The determination of "unreasonable degradation" of the marine environment is based on consideration of the ten criteria listed in Section 1.0.

Criterion #8: "Any applicable requirements of an approved Coastal Zone Management Plan"

Criterion #5: "The existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs"

8.1.1 Alaska Coastal Management Program- Air, land and water quality statewide standard

The 11 AAC 112.310.Air, land and water quality, ACMP statewide standard incorporates the statutes and regulations of ADEC with respect to the protection of air, land and water quality into the ACMP as the exclusive enforceable policies of the ACMP for those purposes. As of 2004 the issuance of an ADEC permit, certification, approval, and authorization by the Department establishes consistency with the Alaska coastal management program for the protection of air, land and water quality (11 AAC 110.010(d)).

According to ACMP statutes, discharges associated with floating seafood processing facilities covered under the APDES general permit are consistent with this statewide standard of the ACMP when the general permit is issued.

This assessment is based on the following findings:

- Discharges shall comply with ADEC APDES requirements and the Alaska's water quality criteria as discussed in Section 9.

8.1.2 Coastal District Enforceable Policies of an Approved Plan

According to ACMP regulation **11 AAC 110.760 Review process for resource agency general permits**, if a resource agency proposes a new or amended resource agency general permit, the permit is subject to a consistency review. Prior to coordinating a consistency review the Department consults with coastal districts through implementation of the *DEC Single Agency Coastal Management Consistency Review Procedures,* April 1, 2008, in order to determine if the permit includes activities subject to a coastal district enforceable policy (AS 46.40.096 (k)).

The specific aspects of an activity that are subject to an authorization by ADEC are excluded from consistency review processes according to AS 46.40. 040(b)(1). Also, the issuance of a ADEC permit establishes consistency with the Alaska coastal management program for those activities subject to the permit (AS 46.40.040(b)(1)). ADEC contacted affected coastal districts with approved coastal district plans. Based on district responses ADEC determined that a Department coordinated

consistency review is not required for the permit. The Department completed the *DEC Single Agency Coastal Management Consistency Review Procedures* and concluded that no additional ACMP process applies.

ADEC will submit the final permit to the State of Alaska, Division of Coastal and Ocean Management for inclusion in the "*List of Expedited Consistency Reviews and State Authorizations Subject to the ACMP*, Volume I, B List, Section II, General Permits and General NPDES Permits Statewide or More Than One Region". An individual seafood processing activity authorized under the terms and conditions of the permit are consistent with the Alaska Coastal Management Program for those activities subject to the permit.

8.1.3 ACMP Coastal District Special Aquatic Sites

8.1.3.1 Special Area management plans -ACMP regulation 11 AAC 114.400 allows a district to develop a special area management plan to manage a specific resource or activity within the district. Examples of a special area management plan include a harbor management plan, an ocean resource management plan, a public use management plan, a recreation management plan, a watershed management plan, and a wetlands management plan. A special area management plan may provide for increased specificity in protecting significant natural resources, coastal-dependent economic growth, improved protection of life and property in hazardous areas, and improved predictability in governmental decision making.

8.1.3.2 Areas which merit special attention –A district may develop a plan for an area which merits special attention in areas; important for subsistence uses; coastal resources important to subsistence uses; areas with special scientific value or a potential estuarine or marine sanctuary. Districts with approved AMSAs are Juneau, Ketchikan, Skagway, Cordova, Kenai, and the Matanuska Susitna Borough.

8.2 **Special Aquatic Sites**

8.2.1 Federal and State Special Aquatic Sites

8.2.1.1 All facilities covered under the permit are prohibited from discharging within the boundaries or within 1 nautical mile of a State Game Sanctuary, State Game Refuge, State Critical Habitat Area, National Park, Preserve, or Monument, National Wildlife Refuge or National Wilderness Area. A list of special aquatic sites is found in Appendix A and legal descriptions of the state special areas can be found in Alaska Statute section 16.20. The permit may allow a mixing zone with a maximum 100 foot radius and a maximum zone of deposit of up to 1 acre. While water quality criteria do not have to be achieved within mixing zones or zones of deposit, it is assumed that their small size and

relative distance from any sensitive habitats make impacts to special aquatic sites unlikely.

8.3 Summary

Waste discharges associated with seafood processing facilities in the area covered under the permit have been evaluated and determined to not cause unreasonable degradation of the marine environment based on the permit's consistency with ACMP Air, land and water quality statewide standard and coastal district enforceable policies. After implementing the *DEC Single Agency Coastal Management Consistency Review Procedures* ADEC determined that a consistency review was not required. No coastal district special aquatic site or approved plan enforceable policies were identified during the consultation with district coordinators. The proposed permit retains the prohibition of discharges within 1 nautical mile of federal and state special aquatic sites. If complied with, the maximum mixing zone size and the imposition of limits on the amount of residues that can be discharged greater than one mile from the boundary of a special aquatic site are adequate to protect these sites.

9.0 Marine Water Quality

The determination of "unreasonable degradation" of the marine environment is to be based on consideration of the ten criteria listed in Section 1.0. The following section provides information pertinent for the consideration of the ocean discharge criterion listed below:

Criterion #l0: "Marine water quality criteria developed pursuant to Section 304(a)(l)."

9.1 Introduction

The state of Alaska's marine water quality standards at Alaska Administrative Code (AAC) 18 Chapter 70 are established for the protection of the designated beneficial uses of the receiving water. These uses include 1) water supply for aquaculture, seafood processing, and industrial uses, 2) water recreation including primary or contact recreation (e.g., swimming) and secondary recreation (e.g., boating), 3) growth and propagation of fish, shellfish, and other aquatic life, and 4) harvesting for consumption of raw mollusks or other raw aquatic life."

Every three years, ADEC conducts a comprehensive review of the WQS in 18 AAC 70. This review helps to keep the pollution limits for Alaska's waters up to date by integrating the latest science and technology, and federal requirements into how the State regulates water quality. In 2006, ADEC completed a three year review of the WQS, made revisions to 18 AAC 70, and submitted the revisions for approval by EPA. EPA did not approve all of the revisions in the December 28, 2006 revision of 18 AAC 70. On July 1, 2008 ADEC adopted additional revisions to 18 AAC 70 and submitted them for EPA review. In 2009, ADEC made additional revisions to 18 AAC 70, which were adopted September 19, 2009. These revisions were submitted to EPA for review and approval, which EPA granted for certain revisions on September 17, 2009.

The revisions that have bearing on the permit are the mixing zone sections and residues standards of 18 AAC 70. Because EPA has not approved the 2009 mixing zone and residues standard revisions to 18 AAC 70, the controlling regulations for mixing zones are 18 AAC 70.240-270, as revised through June 26, 2003; and the residues standard is 18 AAC 70.020(b)(20), as revised through June 26, 2003. Except for those revisions that have not been approved by EPA, the applicable WQS for this permit are in 18 AAC 70, as revised through September 19, 2009.

The primary discharges of concern for water quality impairment result from the discharge of solid wastes that may accumulate in the vicinity of the discharge and the discharge of soluble wastes. Soluble wastes include soluble organic matter and nutrients with the potential to reduce the dissolved oxygen levels of the receiving water, enhance the growth of attached algae and phytoplankton, and alter phytoplankton species composition. Chlorine and other disinfectant wastes are an additional concern when these products are used to sanitize seafood processing work areas and are then discharged without treatment to the receiving water.

In this section the potential discharge resulting from seafood processing operations is discussed in terms of its compliance with state water quality criteria.

The permit may authorize up to a maximum 100-foot radius mixing zone, which is the same size as the previous permit. Further, under 18 AAC 70.210, the Alaska Department of Environmental Conservation (ADEC) may authorize a zone of deposit where water quality criteria may be exceeded. The permit may authorize a maximum one acre zone of deposit, which is the same size as allowed by the previous permit.

The state water quality criteria that are relevant to the evaluation of potential' adverse impacts of the discharge of seafood processing waste include:

- Residues
- Turbidity and color
- Petroleum hydrocarbons, oil and grease
- Dissolved oxygen
- Fecal coliform
- Toxic substances including residual chlorine, unionized ammonia, and undissociated sulfide
- pH
- Temperature

The application of these criteria is described below.

Under CWA Section 305(b), states are required to characterize all waters within its boundaries and under CWA Section 303(d), states are required to identify those waters that are impaired, i.e., not meeting applicable water quality standards. Alaska has complied with these requirements by preparing its Final 2008 Integrated Water Quality Monitoring Assessment Report which specifically identifies waterbodies impaired due to effects from seafood processing facility discharges. These waterbodies are discussed in Section 9.9.

9.1.1 Residues

The State of Alaska applies a residue standard to protect surface waters from accumulation of solid materials on the water surface, in the water column, along the sea bottom, and on the shoreline. Specifically, the water quality criteria for marine waters requires that *floating solids, debris, sludge, deposits, foam, scum, or other residues shall not alone or in combination with other substances or wastes cause the water to be unfit or unsafe for use; cause a film, sheen, or discoloration on the surface of the water or adjoining shorelines; cause leaching of toxic or deleterious substances; cause a sludge, solid, or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom, or upon adjoining shorelines.*

The State of Alaska adopted revised residue criteria. The revised criteria, however, were not approved by EPA and, therefore, have not been considered in developing the permit or preparing this ODCE.

Any deposition of seafood processing waste on the sea bottom would violate the residue criteria. As noted above, however, 18 AAC 70.210 allows ADEC to authorize zone of deposits. Water quality criteria and antidegradation requirements may be exceeded in a zone of deposit, but water quality criteria must be met at every point outside of the zone of deposit. The physical limits of the zone of deposit may be defined in a permit issued or certified under 18 AAC Chapter 70.015. ADEC, in deciding whether to authorize a zone of deposit, considers:

- The alternatives that would eliminate, or reduce, any adverse effects of the deposit
- The potential direct and indirect impacts on human health
- The potential impacts on aquatic life and other wildlife, including the potential for bioaccumulation and persistence
- The potential impacts on other uses of the water body
- The expected duration of the deposit and any adverse effects
- The potential transport of pollutants by biological, physical, and chemical processes.

ADEC has considered these items and has determined that the permit should retain the allowance for allowing a zone of deposit of up to one acre. No residue is allowed to accumulate outside of the zone of deposit and the permit retains the requirement to conduct seafloor surveys to measure seafood waste accumulations if a seafood processing waste discharge occurs for 7 days (168 hours) at a single location. Where EPA has found exceedances of the 1 acre pile size through review of seafloor surveys and compliance inspections, it has taken compliance and enforcement actions to ensure that the requirement is met. Where pile sizes of greater than 1.5 acres have been found from historic and ongoing seafood processing discharges, waterbodies have been identified as impaired (see Section 9.9) and total maximum daily loads (TMDLs) or other controls are required to address the impairment.

18 AAC 70.240 allows ADEC to authorize mixing zones, i.e., areas on the water surface or within the water column where water quality criteria can be exceeded provided certain requirements are met. The permit retains the authority to authorize up to a100 foot radius mixing zone for the pollutants listed above, including residues. All criteria must be met at the boundary of the mixing zone. The permit specifically includes sea surface monitoring to ensure compliance with this requirement. This includes determining the daily incidence of film sheen, or discoloration on the surface of the water or adjoining shorelines both within and outside the mixing. In addition, the permit requires development and implementation of best management

practices (BMP) to minimize the discharge of pollutants, including residues.

9.1.2 Turbidity and Color

Turbidity is regulated by numeric and narrative criteria depending on the designated use of the water. For marine water supply and recreational uses the criteria is m*ay not exceed 25 nephelometric turbidity units (NTU); may not reduce the depth of the compensation point for photosynthetic activity by more than 10%; and may not cause detrimental effects on established levels of water supply treatment.*

For Color, s*urface waters must be free of substances that produce objectionable color, and the water may not exceed 15 color units.*

Whether or not the state turbidity criteria will be violated depends on the initial dilution of the seafood wastewater and the optical properties of the solid waste particles and any dissolved organic matter. Because seafood processing waste effluent can contain an appreciable amount of suspended solids the turbidity standard of 25 NTU may be exceeded during the initial mixing of the wastewater discharge. However, due to dilution and settling of particulate solids the turbidity following initial mixing is likely to be lower than the 25 NTU criteria depending on the background turbidity of the receiving water.

The most stringent numeric color criteria is for seafood processing water supply use, 15 color units or the natural condition whichever is greater. This must be achieved at the boundary of an authorized mixing zone.

Violations of the narrative turbidity and color criteria for the compensation point for photosynthetic activity and Secchi depth will depend on the ambient conditions at each discharge location. However, considering the potential for exceedance of the turbidity criteria, violation of the narrative criteria will likely be confined to the area of any visible surface plumes, which are prohibited outside of the mixing zone.

9.1.3 Petroleum Hydrocarbons and Oil and Grease

Oil and grease is regulated by numeric and narrative standards depending on the designated use of the water. The following numeric criteria are established for the protection of water supplies for aquaculture and for the protection of growth and propagation of aquatic life and wildlife:

Total aqueous hydrocarbons (TAqH) in the water column may not exceed 15 ug/L. Total aromatic hydrocarbons (TAH) in the water column may not exceed 10 ug/L. The discharge may not cause a film, sheen, or discoloration on the surface or floor of the waterbody or adjoining shorelines. Surface waters must be virtually free from floating oils. There may be no concentrations of animal fats in shoreline or bottom sediments that cause deleterious effects to aquatic life. Substances shall not exceed concentrations that individually or in combination impart undesirable odor

or taste to organisms as determined by either bioassay or organoleptic tests.

Although relatively small amounts of petroleum hydrocarbons derived from machinery lubricating oils may be discharged along with the seafood processing waste, the primary water quality concern is the creation of floating oil sheens derived from fish and shellfish fats and oils that are discharged as wastes. Some petroleum hydrocarbon releases associated with vessel and boat operations (e.g., refueling) may also occur. As with foam and floating material, the presence of a floating oil sheen will depend on the physical and chemical characteristics of the discharged wastewater and the receiving water.

The permit does not authorize the discharge of seafood sludge, deposits, debris, floating solids, oily wastes or foam that would cause a film, sheen, or emulsion on the surface water or a scum, emulsion, sludge, or solid to be deposited on the shore outside of the mixing zone. It also does not authorize a discharge that would cause a scum, emulsion, sludge or solid outside of the ZOD.

9.1.4 Dissolved Oxygen

Numeric dissolved oxygen criteria have been established for the protection of marine water uses. *Surface dissolved oxygen (DO) may not be less than 6.0 mg/l for a depth of one meter, except when natural conditions cause this value to be depressed. DO in estuaries and tidal tributaries may not be less than 5.0 mg/l, except where natural conditions cause this value to be depressed. DO may not be reduced below 4 mg/l at any point below the surface.*

Dissolved oxygen concentrations at the surface of cold marine waters in Alaska are typically greater than 7.0-8.0 mg/L. As a result, it is expected that dissolved oxygen levels near the surface at the edge of seafood processing mixing zones should be greater than 6.0 mg/L. Where naturally depressed dissolved oxygen levels are found, the surface concentrations at the edge of mixing zone should approximate the natural conditions as allowed by the criteria. Monitoring performed in 2003 by Tetra Tech for ADEC downstream of 2 seafood processing discharges in Ketchikan consistently showed dissolved oxygen levels above 8.0 mg/L. The samples were collected at 6-12 foot depth from 20 to 4,000 feet down gradient of the discharge points (Tetra Tech 2003).

Dissolved oxygen concentrations may also be depleted in the water column near decaying bottom accumulations of seafood waste due to bacterial oxidation of the seafood waste. Chemical oxidation of the reduced byproducts of bacterially-mediated waste decay (e.g., methane and sulfide) also act to reduce water column dissolved oxygen concentrations above decaying seafood wastepiles. Seafood wastepile modeling studies of a relatively large wastepile accumulation [approximately 3 acres or more] in Akutan Harbor, a harbor with restricted water exchange, indicated that

oxygen consumed by wastepile decay and decay byproducts did not reduce ambient dissolved oxygen concentrations by more than 6-7 percent (Tetra Tech 1986). More recent work, however, has shown benthic impacts associated with low dissolved oxygen concentrations at the sediment/water column interface in areas beyond the boundaries of the ZOD (Germano & Associates 2004). The permit does not require any dissolved oxygen monitoring to verify compliance with the standards.

9.1.5 Fecal Coliform and Enterococci

The most stringent marine water quality criteria for fecal coliform is, *based on a 5-tube decimal dilation test, the fecal coliform median MPN may not exceed 14 FC/100 ml and not more than 10% of the samples may exceed a fecal coliform median MPN of 43 FC/100 ml.* The water quality criteria for enterococci bacteria is, t*he geometric mean shall not exceed 35/100 ml and a single sample maximum of 501/100 ml for infrequent use of coastal recreation waters [40 CFR 131.41]*. These are the criterion that must be met at the edge of the mixing zone. With the dilution available at the boundary of the authorized mixing zone and the technology based bacteria standard for a properly operating MSD of 200 colonies per 100 milliliters, the fecal coliform standard should be met at the boundary of the mixing zone. The permit requires a BMP plan be developed and implemented to meet the applicable pollution control standards for the proper operation of a Type II MSD.

Microbiological monitoring is not required in the permit due to the extreme difficulty in getting samples analyzed in accordance with approved methods. While it will not be verified that the numeric bacteria criteria will be met at the boundary of the mixing zone, with BMP controls it is likely that the criteria will be met at the boundary of the mixing zone.

9.1.6 Toxics and Other Deleterious Organic and Inorganic Substances

The toxic pollutants of concern for seafood processing waste include residual chlorine, unionized ammonia, and undissociated sulfide.

9.1.6.1 Total Residual Chlorine

Disinfectants, including chlorine-based products, are used in the seafood processing industry to destroy potential disease-causing microorganisms that could contaminate finished seafood products destined for human consumption. The Food and Drug Administration (FDA) regulations mandate frequent cleaning (through the use of alkaline detergents) and disinfection (through the use of hypochlorites, iodophors, and quaternary ammonium compounds) of seafood processing utensils, equipment, and processing areas to minimize microbiological contamination of seafood products (21 CFR 123). Associated with the benefits of disinfection, however, are potential adverse effects associated with the reaction of chlorine and chlorine compounds with organic matter and ammonia in the wastewater.

Disinfectant reaction byproducts include potentially carcinogenic chlorinated organic compounds and toxic forms of chlorinated ammonia and chloroamines. In freshwater, chlorine reacts with water to form hypchlorous acid, hypochlorite ion, and other reactive forms that include mono- and dichloroamines. These reactive forms are termed "residual chlorine". In seawater, chlorine also reacts with bromide to form hypobromous acid, hypobromite ion, and bromamines. Therefore, the term "chlorine-produced oxidants" is used to refer to the residual chlorine forms measured in seawater.

Marine water quality criteria for total residual chlorine have been established by the State of Alaska. *The 1 hour average shall not exceed 13 µg/l and 4 day average shall not exceed 7.5 µg/l.*

Because the complexity of the reactions of chlorine in fresh and marine waters (Carpenter and Smith 1980; Johnson 1980) it is difficult to assess the potential adverse effects of the intermittent application of disinfectants to seafood processing areas. No data are available on the typical amounts and rates of application of active disinfectant ingredients in a typical Alaskan seafood processing facility. However, it is assumed that residual chlorine concentrations in the effluent discharged to the receiving water is low considering the following:

The equipment to be disinfected is first washed to remove much of the visible organic residue and contamination to minimize the quantity of disinfectant required. The disinfectants are applied in diluted form only to the areas to be disinfected.

The process wastewater effectively dilutes residual disinfectant concentrations.

The residual chlorine compounds remaining after equipment disinfection are reduced when they contact the high concentration of readily oxidized organic waste matter in the wastestream.

The permit does not include chlorine monitoring at the discharge point or at the edge of the mixing zone. The permit does include a requirement that a BMP plan be developed and implemented to minimize the use of chlorine-based or other toxic disinfectants or limiting their potential exposure to process wastewater. While it will not be verified that the numeric chlorine criteria will be met outside the mixing zone, with BMP controls it is likely that the criteria will be met at the boundary of the mixing zone.

9.1.6.2 Unionized Ammonia

Unionized ammonia can be toxic to marine organisms. The concentration of unionized ammonia depends on the total ammonia concentration and the salinity, temperature, and pH of the water. A relatively conservative estimate of the chronic criterion for total

ammonia, based on a salinity of 30 parts per thousand (ppt), pH of 8.2, and water temperature of 15° C, is 0.8 mg-N/L.

Sources of ammonia attributable to seafood processing discharges include ammonia dissolved in the seafood processing wastewater, ammonia used in refrigerants, and ammonia released from the decaying waste organic matter in the water column or from seafood waste that has accumulated on the bottom.

Review of historical water quality studies conducted in confined bays in the vicinity of active Alaskan seafood processing discharges (Tetra Tech 1993; Tetra Tech 1986; Jones & Stokes Associates and Tetra Tech 1984; Feder and Burrell 1979; USEPA 1976) indicates that maximum water column total ammonia concentrations did not exceed 0.75 mg/L. No more recent data are available. The historical data, however, remain valid because ammonia use has not changed in the industry over the past 20 years.

Ammonia nitrogen is also produced by the bacterially-mediated decay of seafood waste, particularly during the anaerobic decay of seafood wastepile accumulations (see Section 3.1.3). Although Tetra Tech (1987) attempted to develop a simple wastepile decay model to predict the concentration of ammonia nitrogen above a seafood wastepile in Akutan Harbor, the model predicted higher water column concentrations of total ammonia (greater than 1.0 mg/L) than were actually measured above the wastepile (0.22 mg/L). Overestimation of ammonia released from decaying organic matter using simple stoichiometric models has been noted in other studies (e.g., Almgren et al. 1975). Additional loss processes not considered by this model included nitrification and assimilation of the released ammonia. These processes likely reduce the actual concentration of total ammonia to concentrations below levels predicted to be harmful to marine organisms.

9.1.6.3 Undissociated Sulfide

Hydrogen sulfide (H_2S) is produced by the anaerobic decay of organic matter by bacteria that use sulfate as an electron acceptor (see Section 3.1.3). In seawater most of the hydrogen sulfide (approximately 97.5 percent) dissociates to HS^- and H^+ at the pH, temperature, and salinity of Alaskan marine waters (Tetra Tech 1987; Goldhaber and Kaplan 1975). The remaining undissociated sulfide (approximately 2.5 percent) can be toxic to marine organisms. The saltwater chronic criterion for undissociated sulfide is 2.0 µg/L

Because hydrogen sulfide in marine water occurs primarily in the dissociated form, and because hydrogen sulfide is also rapidly oxidized to sulfate in sea water (Almgren and Hagstrom 1974), undissociated sulfide concentrations above seafood waste piles are expected to be below water quality criteria, except possibly just above the waste pile

(Tetra Tech 1987). The undissociated hydrogen sulfide concentrations within the pile likely occur at concentrations that exceed water quality criteria, especially in anaerobic zones of the waste pile where oxidation of the released hydrogen sulfide does not occur.

9.1.7 pH

The most stringent applicable water quality criterion for pH is *pH shall be no less than 6.5 or greater than 8.5, and shall not vary more than 0.2 pH units from the naturally occurring range*. Some of the wastewater associated with seafood processing wastes can be slightly akaline or acidic but should generally be within the range of the water quality criteria. This is evidence by monitoring data from individual permits, which show most values within the 6.5-8.5 range between 2002 and 2005. All values ranged between 6.3 and 9.4. Given the neutral background levels in Alaska marine waters, the pH values at the edge of the mixing zone should be within the most stringent criterion range.

9.1.8 Temperature

The most stringent applicable water quality criterion for temperature in marine water, *may not exceed 15º C and may not cause the weekly average temperature to increase more than 1º C. Normal daily temperature cycles shall not be altered in amplitude or frequency.* While there may be some wastewater discharges that have elevated temperature (such as cooking water and boiler water), the primary component of the discharge is process water which will likely be below the water quality criteria. Given the volume of water available for dilution, the temperature at the boundary of the mixing zone should be within the criterion range.

9.2 Degraded Water Resources

In accordance with the requirements of the CWA, the State of Alaska has identified those waters which are impaired. *Alaska's Final 2008 Integrated Water Quality Monitoring and Assessment Report*, indentified the following waterbodies as impaired due to seafood processing activity:

- Udagak Bay – residues, TMDL completed.
- South Unalaska Bay – Residues and dissolved oxygen. TMDL completed.
- Akutan Harbor – residues and dissolved oxygen. TMDL completed.
- King Cove – residues. TMDL completed.
- Popof Strait – residues. 303(d) listed, no TMDL completed.

The permit excludes from coverage any discharge to a waterbody that has been identified in ADEC's most recent *Final Integrated Water Quality Monitoring and Assessment Report* which are impaired or water quality-limited for pollutants authorized by the permit

9.3 Summary

The permit contains requirements to comply with all applicable marine water quality criteria. If an operator complies with the permit limits and monitoring requirements then exceedances of water quality criteria outside of the mixing zone and zone of deposit should generally be prevented. There is, however, uncertainty regarding compliance with the residual chlorine, dissolved oxygen, and bacteria criteria since no monitoring or limits for these pollutants are included in permit, but BMP plans are required to minimize the discharge of chlorine and for the proper operation of the MSD that would control the bacteria discharges.

10.0 Determination of Unreasonable Degradation

Section 1.0 of this ODCE provides the regulatory definition of unreasonable degradation of the marine environment (40 CFR 125.121[e]) and indicates the ten criteria which are to be considered when making this determination (40 CFR 125.122). The actual determination of whether the discharge will cause unreasonable degradation is made by the Department. Section 10.1 briefly summarizes information pertinent to the determination of unreasonable degradation with respect to the ten criteria.

10.1 Determination Criteria

10.1.1 Criterion 1

The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged.

- Seafood processors operating under the AKG520000 permit discharged over 1 billion pounds of solid waste in 2005. Of the facilities that reported their projected annual discharges during the term of the existing permit, 54 indicated that they planned to discharge between 5 and 10 million pounds of seafood processing solid waste. These facilities also discharge soluble wastes that may reduce dissolved oxygen concentrations and can contain nutrients (nitrogen and phosphorus) and diluted disinfectant solutions as well as other low-volume, miscellaneous waste waters.
- The quantity and character of seafood processing wastes varies seasonally depending on the species processed and the types of products that are produced.
- Seafood processing wastes are not expected to contain significant quantities of pollutants that may bioaccumulate in aquatic organisms, and therefore are not expected to pose a long-term threat to the health of aquatic organisms or humans. Solid wastes have been observed to accumulate and persist in the vicinity of seafood processing waste discharges.

10.1.2 Criterion 2

The potential transport of such pollutants by biological, physical, or chemical processes.

- The extent of the initial accumulation of solid waste on the bottom depends on the height of the discharge above the seafloor, current speed, and the settling velocities of the waste particles. The extent of bottom waste accumulation over the long-term depends primarily on the volume of waste discharged, the decay rate of the waste organic matter and the degree of resuspension and transport of the deposited waste.
- Soluble wastes from these discharges are expected to be rapidly diluted or degraded by biological, physical, and chemical processes.

10.1.3 Criterion 3

The composition and vulnerability of the biological communities which may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the ESA, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain.

- Benthic communities in the area of seafood waste discharges may be adversely impacted by smothering or anoxic conditions due to decay of the accumulated organic wastes. Benthic communities outside the zone of deposit may also be impacted due to anoxic or hypoxic conditions in the sediments due to the waste as it fans out and disperses. However, the impacts to benthic communities should be minimal as mobile offshore seafood processors are located in areas of high tidal activity which allows for dispersion and dilution of wastes and minimizes the potential for accumulation of these wastes in waste piles.
- Cetaceans found in Alaskan waters currently identified as endangered species pursuant to the ESA include the following: blue, bowhead, fin, gray, humpback. North Pacific right, sei, and sperm whales. There are no cetaceans currently identified as a threatened species. The Steller sea lion and northern sea otters, both of which occur from southeast Alaska to the Bering Strait, are listed as a threatened species pursuant to the ESA. The short-tailed albatross is a marine bird identified as endangered while Steller's eider and spectacled eider are waterfowl presently identified as threatened. The Snake River sockeye salmon and Snake River spring/summer and fall Chinook salmon are presently identified as endangered and threatened species, respectively. The discharge of offshore seafood processing wastes are not likely to adversely effect the following species: blue, bowhead, gray, fin, humpback, North Pacific right, sei and sperm whales, short-tailed albatross, Snake River sockeye salmon, and Snake River spring/summer and fall Chinook salmon. The Steller sea lion and northern sea otter may be impacted by attraction to seafood waste discharges putting them at risk for parasites or predation by other species, however, the dispersion of the wastes by offshore seafood processors should minimize these impacts and therefore Steller sea lion and northern sea otters are not likely to be adversely affected. The Steller's and spectacled eider have the potential to be impacted from increased localized populations of gulls and parasitic birds which may adversely affect breeding success, however, the dispersion of seafood wastes by offshore processors should minimize this impact and therefore Steller's and spectacled eiders are not likely to be adversely affected.

10.1.4 Criterion 4

The importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism.

- There are numerous areas in the Alaskan coastal waters that are important areas for a variety of species, ranging from phytoplankton to marine mammals. Areas in the Chukchi Sea include most coastal waters. These areas are used by a variety of marine mammals for migration and feeding. The Bering Sea is also an important area for many species including crab species, many commercial fish species, and many marine birds and mammals. Bristol Bay and the Yukon-Kuskokwim Delta are important areas for sockeye salmon, seabirds and waterfowl.
- The Aleutian Islands and the Pribilof Islands, in particular, are very important areas for marine mammals and seabirds. Discharges from facilities operating in the Pribilof Islands are excluded from coverage under the permit and are covered in a separate permit. Exclusions for a number of important ecological areas in the Aleutians prohibit discharges in these areas.
- St. George Island supports possibly the largest thick-billed murre colony in the world and is also the primary nesting area for most of the world's population of red-legged kittiwakes. Discharges from facilities operating on St. George Island are excluded from coverage under the permit and are covered in a separate permit.
- Shelikof Strait/Cook Inlet is a known migratory route for gray whales and a possible migratory route for fin and humpback whales. This area is also a major spawning area for walleye pollock. Cook Inlet and Kachemak Bay are important areas for killer whales, beluga whales, Dall's porpoises, and harbor porpoises. Sea otters utilize the Kenai Peninsula, Kodiak Island, and Cook Inlet areas. Steller sea lions use the entire coastal area, with Shelikof Strait being a particularly critical habitat resource area.
- Areas of major significance to waterfowl include lower and upper Cook Inlet, Kodiak Island, and the eastern side of the Alaska Peninsula. Kachemak Bay, Shelikof Strait, and the Barren Islands are important resource areas for many seabirds. In the Gulf of Alaska, important areas include the Copper River Delta, Prince William Sound and several bays in Cook Inlet. The largest concentration of waterfowl during spring and fall are found in the Kenai Lowlands, Trading Bay, Redoubt Bay, and Fox River Flats.
- Karnishak Bay, Kachemak Bay, and pan of Shelikof Strait are nurseries for Tanner crab as well as important habitats for King and Dungeness crabs.

10.1.5 Criterion 5

The existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs.

- There are eight national wildlife refuges (Alaska Maritime, Alaska Peninsula, Becharof, Izembek, Kenai, Kodiak, Togiak, and Yukon Delta), twelve state game refuges and sanctuaries (Anchorage Coastal, Cape Newenham, Goose Bay, Mendenhall Wetlands, Palmer Hay Flats, McNeil River, Susitna Flats, Trading Bay, Yakataga, McNeil River, Stan Price, and Walrus Islands), six national parks and preserves (Bering Land Bridge, Katmai, Kenai Fjords, Lake Clark, Wrangell-St. Elias, and Glacier Bay), and two national monuments (Aniakchak and Cape Krusenstern), which exist in the vicinity of potential seafood processing activities.
- Twelve state designated Critical Habitat Areas (CHA) exist in the vicinity of potential seafood processing wastes discharges: Cinder River, Clam Gulch, Copper River Delta, Egegik, Fox River Flats, Kachemak Bay, Kalgin Island, Pilot Point, Port Heiden, Port Moller, Redoubt Bay, and Tugidak.
- NMFS has designated critical habitat for the Steller sea lion pursuant to the Endangered Species Act. Specific sites include: all Steller sea lion rookeries and major haulouts (> 200 sea lions) located within state and federally managed waters off Alaska, including a zone that extends 3,000 feet landward of each rookery and haulout and a vertical boundary that extends 3,000 feet seaward from rookeries and major haulouts located east of 144° W longitude. The horizontal boundary extends 20 nautical miles seaward from rookeries and major haulouts west of 144° W longitude, and one aquatic foraging zone located exclusively in the Gulf of Alaska and two aquatic zones located in the Bering Sea/Aleutian Islands area. All of Shelikof Strait has been designated as critical habitat. Air zones extending 3000 feet above these terrestrial and aquatic zones have also been designated as critical habitat.
- The permit will retain the exclusion for coverage of discharges that occur within one nautical mile of sensitive areas including those discussed above. In addition, the permit excludes areas within 3 nm of rookeries and haulouts for Steller sea lion and excludes critical habitat for Steller's and spectacled eider.

10.1.6 Criterion 6

The potential impacts on human health through direct and indirect pathways.

- Seafood processing waste discharges are not expected to result in impacts to human health. However, when seafood wastes have been

commingled with sanitary wastewater, this contaminated waste was observed on beaches where humans were setting drift nets and set netters in the vicinity of the plume. In this kind of instance, there is a chance of human contact with contaminated seafood waste and potential for disease or pathogen contact. Seafood discharges are not thought to contain significant quantities of pollutants that bioaccumulate in aquatic organisms. Therefore seafood processing discharges are not expected to result in elevated levels of toxic or carcinogenic pollutants in marine organisms consumed by humans. However, there have been no known studies to evaluate this relationship.

10.1.7 Criterion 7

Existing or potential recreational and commercial fishing, including finfishing and shellfishing.

- Nearshore locations used for recreational and subsistence fisheries can be impacted by seafood processing waste discharges under the limitations and conditions set forth in the reissued general permit.
- Commercial fisheries in Alaska include: salmon, groundfish (chiefly walleye pollock, Pacific cod, and Pacific halibut), herring, Tanner, Dungeness, and king crabs, clams, shrimp, scallops, and abalone. Seafood waste discharges may potentially adversely impact stocks of walleye pollock and Pacific cod. The likelihood of impacts to these species is strongly dependent on the timing, composition, quantity, and location of discharges, although the overall impact is assumed to be minimal. Other species commercially harvested are also assumed to not be impacted.

10.1.8 Criterion 8

Any applicable requirements of an approved Coastal Zone Management Plan

ADEC contacted affected coastal districts with approved coastal district plans. Based on district responses, ADEC determined that a Department coordinated consistency review is not required for the permit in accordance with the *DEC Single Agency Coastal Management Consistency Review Procedures*.

10.1.9 Criterion 9

Such other factors relating to the effects of the discharge as may be appropriate.

Concerns have been raised about potential indirect effects of the discharge of seafood processing waste on marine organisms. These indirect effects include the following:

- Nutrient enrichment of coastal waters which may result in enhanced biomass of phytoplankton and alteration of plankton species

composition. Toxic phytoplankton species may occur more frequently and at higher levels under these conditions resulting in adverse effects to aquatic organisms, and potentially to human health.

- The attraction of marine mammals to waste discharges which makes them easier prey for predators.
- The attraction of seabirds to waste discharges which may result in a number of adverse effects that range from oiling, enhancement of the numbers of species of gulls that may adversely affect threatened or endangered bird species, and adverse effects on birds that consume decaying, bacterially contaminated seafood waste.

These concerns should be minimal due to the fact that mobile offshore seafood processors will be located in areas of high tidal activity allowing for dilution and dispersion of seafood waste discharges.

10.1.10 Criterion 10

Marine water quality developed pursuant to Section 304(a) of the Clean Water Act.

The regulated discharge of seafood processing waste is expected to comply with relevant water quality criteria.

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APPENDIX A

ADEC compiled the following list of waters excluded from coverage under the permit. **This list is only a partial list of all of the waters that are excluded from coverage.** The operator is responsible for determining that a proposed discharge is **not** to an excluded water.

Code to abbreviations used for status:

NM – national monuments
NP – national parks
Np – national preserves
NP&p – national parks and preserves
NM&p-national monuments and preserves
NWR – national wildlife refuges
NWA – national wilderness areas

SCHA – state critical habitat areas
SGR – state game refuge
SGS – state game sanctuary

SMP-state marine park
SP-state park
SSCH – Steller sea lion critical habitat
W&SR – wild and scenic river
WQ-ar – water quality at-risk
IW – Impaired waterbodies
TMDL –Total Maximum Daily Load allocations completed for waterbodies

SBN – seabird nesting areas
SECH – Steller's eider critical habitat
SEWA – Steller's eider wintering habitat

Receiving Waters	Location	Status	Excluded Area
1. Admiralty Island, rivers and coastal waters	Admiralty Island, SE Alaska	NM	Admiralty Island National Monument
2. Akutan Harbor	Akutan Island, Eastern Aleutians	TMDL	Akutan Harbor
3. Alagnak River	Bristol Bay lowland west of the Katmai National Park and Preserve.	W&SR	Alagnak River, 67 miles.
4. Alatna River	Central Brooks Range	W&SR	Alatna River, 83 miles
5. Aleutian Islands, coastal waters	Bering Sea, Gulf of Alaska, Chukchi Sea, Pacific Ocean	NWR	Alaska Maritime NWR
6. Alinchak Bay	Alaska Peninsula	NWR	Becharof NWR
7. Alitak Bay	Kodiak Island	NWR	Kodiak NWR
8. Amber Bay	South central Alaska Peninsula	NM&p	Aniakchak NM&p
9. Anchor River	In the center of the southern Kenai Peninsula, north of Homer.	SCHA	Anchor River-Fritz Creek SCHA
10. Aniakchak Bay	South central Alaska Peninsula	NM&p	Aniakchak NM&p
11. Aniakchak River	South central Alaska Peninsula	W&SR	Aniakchak River, 63 miles, within the Aniakchak NM&p
12. Atka Island, includes Nazan and Korovin Bay	Aleutians	NWR	National Maritime Wildlife Refuge
13. Baird Inlet	West of Bethel	NWR	Yukon Delta NWR
14. Big River wetlands, north Redoubt Bay	West of the town of Nikiski	SCHA	Redoubt Bay SCHA
15. Chagvan Bay	South of Goodnews Bay	SGR/NWR	Togiak NWR

Receiving Waters	Location	Status	Excluded Area
16. Charley River	Between the towns of Eagle and Circle in Interior Alaska	W&SR	Charley River, stretch of the larger Yukon River, 208 miles, W&SR within the Yukon-Charley Rivers Natural Preserve
17.Chilikadrotna River	Central Brooks Mountain Range	W&SR	Chilikadrotna River, 11 miles, W&SR within the Lake Clark NP&p
18. Chilkat River Wetlands	Adjacent to Klukwan, north of the City of Haines	SCHA	Chilkat River, SCHA
19. Chinitna Bay	West of Homer on the west side of Cook Inlet	NP&p	Lake Clark NP&p
20. Chuck River	Flows into Windham Bay, north of Hobart Bay, SE Alaska	NWA	Chuck River NWA
21 Cinder River Delta and tidal flats	SW of the village of Pilot Point	SCHA	Cinder River SCHA
22. Cold Bay	Near town of Cold Bay on the Alaska Peninsula	NWR	Alaska Peninsula NWR, Izembek NWR
23. Cook Inlet shoreline near Kasilof	From Cape Kasilof south along the coastline to Happy Valley.	SCHA	Clam Gulch SCHA
24. Copper River Delta	SE of the City of Cordova	SCHA	Copper River Delta SCHA
25. Coronation Island coves, bays and harbor	Located off the northwest coast of Prince of Wales Island, south of Kuiu Island and north of Noyes Island.	NWA	Coronation Island NWA
26. Cross Sound	A passage in the Alexander Archipelago located between Chichagof Island to its south and the mainland to its north. It is 30 miles long and extends from the Gulf of Alaska to Icy Strait.	NP&p	Glacier Bay NP&p
27. Cube Cove	Located on the northwestern side of Admiralty Island	NM	Admiralty Island NM
28. Dixon Harbor	North Alexander Archipelago	NP&p	Glacier NP&p
29. Dude Creek	Located north of Icy Passage west of the town of Gustavus	SCHA	Dude Creek SCHA
30. Egegik Bay, southwest portion	West of the town of Egegik	SCHA	Egegik SCHA
31. Endicott River	Chilkat Peninsula, on the west side of Lynn Canal, 45 miles NW of Juneau and 30 miles south of Haines in SE Alaska.	NWA	Endicott River NWA
32. Etolin Island, coves, bay and inlets around the wilderness area.	South end of Etolin Island about midway between Ketchikan and Wrangell on the Inside Passage, and about 15 miles north of the community of Thorne Bay across Clarence Strait.	NWA	South Etolin NWA
33. False Pass	Located on Unimak Island on the southern end of the Alaskan Peninsula.	NWR, SEWA	Alaska Peninsula NWR, Alaska Maritime NWR Steller's Eider wintering area

Receiving Waters	Location	Status	Excluded Area
34. Fox River Delta	Located at the head of Kachemak Bay, NE of the town of Homer	SCHA	Fox River Flats SCHA
35. Fritz Cove	Stretches 9 miles along Gastineau Channel north west of downtown Juneau, SE Alaska	SGR	Mendenhall Wetlands State Game Refuge
36. Fritz Creek	In the heart of the southern Kenai Peninsula, spanning the Anchor River and Fritz Creek drainages, north of Homer.	SCHA	Anchor River-Fritz Creek SCHA
37. Glacier Bay, and its coves, bays and inlets	Adjacent to Gustavus, SE Alaska.	NP&p	Glacier Bay Nat'l Park and Preserve
38 Goose Bay	Located in Upper Cook Inlet on the west side of Knik Arm north of Anchorage..	SGR	Goose Bay SGR
39. Hagemeister Strait, and coves, inlets and bays surrounding Togiak NWR	South of the town of Togiak, located adjacent to Bristol Bay in southwest Alaska.	NWR	Togiak NWR
40. Hallo Bay	Located on the west side of Shelikof Strait, west of Afognak Island in southwest Alaska.	NP&p	Katmai Nat'l Park/Preserve
41. Hazen Bay	A 10 mile wide bay of the Bering Sea 37 miles southeast of Hooper Bay in Western Alaska.	NWR	Yukon Delta NWR
42. Herendeen Bay,	Located SW of Port Moller on the Alaska Peninsula	NWR	Alaska Peninsula NWR
43. Herring Cove	South of the City of Sitka	TMDL	Herring Cove
44. Hooper Bay	Closest village is Hooper Bay, in Western Alaska on the Bering Sea	NWR	Yukon Delta NWR
45. Icy Bay, north	NW of the City of Yakutat	NP&p	Wrangell-St. Elias Nat'l P&p
46. Isabella River wetlands	City of Fairbanks	SGR	Creamers Field SGR
47. Izembek Lagoon	Located on the northern shore of the Alaskan Peninsula near the community of Cold Bay.	SGR NWR	Izembek SGR Izembek NWR
48. Jacksmith Bay	Located south of the village of Quinhagak in Western Alaska on Kuskokwim Bay.	NWR	Togiak NWR
49. John River	Flows out of the Endicott Mountains located in the central Brooks Mountains Range. Closest town is Bettles.	W&SR	John River W&SR
50. Kachemak Bay	Kachemak Bay is a 64 km long arm of Cook Inlet, located on the southwest side of the Kenai Peninsula. The communities of Homer, Halibut Cove, and Kachemak are on the bay within the SCHA. Seldovia is outside the SCHA.	SCHA	Kachemak Bay SCHA
51. Kaliakh River delta	West of Cape Yakataga on the Gulf of Alaska	SGR	Yakataga SGR
52. Kamishak Bay, including inner tidal flats	Located about 20 miles northwest of Cape Douglas. Iliamna Bay is on the north side of Kamishak Bay and 13 miles north from Augustine Island. Homer is northeast of the bay.	NP&p SGR	Katmai Nat'l Park/Preserve, McNeil River SGR

Receiving Waters	Location	Status	Excluded Area
53. Kangirlvar Bay	Located on Etolin Strait in Western Alaska. Bethel is to the east.	NWR	Yukon Delta NWR
54. Karta Bay, and River	Located on Prince of Wales Island next to Kasaan Bay in SE Alaska	NWA	Karta NWA
55. Katmai Bay	Located adjacent to Shelikof Strait on the Alaskan Peninsula, northwest of Kodiak Island.	NP&p	Katmai Nat'l Park/Preserver
56. Kiliuda Bay	East side of Kodiak Island south of the town of Kodiak and north of Old Harbor.	NWR	Kodiak NWR
57. Kinak Bay	Located adjacent to Shelikof Strait on the Alaskan Peninsula, north west of Kodiak Island.	NP&p	Katmai Nat'l Park/Preserver
58. King Cove	King Cove is located adjacent to Deer Passage and the village of King Cove. The town of Cold Bay is located to the northwest.	TMDL	King Cove
59. Knik River tidal flats	Located north of Anchorage at the head of Knik Arm in Cook Inlet.	SGR	Palmer Hay Flats SGR
60. Kobuk River	Headwaters in the Endicott Mountains and Walker Lake, the wild and scenic portion of the river courses south and west for 110 miles. It drains a large area on the southern side of the Brooks Range.	W&SR NP&p	Kobuk River, W&SR Gates of the Arctic NP&p
61. Kokechik Bay	Closest village is Hooper Bay, in Western Alaska on the Bering Sea.	NWR	Yukon Delta NWR
62. Kootznoowoo, Bays, coves and inlets adjacent to the Kootznoowoo Wilderness Area	On Admiralty Island, in SE Alaska. Closest village is Angoon.	NWA	Kootznoowoo NWA. The Kootznoowoo Wilderness includes most of Admiralty Island, except the Mansfield Peninsula, the village of Angoon, and Native lands along the island's western shore.
63. Koyukuk River, North Fork	Headwaters in the Endicott Mountains, drains on the southern side of the Brooks Range and is a tributary of the Yukon River. The village of Bettles is nearby.	W&SR NWA NP&p	North Fork Koyukuk River, W&SR, 102 miles Koyukuk NWA Gates of the Arctic NP&p
64. Kuiu Bays, coves, canals, and inlets adjacent to the Kuiu Wilderness Area	Located on the southern end of Kuiu Island in SE Alaska, bounded by Chatham and Summer Straits. Kake is the closest town.	NWA	Kuiu NWA
65. Kukak Bay	Located adjacent to Shelikof Strait on the Alaskan Peninsula, northwest of Kodiak Island.	NP&p	Katamai Nat'l Park/Preserve
66. Kulukak Bay	East of the village of Togiak. on Bristol Bay.	NWR	Togiak NWA
67. Kuskokwim River Delta and adjacent Bay	Located in southwest Alaska, flows into Kuskokwim Bay on the Bering Sea. The town of Bethel is located on the river to the northeast.	NWR	Yukon Delta NWR
68. Kuskokwim Bay, southern	South of the village of Good News Bay and northwest of the village of Togiak in western Alaska.	NWR	Togiak NWR

Receiving Waters	Location	Status	Excluded Area
69. Little Kamishak River, lower	Drains into Lower Cook Inlet and located on the Alaska Peninsula.	SGS	McNeil River SGS
70. Lituya Bay	Located on the Gulf of Alaska about 97 miles southeast of Yakutat and 120 miles northwest of Juneau.	NP&p	Glacier Bay Nat'l Park/Preserve
71. Lost Harbor	Akun Island, east Aleutian Islands	WQ-ar	Lost Harbor
72. Maurelle Islands,	Located off the northwest coast of Prince of Wales Island south of Kuiu Island and north of Noyes Island. The nearest town is Craig, 20 miles southeast of the islands.	NWA	Maurelle Islands, NWA
73. McNeil River, lower	Drains into Lower Cook Inlet and located on the Alaska Peninsula.	SGS	McNeil River, SGS
74. Misty Fjords, Canals, bays, islets and waters adjacent to and within the wilderness area.	Located in the Tongass Nat'l Forest in the southernmost part of SE Alaska. It extends from Dixon Entrance to beyond the Unuk River. The western boundary is about 22 miles east of Ketchikan.	NWA, NM	Misty Fjords NWA, Misty Fjords NM
75. Mulchatna River	Located in Southwestern Alaska, about 140 miles southwest of Anchorage.	W&SR	Mulchatna River, 24 miles, W&SR Lake Clark NP&p
76. Nelson Lagoon.	Located on the Alaska Peninsula, about 25 miles west of the village Port Moller	SCHA, SECH	Port Moller SCHA, Steller's Eiders Critical Habitat
77. Noatak River	Located in northwestern Alaska. Headwaters on Mount Igikpak in the Schwatka Mountains of the Brooks Range.	W&SR NP, NP&p NWA	Noatak River, W&SR Noatak NP Gates of the Arctic NP&p Noatak Wilderness
78. Nuka Bay	South Kenai Peninsula	Np	Kenai Fjords Nat'l Preserve
79. Nushagak Bay, west	Located about 30 miles southwest of the town of Dillingham. Bay opens onto Bristol Bay.West of the village of Clarks Point.	NWR	Togiak NWR
80. NW Gastineau Channel	Located between North Douglas island and the mainland. City of Juneau is southeast down the channel about 3 miles.	SGR	Mendenhall Wetlands SGR
81. Olga Bay	On the southern end of Kodiak Island.	NWR	Kodiak NWR
82. Pack Creek	Located north of Windfall Harbor and adjacent to Windfall Island on E. Admiralty Island in SE Alaska	SGS	Stan Price SGS
84. Palma Bay	SE Alaska	NP&p	Glacier Bay NP&p
85. Petersburg Creek	Located directly across the Wrangell Narrows west of Petersburg in SE Alaska	NWA	Petersburg Creek-Duncan Salt Chuck NWA
86. Perenosa Bay	Located on the northern end of Afognak Island.	SP	Afognak State Island Park
87. Pleasant Island~~s~~	Pleasant Island Is the largest island in Icy Strait between northern Chichagof Island and the mainland of the Alaska Panhandle. It lies southeast of Gustavus and southwest of Excursion Inlet.	NWA	Pleasant/Lemusurier/Inian Islands NWA

Receiving Waters	Location	Status	Excluded Area
88. Popof Strait	Located between Popof Island and Unga Island south of the Alaskan Peninsula. Nearest town is Sandpoint.	IW	Popof Strait
89. Port Moller, south and other select bays, inlets and stretches of coastline.	Alaska Peninsula	NWR, SCHA, Steller's Eider CHA	Alaska Peninsula NWR, SCHA, Steller's Eiders CHA
90. Port Heiden	North-central Alaska Peninsula	SCHA, Steller's Eiders habitat	Port Heiden, SCHA Steller's Eiders habitat
91. Pribilof Islands, coastal waters.	Bering Sea	NWR	Alaska Maritime NWR
92. Prince of Wales, bays, coves, inlets and the Barrier Islands	Located on the southern tip of Prince of Wales Island, 40 air miles southwest of Ketchikan in SE Alaska.	NWA	South Prince of Wales, NWA
93. Russell Fjord	The fjord extends north to Disenchantment Bay, the terminus of the Hubbard Glacier at the head of Yakutat Bay.	NWA	Russell Fjord NWA
94. Saint James Bay	Located on the west side of Lynn Canal on the Chilkat Peninsula northwest of Juneau in SE Alaska.	SMP	Saint James Bay
95. Salmon River	Flows out of the Baird Mountains and into the Kobuk River.	W&SR, NP	Salmon River W&SR, Kobuk Valley NP, 70 miles
96. Scammon Bay	Scammon Bay opens onto the Bering Sea in Western Alaska. The village of Scammon Bay is the nearest settlement.	NWR	Yukon Delta NWR
97. Security Cove	South of the town ~~City~~ of Platinum	NWR	Togiak NWR
98. Silver Bay	Located south of the town of Sitka in SE Alaska.	TMDL	Silver Bay
99. Skilak Lake	Located about 16 miles east of Soldotna on the Kenai Peninsula	NWR, Kenai Wilderness Area	Kenai NWR Kenai Wilderness Area
100. Stikine River and tributaries	Located on the mainland of SE Alaska, 6 miles west of Petersburg and 7 miles north of Wrangell.	NWA	Stikine-LeConte NWA
101. Susitna River tidal flats	West of the City of Anchorage	SGR	Susitna Flats SGR
102. Swamp Creek Wetlands	SW Kalgin Island in Cook Inlet	SCHA	Kalgin Island SCHA
103. Tanana River wetlands	West of the City of Fairbanks	SGR	Minto Flats SGR
104. Tebenkof Bay	Located on Kuiu Island in SE Alaska.	NWA	Tebenkof Bay NWA
105. Thorne Bay	Located 42 miles northwest of Ketchikan on Prince of Wales Island.	IW	Thorne Bay

Receiving Waters	Location	Status	Excluded Area
106. Tinayguk River	Flows out of the Endicott Mountains of the Brooks Range. Nearest town is Bettles.	W&SR, NP&p	Tinayguk River W&SR, 44 miles Gates of the Arctic NP&p
107. Tlikakila River	Located on the Alaska Peninsula southwest of Anchorage. Flows into Lake Clark	W&SR, NP&p, Lake Clark Wilderness	Tlikakila River W&SR, 51 miles Lake Clark NP&p, Lake Clark Wilderness
108. Togiak Bay, mouth of	Walrus Islands and Summit Island located between Togiak Bay and Bristol Bay.	SGS	Walrus Islands, SGS
109. Togiak Bay	Adjacent to the village of Togiak.	NWR	Togiak NWR
110. Tonki Bay	Located on the northeast side of Afognak Island.	SP	Afognak Island State Park
111. Tracy Arm and Endicott Arm	Located south of Juneau on the mainland in SE Alaska	NWA	Tracy Arm-Fords Terror NWA
112. Trading Bay	SW of the City of Anchorage	SGR	Trading Bay SGR
113. Tugidak Island coastal water	Tugidak Island, southwest of Kodiak Island	SCHA	Tugidak Island SCHA
114. Turnagain Arm, south shore	NW Kenai Peninsula	NWR	Kenai NWR
115. Turnagain Arm tidal flats	Adjacent to the City of Anchorage	SGR	Anchorage Coastal, SGR
116. Tustumena Lake	South of the town of Soldotna on the Kenai Peninsula	NWR, NWA	Kenai NWR, Kenai Wilderness Area
117. Tuxedni Bay	West of the town of Ninilchik along the coast of Cook Inlet	NP&p	Lake Clark NP&P
118. Two Arm Bay	Located on the east side of the Kenai Peninsula	Np	Kenai Fjords Nat'l Park
119. Udagak Bay	Located adjacent to Beaver Inlet on Unalaska Island in the Aleutians.	WQ-ar	Udagak Bay
120. Uganik Bay and Passage	Kodiak Island	NWR	Kodiak NWR
121. Ugashik Bay	South and west of the City of Pilot Point	SCHA	Pilot Point SCHA
122. Unalaska Bay, South	Unalaska Island in the Aleutians	TMDL	South Unalaska Bay
123. Uyak Bay	Kodiak Island	NWR	Kodiak NWR
124. Ward Cove	Located north of the City of Ketchikan in SE Alaska.	TMDL	Ward Cove
125. Warren Island	Located off the northwest side of Prince of Wales Island in SE Alaska	NWA	Warren Island NWA
126. Willow Creek tributaries	NW of the City of Palmer	SCHA	Willow Mountain
127. Yakutat Bay, west	Adjacent to the City of Yakutat	NP&p	Wrangell-St. Elias NP&p
128. Yukon River delta	Flows into Norton Sound in Western Alaska	NWR	Yukon Delta NWR