United States
Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, Washington 98101

Total Maximum Daily Load (TMDL) for Seafood Residues in the Waters of King Cove, Alaska

In compliance with the provisions of the Clean Water Act, 33 U.S.C. Section 1251 et seq., as amended by the Water Quality Act of 1987,P.L. 100-4, the Environmental Protection Agency (EPA) is establishing a Total Maximum Daily Load (TMDL) that will significantly reduce the presence of seafood residues in King Cove to comply with the designated use in Alaska's water quality standards.

This TMDL shall become effective immediately. Subsequent actions must be consistent with this TMDL.

Signed this 9th day of October, 1998.

Philip G. Millam for
Director
Office of Water

United States
Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, Washington 98101

Total Maximum Daily Load (TMDL) for Seafood Residues in the Waters of King Cove, Alaska

October 1998

Total Maximum Daily Load for

Settleable Solid Residues

in the Waters of

King Cove, Alaska

TMDL AT A GLANCE:

Water Quality-limited?	Yes
Hydrologic Unit Code:	30101
Standard of Concern:	Residues in marine waters
Designated Use Affected:	Growth and propagation of fish, shellfish, other aquatic life and wildlife
Environmental Indicator:	11 acre deposit of settleable solid seafood wastes
Source(s):	Seafood Processing (Peter Pan Seafoods)
Loading Capacity:	500,000 lbs of settleable solid seafood wastes per year assuming no authorized zone of deposit
Wasteload Allocation:	450,000 lbs of settleable solid seafood wastes per year
Margin of Safety:	50,000 lbs of settleable solid seafood wastes per year
Remedial Action to Date:	Construction of a fish meal reduction plant
Monitoring to Date:	Dive surveys, wastewater chemistry, mass balance assessment
Proposed Future Actions:	Reduction of waste pile; re-issue NPDES permit with limitations on settleable solids, requirements for appropriate management practices, and monitoring

Overview

Section 303(d)(1)(C) of the Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (EPA) implementing regulations (40 CFR Part 130) require the establishment of a Total Maximum Daily Load (TMDL) for the achievement of state water quality standards when a waterbody is water quality-limited. A TMDL identifies the degree of pollution control needed to maintain compliance with standards using an appropriate margin of safety. The focus of the TMDL is the reduction of pollutant inputs to a level (or "load") that fully supports the designated uses of a given waterbody. The mechanisms used to address water quality problems after the TMDL is developed can include best management practices and/or effluent limits and monitoring required under National Pollutant Discharge Elimination (NPDES) permits.

The state of Alaska identified King Cove (Figure 1) as being water quality-limited for seafood wastes (ADEC 1996, 1998a). The Alaska Department of Environmental Conservation (ADEC) has drafted a Waterbody Recovery and Pollution Prevention Plan (a.k.a. "TMDL problem assessment") for King Cove (ADEC 1998b) that states that seafood processing wastes from the Peter Pan Seafoods facility created a waste pile deposit of settleable solid residues measuring 11 acres in area and and average of 3 feet deep on the seafloor (ADEC 1998b, Enviro-Tech Diving 1998). This waste pile exceeds water quality standards for residues. Designated uses for King Cove include: (1) water supply for aquaculture, (2) water supply for seafood processing, (3) growth and propagation of fish, shellfish, other aquatic life and wildlife, and 4) harvesting for consumption of raw mollusks or other raw aquatic life [Alaska Administrative Code (AAC) §18.70.020]. Existing data show that the affected designated use is growth and propagation of fish, shellfish, other aquatic life and wildlife. King Cove was placed on Alaska's §303(d) list in 1996 and 1998 for seafood residues from seafood processing.

This TMDL establishes that the loading capacity for settleable solids in King Cove is 500,000 lbs/year. Settleable solids is a parameter directly related to the impact of effluent discharges of residues deposited on the seafloor in a receiving water. The margin of safety is 50,000 lbs/year. The wasteload allocation (WLA) for settleable solids is 450,000 lbs/year and requires that the particles size approximate one (1) millimeter in width. Future actions include EPA issuing a permit incorporating the WLA as an effluent limit and monitoring requirements, and possibly including measures to reduce the size of the waste pile. The draft King Cove Waterbody Recovery and Pollution Prevention Plan (ADEC 1998b) discusses the waste pile remediation alternatives in greater depth.

General Background

King Cove is located adjacent to the City of King Cove, in the Aleutians East Borough near the west tip of the Alaska Peninsula. The cove itself is approximately 1.5 square miles, or 800 acres. The watershed includes the small community of the City of King Cove, the Peter Pan Seafoods processing facility and a road connecting King Cove with the community airstrip in an adjacent watershed. This summary highlights important features of King Cove from the draft Waterbody Recovery and Pollution Prevention Plan[1].

The local stream that drains the small (10 square miles) watershed supports subsistence use of chum and coho salmon, and the King Cove lagoon supports subsistence use of clams from the beaches.

[1]The Waterbody Recovery and Pollution Prevention Plan will be available from ADEC for public review in mid-October.

Commercial fishing and seafood processing are the principle components of the local economy. Peter Pan Seafoods processes locally harvested fish and shellfish: crab, cod, halibut, herring, pollock and salmon and a variety of other fish.

Climate

Historical temperature is available for Cold Bay, which has similar climate to King Cove. The temperature ranges from daily highs of 32-56 degrees Fahrenheit (F) and daily lows of 22-47 degrees F. Rainfall averages 36 inches per year, ranging from under two inches per month to over four inches per month. Snowfall averages over 60 inches per year, ranging from 0 to 11 inches per month. Wind averages about 17 mph daily (National Weather Service).

Applicable Water Quality Standards

Designated Uses

Designated uses for Alaska's marine waters are established by regulation and are found in the State of Alaska Water Quality Standards [18 AAC 70]. For marine waters of the state, these designated uses include:(1) water supply, (2) water recreation, (3) growth and propagation of fish, shellfish, other aquatic life, and wildlife, and(4) harvesting for consumption of raw mollusks or other raw aquatic life [18 AAC 70.020(a)(2)]. King Cove does not support the designated use of growth and propagation of fish, shellfish, other aquatic life, and wildlife.

Parameter of Concern

The Alaska 1998 §303(d) list identified King Cove as water quality limited due to exceedences of seafood residues from seafood processing.

Applicable Water Quality Criteria

The Alaska Water Quality Standards state that residues in marine waters "May not .... 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" [AAC §18.70.020(b)(2)].

Zone of Deposit

ADEC may issue or certify a permit that allows a deposit of substances on the seafloor within limits set by ADEC [AAC § 18.70.210]. A zone of deposit (ZOD) allows deposit of substances on the bottom of marine waters, but standards must be met at every point outside the ZOD. Consequently, King Cove's loading capacity for settleable solids is dependent on whether ADEC authorizes a zone of deposit. Therefore, this TMDL addresses the range of ZODs that ADEC might authorize for settleable solid residues in King Cove, and the subsequent calculations of King Cove's loading capacity and WLA.

One processing facility, Peter Pan Seafoods, discharges to the receiving waters of King Cove on the northwest side of the bay. At present Peter Pan

Seafoods does not have a State-authorized ZOD. However, elsewhere ADEC has authorized (1) a one-acre ZOD as a standard for shore-based and near-shore seafood processing facilities permitted under general NPDES permit AKG-52-0000, (2) a one-acre ZOD for Royal Aleutian Seafoods in south Unalaska Bay, and (3) a two-acre ZOD for Westward Seafoods in Captains Bay. Peter Pan Seafoods has submitted a request for a ZOD to ADEC (Huynh 1998a, 1998b). Therefore, EPA has assessed the amount of settleable solid seafood processing residues which, when discharged, would create no significant deposition (based on a minimum detection level of 0.08 acre and 1.1 cm deep), a one-acre deposit, and a two-acre deposit.

Pollutant Sources

Point Source

Peter Pan Seafoods is the only point source and also the only seafood processing facility in King Cove. Peter Pan Seafoods discharges through a pipe in the northwest side of the bay.

Seafood processors discharge wastewater that consists of a combination of dissolved and solid waste particles. The dissolved portion of the wastewater consists of water soluble organic compounds and soluble nutrients, and may intermittently include trace disinfectants. The solid fraction consists of a variety of particles of shell, skin, muscle, fat, organs, and bone. In compliance with the determination of best conventional treatment technology for seafood processors in Alaska, the solid fraction of the waste should be ground to a particle size of 1.3 cm (0.5 in.) diameter or less before discharge; large volume seafood processors may screen waste solids to one millimeter or smaller (and reduce the solids recovered thereby to fish meal). 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 (e.g., Table 1).

These particulate residues settle through the water column to the seafloor at various rates of descent (Table 2) following discharge and may form deposits ranging from organic mats to thick waste piles rising 40 feet or more above the seafloor. These deposits, as mats or waste piles, exceed water quality standards for residue.

Labile organic material undergoes microbial decomposition which progresses at a variety of decay rates measured across a range of at least 4.1×10^{-4} per day to 1.4×10^{-1} per day (Table 3). Accumulation of deposits into mats or waste piles indicates that the rate of discharge of settleable solids exceeds both the assimilation rate of the natural benthic community and the decomposition rate.

In the spring of 1998, Peter Pan installed a fish meal plant to reduce the amount seafood processing waste. The fishmeal plant grinds, cooks and dries fish waste to create fish meal, fish bone meal and fish oil. The discharge process includes grinding the seafood waste through screens to reach an average particle size of 1 mm. This ground waste is combined with additional water and discharged through the pipe 300 feet into King Cove. The waste pile surrounds this outfall pipe.

Other Sources and Natural Sources

Other sources of seafood residues may include seafood residues washed off the loading dock areas. On a site visit in February 1998, EPA and ADEC staff observed no accumulation of seafood residues on the cove or lagoon shorelines. The dive surveys to date did not look for waste piles under the loading dock. This TMDL assumes loading dock to be a negligible contributor to the water quality impairment, although we note that the area under and adjacent to the loading dock should be inspected by a dive survey to verify this assumption.

Based upon field studies (e.g., Jones and Stokes 1993, Tetra Tech 1993), EPA believes that the contribution of settleable solid seafood residues from natural sources is insignificant, and therefore is not treated as a source in this TMDL.

Water Quality Analysis

Water Quality Data

The ADEC draft Waterbody Recovery and Pollution Prevention Plan for King Cove concluded that past practices of seafood processing resulted in a waste pile 11 acres and and average of 3 feet deep of settleable solid residues on the bottom of the cove. Peter Pan Seafoods provided additional data on wind direction and velocity, current direction and velocity, survey of the waste pile around the terminus of the outfall, and a mass materials balance of the inputs and outputs of the seafood processing facility. The Waterbody Recovery and Pollution Prevention Plan summarizes the data from Peter Pan Seafoods (ADEC 1998b). The mass balance reflects the situation before the meal plant. The meal plant began operating in June 1998, so little data is available regarding reduced discharges of settleable solids.

Analytic Approach

A model of the fate, transport, and persistence of settleable solid seafood processing waste residues was presented in the "Ocean discharge criteria evaluation for the NPDES general permit for Alaskan seafood processors" (TetraTech 1994) which estimates the potential area of deposition caused by the discharge of such residues. A number of biological, chemical and physical factors control the fate of the discharged waste solids. 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. Physical factors that control the fate, transport and persistence of the waste include water column stratification; storm-, tidal- and wind-induced currents; water temperature; and seafloor topography. These various factors were conceptualized (Figure 2) and modeled for computer simulation using EPA's Water Quality Analysis

Simulation Program (WASP5; Ambrose et al. 1993) and the contouring software SURFER™.

A number of hypothetical discharge scenarios were evaluated in the "Seafood discharge model simulation" applications of WASP5 and SURFER™ (TetraTech 1996). The selected set of assumptions for solids distribution, decay rate, and dispersion coefficients are presented in Table 4. Three particle widths were evaluated: 1.3 cm (0.5 in; Table 5), 0.95 cm (0.375 in; Table 6), and 1.0 mm (Table 7). Shore-based processors were evaluated for discharges at 15.2 m (50 ft) depth into a low average current speed (5 cm/sec or 0.1 knot) and a medium average current speed (15 cm/sec or 0.3 knots) over both flat and sloped seafloors. Floating processors were evaluated for discharges into low and medium average current speeds in water depths of 15.2 m (50 ft), 30.5 m (100 ft), and 45.7 m (150 ft) over a flat seafloor. In each scenario the model was run to determine the mass (weight) of settleable solid seafood processing waste residues which could be discharged over a year to create an undetectable deposit, a one-acre deposit, and a two-acre deposit.

The WASP5 seafood waste model was run iteratively to determine, for each of the case scenarios, the rate of seafood waste discharge that would result in the accumulation of waste piles of from 0.1 to 2.3 acres (Tables 5 - 7). Since the WASP5 model consists of a grid of parallelograms, the depositional grid from WASP5 (Figure 3) was contoured using SURFER™ software (Figure 4). This contouring of the WASP5 modeling results by SURFER™ produces more realistic simulations of the waste piles.

Peter Pan Seafoods discharges screened seafood wastewater with settleable solid particulates of approximately one (1) mm width into King Cove at a depth of approximately 15.2 m and in average currents of 5 cm/sec or less. The analysis of total maximum yearly load for these conditions is represented by Case 1 in Table 7 (row # 1 of the "shore-based discharges"). Using this total maximum yearly load as a basis, EPA calculated the loading capacity for settleable solid seafood processing residues in King Cove and the wasteload allocation for Peter Pan Seafoods' facility in King Cove.

Loading Capacity

The loading capacity is the pollutant load a particular water body can receive without violating water quality standards. For the purposes of this TMDL, EPA calculated the loading capacity assuming no ZOD. EPA also calculated alternative loading capacities in case ADEC were to authorize a ZOD for seafood residues in King Cove. See the discussion below.

The loading capacity of King Cove for settleable seafood processing wastes is 500,000 lbs/yr (total annual wet weight). EPA analysis shows that this level can be discharged without creating a detectible year-round deposit. This annual loading capacity translates into an average daily load of 1,370 lbs/day.

Margin of Safety

In accordance with CWA § 303(d)(1)(C) and federal regulations (40 CFR 130.7), a margin of safety was established to account for uncertainty in the relationship between effluent limitations and water quality. A margin of safety may be provided (1) by using conservative assumptions in the calculation of the loading capacity of the waterbody and/or (2) by establishing allocations that in total are lower than the defined loading capacity. In the case of the King Cove analysis for settleable solids, a combination of the two approaches was relied upon to establish a margin for safety.

A ten percent margin of safety, based on a 500,000 lbs/year loading capacity, is 50,000 lbs/year. This translates into an average daily load of 137 lbs/day.

Load Allocation

The load allocation is the portion of the loading capacity associated with non-point and natural sources. As discussed above, there are no such sources of residue. Consequently, this TMDL has no load allocation.

Wasteload Allocation

The wasteload allocation is the portion of the loading capacity associated with point sources. Because in this TMDL no other significant source exists, the point source wasteload allocation is equal to the loading capacity minus the margin of safety. This yields a wasteload allocation for Peter Pan Seafoods of 450,000 lbs/year. This translates into an average daily wasteload allocation of 1,230 lbs/day. (See Table 8.)

Seasonal Variation

Shore-based seafood processors have significant seasonal variation, determined by species-based regulated open seasons, species abundance, and regional fisheries. The typcially busiest season is from June through September, followed by February through April. November through January and May tend to see relatively little activity (TetraTech 1994). October tends to be busier in recent years than historically, due to delays in the pollock season .

The different species peak at different times of the year, with some overlap. Generally at least two or three species are harvested at any time.

This TMDL is based on modeling of annual discharges. Thus, the loading capacity and WLA also reflect annual total loading. The translations into daily loads are averages. A daily maximum load has little meaning in this context of highly varying seafood harvest. Because of decomposition and natural attenuation (i.e. current dispersion and consumption of residue), King Cove can accept the wide variation in discharge rates that result from the daily and seasonal variation in seafood processing discharges within the annual WLA.

ZOD-Based Loading Capacities and Wasteload Allocations

EPA analyzed alternative loading capacities and wasteload allocations for King Cove because Peter Pan Seafoods requested a ZOD and ADEC responded that they are considering the request. EPA analyzed alternatives of ADEC authorizing a one acre or a two acre ZOD. Table 8 shows these alternative scenarios. They show that Peter Pan Seafoods could discharge up to:

- 3,000,000 lbs/yr (total annual wet weight) of settleable seafood processing wastes without creating a persistent, year-round deposit exceeding a one-acre waste pile (less than 1.0 acre in area and 7.5 cm of maximum thickness). This would result in a wasteload allocation of 2,700,000 lbs/year. A one-acre ZOD would cover approximately 0.1 percent of the cove floor.

- 8,000,000 lbs/yr (total annual wet weight) of settleable seafood processing wastes without creating a persistent, year-round deposit exceeding a two-acre waste pile (i.e., less than 2.0 acre in area and 41.7 cm of maximum thickness). This would result in a wasteload allocation of 7,200,000 lbs/year. A two-acre ZOD would cover approximately 0.2 percent of the cove floor.

If the State chooses to issue a ZOD for up to two acres for King Cove, the NPDES permit may authorize a discharge rate up to the alternative wasteload allocations above without requiring this TMDL be revised.

Possible Future Actions

NPDES Permit

In the fall of 1998, EPA expects to issue an NPDES permit to Peter Pan Seafoods for discharging seafood processing wastes into King Cove. The effluent limit in the permit will comport with the wasteload allocations in this TMDL in Table 8. Prior to issuing the NPDES permit, ADEC will certify that the permit will meet with AK's water quality standards. ADEC anticipates including the requirement of remediation in order to certify compliance with state water quality standards.

Waste Pile Remediation

It is important to address the existence of the eleven acre waste pile in King Cove that exceeds the Alaska Water Quality Standard and any probable ZOD which may be authorized pursuant to Peter Pan's application. To attain the water quality standard in the future, this TMDL needs to address the existing deposits of settleable solid residues on the seafloor.

EPA and ADEC staff believe that the 11 acre waste pile in King Cove could naturally decompose and attenuate in approximately 10 years. This estimate is derived from a combination of decomposition rates and experience with natural attenuation at other sites. This rate could be significantly enhanced by remediation, quite possibly resulting in attainment of water quality standards in one-half the time.

EPA and ADEC raised the question of remediation to expedite attainment of water quality standards with Peter Pan Seafoods.

In its revised application for a ZOD, Peter Pan Seafoods agreed to remediate the waste pile. The King Cove Waterbody Recovery and Pollution Prevention Plan also addresses this issue in further detail.

Alternate approaches to remediate the existing waste pile include (1) removal of some or all of the material through suction, dredging or some other method, and/or (2), spreading the waste pile to expedite decomposition and natural attenuation. Peter Pan Seafoods proposes to remediate the waste pile through the second option, spreading or disbursing the thinner areas of the waste pile.

In response to Peter Pan Seafoods' request for a one-acre ZOD, ADEC stated that it could not approve the request without being able to monitor compliance. ADEC's concern was how to determine the size of the waste pile from the newly permitted discharge apart from the pre-existing waste pile. ADEC suggested that Peter Pan Seafoods include a waste pile cleanup plan in order to show compliance with a one-acre ZOD during the life of the NPDES permit. Further, ADEC recommended a five-year cleanup timeframe and dive survey monitoring to ultimately demonstrate compliance with a one-acre ZOD.

Subsequently, Peter Pan Seafoods revised its appliaction to include a waste pile cleanup plan to reduce the waste pile to one acre within five years. Peter Pan Seafoods expects that the waste reduction from its new meal plant and the new screens that grind seafood waste to one mm will result in no additional accumulation, facilitating the cleanup (Huynh, 1998b).

EPA believes that reducing the waste pile from its current 11 acre size to one acre is feasible and can be accomplished with negligible side effects, if any. Alyeska Seafoods dredged a seafood wastepile in South Unalaska Bay and reduced the volume and area of the pile without reducing levels of dissolved oxygen in the receiving water (pers. comm, Greg Peters 1997). Peter Pan Seafoods' proposed plan would undertake a similar winter dredging of its waste pile in King Cove with attention to weather conditions to avoid impact on biological oxygen demand, smell, or deposition of dredged residue on the shoreline (Schwarzmiller 1998; Huynh 1998b; Attachment I).

Monitoring

EPA anticipates that the seafloor monitoring program conducted by the Peter Pan Seafoods will continue under a reissued NPDES permit, as will monitoring of process wastewater discharges for total suspended solids and settleable solids. The monitoring plan will be developed as part of the NPDES permit. Any monitoring required will be designed and conducted to meet the requirements of a comprehensive and efficient program of assessment (e.g., NRC 1990). The data generated from monitoring will be used to refine and calibrate the solids deposition model for King Cove and to modify the TMDL determination as necessary. Peter Pan Seafoods offered to survey the waste pile annually each September to evaluate the effectiveness of the cleanup method (Huynh 1998b). EPA will assure that the monitoring reports of the reduction and eventual elimination of the waste pile will be available to the community of King Cove.

PUBLIC PROCESS

EPA released the draft TMDL for seafood residues in King Cove for public comment on Monday, August 17, 1998. The public notice was published in the Dutch Harbor Fisherman (Anchorage and Unalaska) and in the Anchorage Daily News. Comments were due postmarked no later than Tuesday, September 15, 1998, or faxed before midnight of Tuesday, September 15, 1998.

EPA requested comments and information on certain specific issues:

- Size of existing seafood waste deposits in King Cove,
- Decay rates of seafood wastes,
- Effects of settleable waste residues on the near-field and far-field marine environment, and
- Alternate approaches to reducing the sizes of waste piles, including technical details of the necessary technology and substantiated basis for projected reduction.

EPA received no public comments.

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Huynh, Hat T. 1998a. Letter of July 24, 1998, from Hat Huynh, Vice President of Quality Assurance for Peter Pan Seafoods, to Robert Dolan, Environmental Engineer for the Alaska Department of Environmental Conservation, requesting the authorization of a one-acre zone of deposit for Peter Pan Seafoods' facility in King Cove, Alaska.
2 p.

Huynh, Hat T. 1998b. Letter of August 11, 1998, from Hat Huynh, Vice President of Quality Assurance for Peter Pan Seafoods, to Robert Dolan, Environmental Engineer for the Alaska Department of Environmental Conservation, revised request for a one-acre zone of deposit for Peter Pan Seafoods' facility in King Cove, Alaska.
5 p.

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Tetra Tech. 1996. Report of seafood discharge and waste pile model simulation results. Prepared for U.S. Environmental Protection Agency, Region 10, Seattle, WA. Tetra Tech, Inc., Redmond, WA.

Figure 1. Map of King Cove, Alaska, showing the Peter Pan Seafoods facility and its outfall and waste pile of settleable solid seafood processing residues.

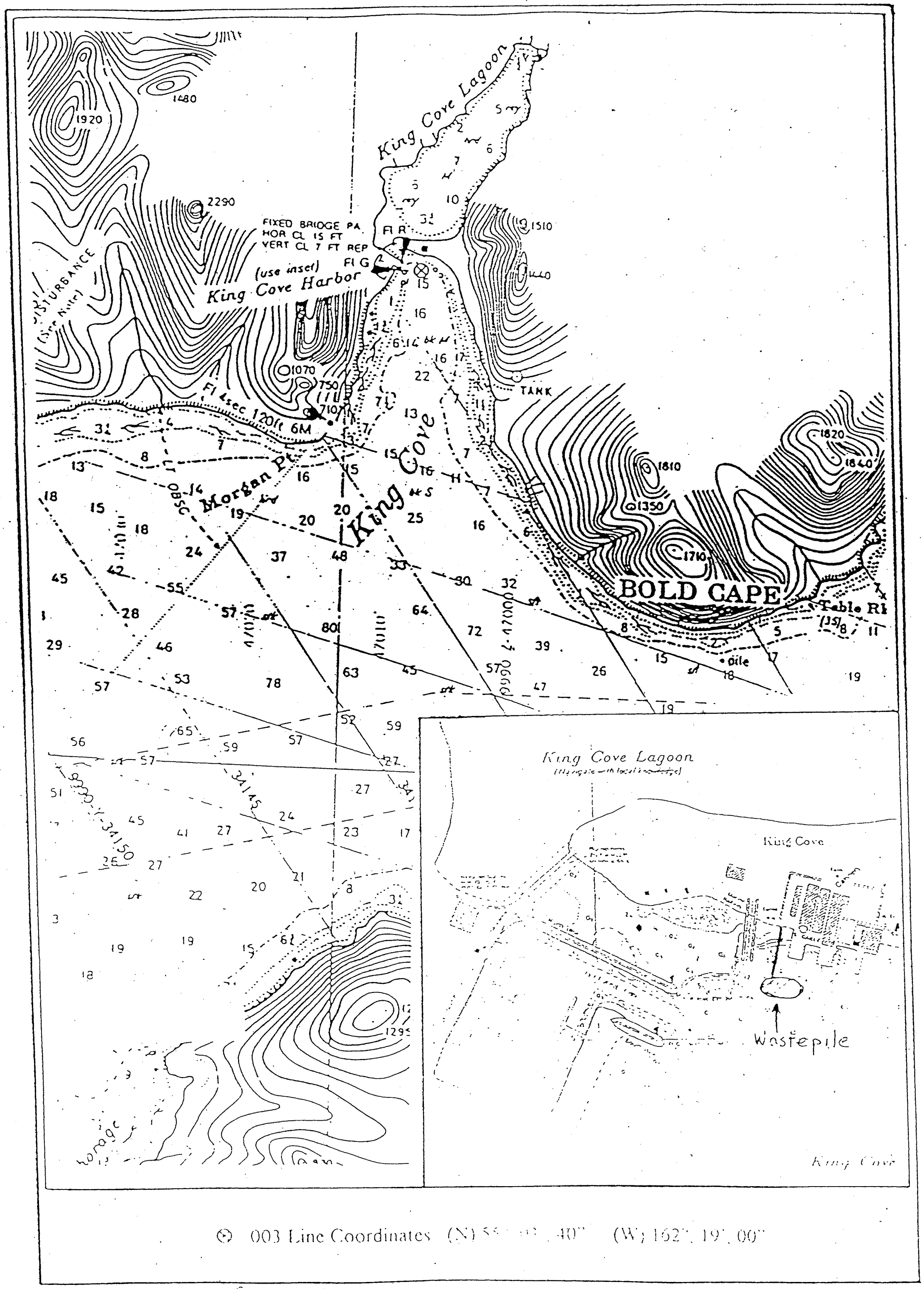

Figure 2. Conceptual model of the fate, transport, persistence, and potential adverse impacts from Alaskan seafood processing waste discharges

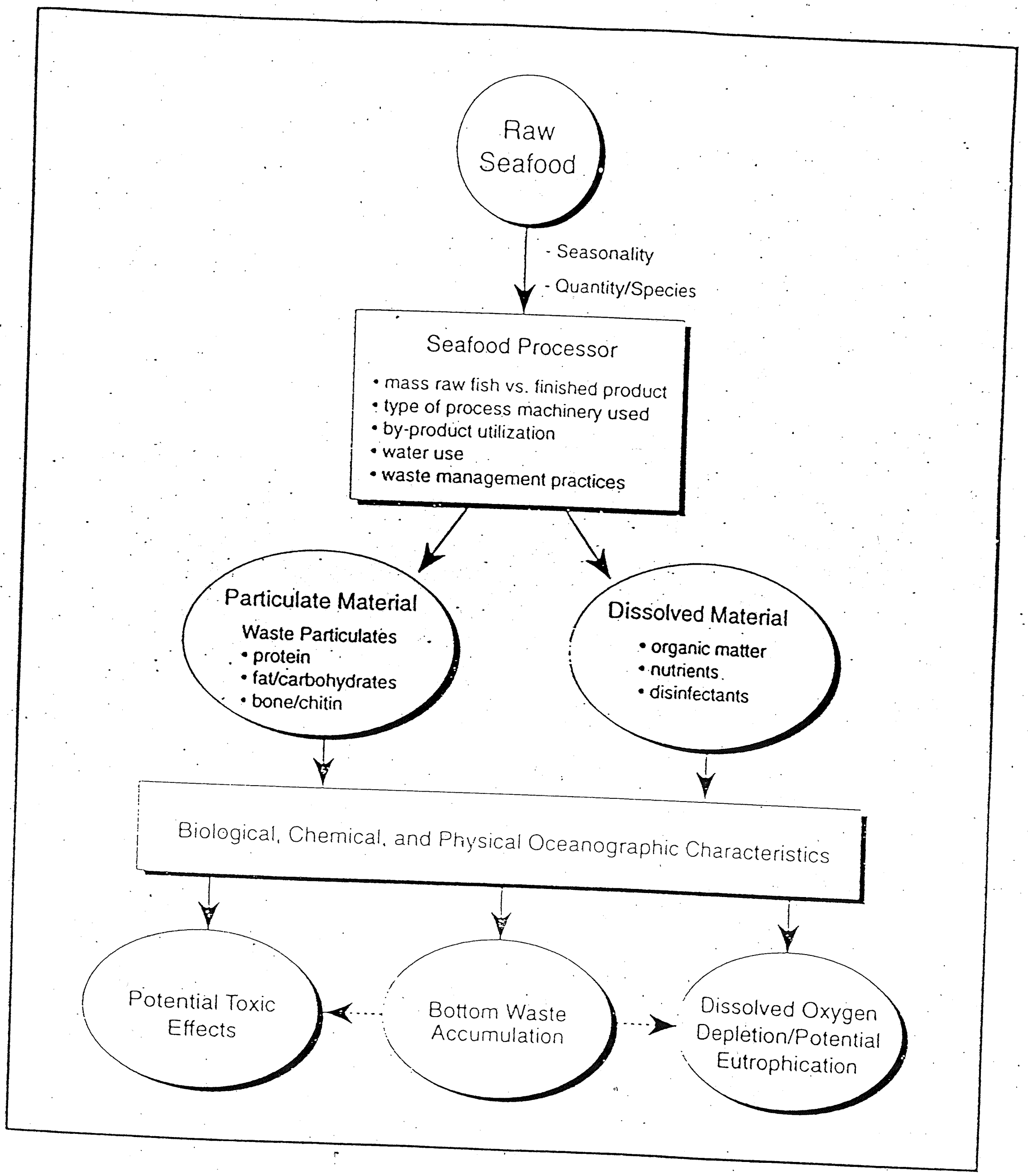

Figure 3. Variable-spaced model grid for WASP5 simulation of seafood waste deposition.

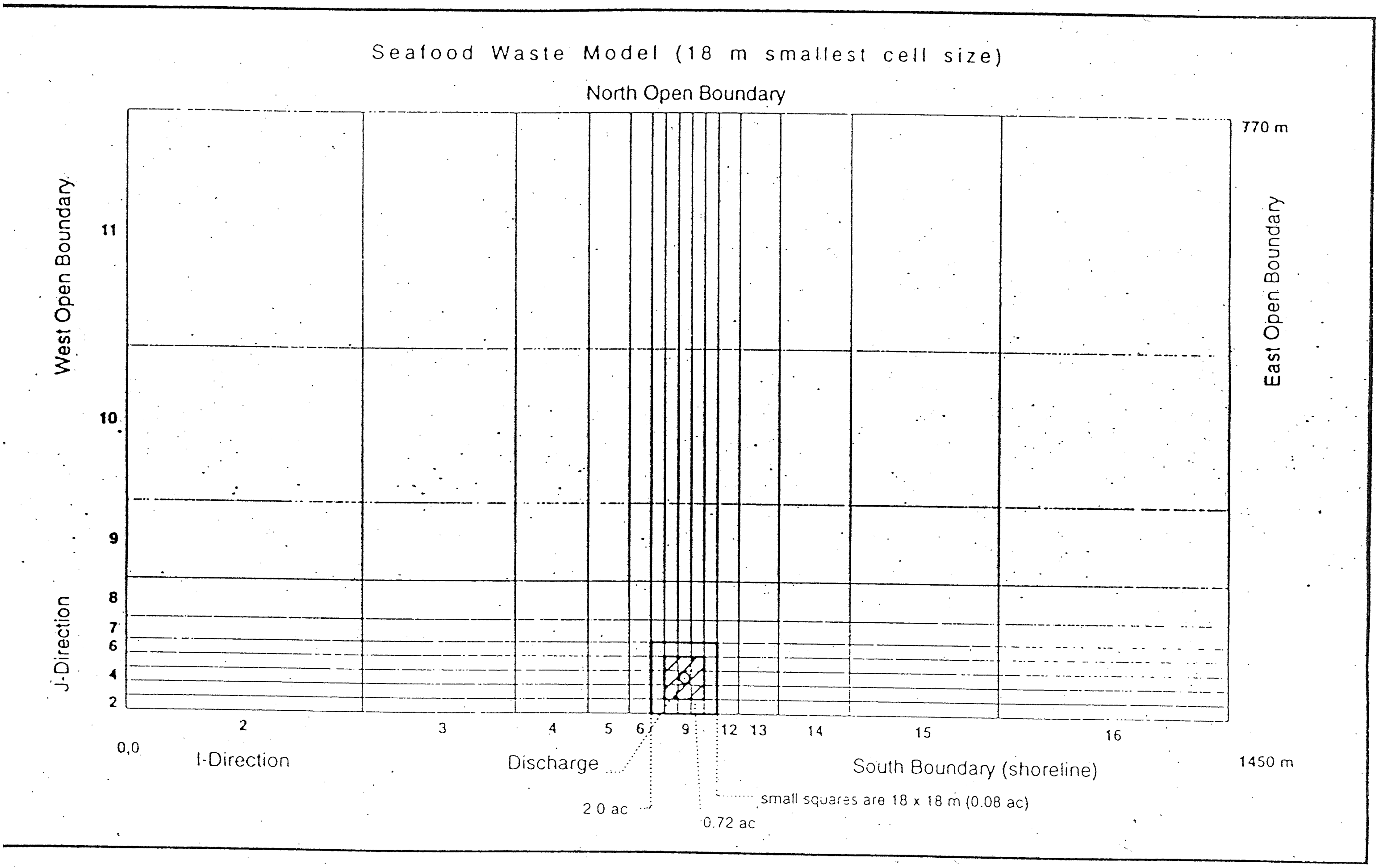

Figure 4. Example of a contoured simulation of seafood waste deposition generated by SURFER™.

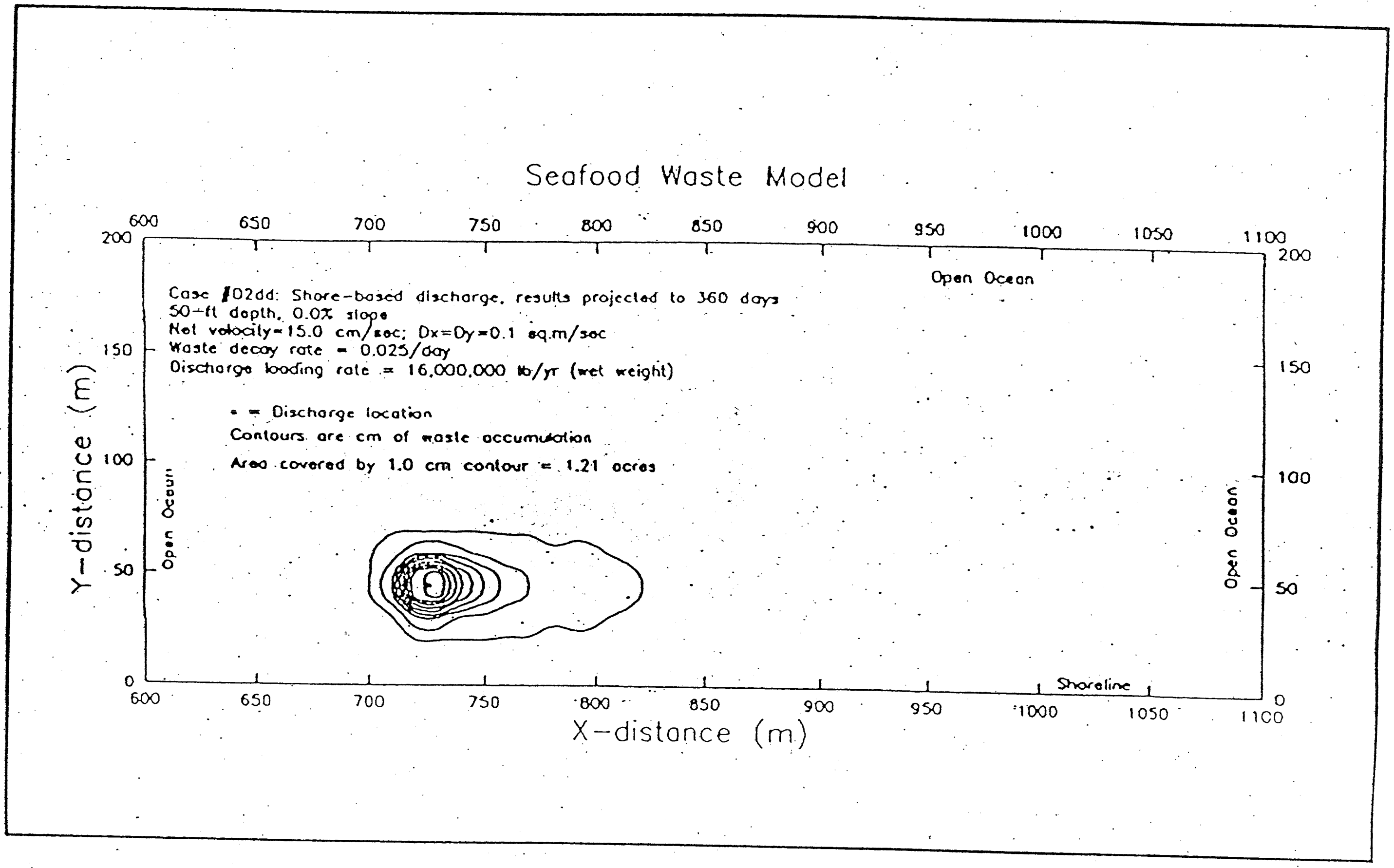

Table 1. Theoretical composition of seafood waste.

Constituent	Percent Wet Weight	Approximate Density[a] (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[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 in the *Handbook of Chemistry and Physics* (Weast 1982).

[b] Typical dry weight carbon (C) content of organic matter used.

[c] Estimated concentrations of nitrogen (N) and phosphorus (P) based on the Redfield ratio of C:N:P (106:16:1 by atoms) in organic matter (Redfield 1958; Redfield et al. 1963). Ratio of sulfur to phosphorus assumed to be 1:1.

Table 2. Estimated settling velocities and current speeds necessary to resuspend different sizes of settleable solid seafood 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^3				
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^o C equal to 1.52×10^{-6} m^2/sec.

[b] The calculation of the resuspension current speed [i.e., the current speed 1 m (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_* and the relation $u_* = (0.003)^{.5} U_{100}$ (Sternberg 1972).

Conversion Factors:

To convert cm to in multiply cm*0.3937

To convert m/sec to knots multiply m/sec*1.9438

To convert m/sec to ft/sec multiply m/sec*3.2808

Table 3. Range of sediment decay rate constants for organic material.

(day^{-1})	Degraded Substrate	Measurement Method	Location	Reference
$1.6x10^{-6}$ [a]	Refractory organic material	Benthic chamber, core incubation, 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 incubation, pore water	Santa Monica Basin, CA	Jahnke 1990
$1.2x10^{-3}$ [a]	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]	Refractory algal 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
$2.7x10^{-3}$ - $8.2x10^{-3}$ [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
$2.4x10^{-2}$ [b]	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: $1.6x10^{-6}$ - $1.4x10^{-1}$ day^{-1}				

[a] Total degradation was measured.

[b] Only anoxic degradation was measured.

[c] No experiments were conducted.

Table 4. Seafood waste accumulation model input variables.

Solids Distribution and Settling Velocities	
Solids Distribution	Settling Velocity (m/sec)
60 percent 20 percent 20 percent	0.085 0.045 0.022
Waste Solids Decay Rate Constant	0.02/day
Lateral and Longitudinal Dispersion Coefficients	$D_x = D_y = 0.1\ m^2/sec$

Table 7. Seafood waste accumulation model results for a particle size of 1.0 mm (0.04 in.)

Case #[a]	Net-Drift Current Speed (cm/sec)	Water Depth (m)	Bottom Slope (%)	Waste Solids Discharge Rate (lb/yr wet weight)	Maximum Waste Accumulation Depth (cm)	Areal Coverage (acres)	
						S[b]	W[c]
Near-Bottom Shore-Based Discharges							
1	5.0	15.2	0.0	500,000 3,000,000 8,000,000	1.1 15.7 41.7	0.0 1.0 2.0	0.1 0.9 1.4
2	15.0	15.2	0.0	600,000 3,000,000 7,000,000	1.5 7.5 17.6	0.0 1.0 2.1	0.2 0.6 1.5
3	5.0	15.2	12.5	300,000 3,000,000 8,000,000	1.6 15.8 42.1	0.0 1.0 2.0	0.1 0.8 1.4
4	15.0	15.2	12.5	600,000 3,000,000 7,000,000	1.5 7.6 17.7	0.0 1.0 2.1	0.2 0.6 1.3
Near-Surface Floating Discharges in Open Ocean							
7	5.0	15.2	0.0	1,000,000 3,500,000 6,000,000	1.1 4.0 6.8	0.0 1.1 2.0	0.2 0.6 2.1
8	15.0	15.2	0.0	3,000,000 6,000,000 8,500,000	1.3 2.6 3.7	0.0 1.0 2.0	0.5 1.0 1.9
9	5.0	30.5	0.0	2,000,000 5,000,000 8,000,000	1.2 2.9 4.7	0.0 1.0 2.2	0.2 0.6 2.1
10	15.0	30.5	0.0	3,000,000 7,000,000 10,000,000	1.1 2.6 3.7	0.0 1.0 2.0	0.3 1.0 1.5
11	5.0	45.7	0.0	3,000,000 7,000,000 10,000,000	1.2 2.3 3.9	0.0 1.0 2.1	0.2 1.0 1.9
12	15.0	45.7	0.0	9,000,000 16,000,000 20,000,000	1.3 2.3 2.9	0.0 1.0 2.0	0.9 1.9 1.9

[a] Case numbers correspond to the case scenarios outlined in Table 3-5 of the ODCE.

[b] Area coverage of solid waste estimated by SURFER™.

[c] Area coverage of solid waste estimated using WASP output.

Table 8. Assessment of total maximum annual loads, wasteload allocations, average monthly limits on settleable solids, and maximum daily limits on settleable solids for King Cove and the Peter Pan Seafoods' facility located therein under scenarios of no authorized zone of deposit, a one-acre zone of deposit, and a two-acre zone of deposit.

Area of Authorized Zone of Deposit (acres)	Annual Loading Capacity (wet lbs/yr)	Total Maximum Daily Load (wet lbs/day)	Wasteload Allocation, Yearly (wet lbs/yr)	Wasteload Allocation, Daily (wet lbs/day)
Basis	Table 7: Waste Solids Discharge Rates for Case #1	TMDL = Annual Loading Capcity/365	WLA_y = TMYL*.90	WLA_d = TMYL*.90)/365
zero	500,000	1,370	450,000	1,230
one acre	3,000,000	8,220	2,700,000	7,398
two acres	8,000,000	21,918	7,200,000	19,726

Table 5. Seafood waste accumulation model results for a maximum particle size of 1.27 cm (0.5 in.)

Case #[a]	Net-Drift Current Speed (cm/sec)	Water Depth (m)	Bottom Slope (%)	Waste Solids Discharge Rate (lb/yr wet weight)	Maximum Waste Accumulation Depth (cm)	Areal Coverage (acres)	
						S[b]	W[c]
Near-Bottom Shore-Based Discharges							
1	5.0	15.2	0.0	200,000 16,000,000 100,000,000	2.9 230 1,435	0.0 1.0 1.8	0.1 0.8 1.3
2	15.0	15.2	0.0	200,000 12,000,000 40,000,000	2.2 133 445	0.0 1.2 2.1	0.1 1.0 1.4
3	5.0	15.2	12.5	100,000 20,000,000 100,000,000	1.4 230 1,438	0.0 1.0 1.8	0.1 0.8 1.4
4	15.0	15.2	12.5	100,000 16,000,000 40,000,000	1.1 179 446.4	0.0 1.3 2.1	0.1 1.1 1.4
5	5.0	15.2	25.0	20,000,000	288	1.0	0.8
6	15.0	15.2	25.0	16,000,000	179	1.3	1.1
Near-Surface Floating Discharges in Open Ocean							
7	5.0	15.2	0.0	200,000 8,000,000 20,000,000	1.8 63.4 176.2	0.0 1.0 2.0	0.1 0.8 1.4
8	15.0	15.2	0.0	300,000 4,000,000 10,000,000	1.4 19.2 48.0	0.0 1.2 2.0	0.2 0.6 1.9
9	5.0	30.5	0.0	300,000 4,000,000 10,000,000	1.8 24.2 60.5	0.0 1.1 2.0	0.2 0.9 1.4
10	15.0	30.5	0.0	400,000 4,000,000 11,000,000	1.2 12.3 44.8	0.0 1.3 2.0	0.1 1.0 1.4
11	5.0	45.7	0.0	300,000 4,000,000 8,000,000	1.4 18.5 37.1	0.0 1.2 2.0	0.1 1.2 1.4
12	15.0	45.7	0.0	700,000 4,000,000 7,000,000	1.4 8.0 14.0	0.0 1.3 2.1	0.2 1.0 1.5

[a] Case numbers correspond to the case scenarios outlined in Table 3-5 of the ODCE.

[b] Area coverage of solid waste estimated by SURFER™.

[c] Area coverage of solid waste estimated using WASP output.

Table 6. Seafood waste accumulation model results for a maximum particle size of 0.95 cm (0.38 in.)

Case #[a]	Net-Drift Current Speed (cm/sec)	Water Depth (m)	Bottom Slope (%)	Waste Solids Discharge Rate (lb/yr wet weight)	Maximum Waste Accumulation Depth (cm)	Areal Coverage (acres)	
						S[b]	W[c]
Near-Bottom Shore-Based Discharges							
1	5.0	15.2	0.0	100,000 16,000,000 90,000,000	1.3 215 1,214	0.0 1.1 2.0	0.1 0.8 1.6
2	15.0	15.2	0.0	150,000 6,000,000 28,000,000	1.5 60.1 280.3	0.0 1.0 2.0	0.1 0.3 1.4
3	5.0	15.2	12.5	150,000 16,000,000 90,000,000	2.0 216.6 1,218	0.0 1.0 2.0	0.1 0.8 1.6
4	15.0	15.2	12.5	150,000 6,000,000 28,000,000	1.5 60.1 280.8	0.0 1.0 2.0	0.1 0.3 1.4
Near-Surface Floating Discharges in Open Ocean							
7	5.0	15.2	0.0	200,000 4,000,000 15,000,000	1.5 30.4 114.1	0.0 1.0 2.0	0.1 0.8 1.4
8	15.0	15.2	0.0	400,000 3,000,000 9,000,000	1.5 11.4 34.2	0.0 1.1 2.1	0.2 0.6 1.9
9	5.0	30.5	0.0	300,000 3,000,000 8,000,000	1.5 15.0 40.0	0.0 1.0 2.0	0.1 0.7 1.4
10	15.0	30.5	0.0	400,000 3,000,000 7,600,000	1.4 10.5 26.5	0.0 1.1 2.0	0.2 0.6 2.3
11	5.0	45.7	0.0	400,000 3,000,000 7,000,000	1.5 11.2 26.2	0.0 1.0 2.0	0.2 0.9 1.9
12	15.0	45.7	0.0	800,000 3,500,000 7,000,000	1.3 5.6 11.0	0.0 1.1 2.1	0.2 1.0 1.0

[a] Case numbers correspond to the case scenarios outlined in Table 3-5 of the ODCE.

[b] Area coverage of solid waste estimated by SURFER™.

[c] Area coverage of solid waste estimated using WASP output.

Table 7. Seafood waste accumulation model results for a particle size of 1.0 mm (0.04 in.)

Case #[a]	Net-Drift Current Speed (cm/sec)	Water Depth (m)	Bottom Slope (%)	Waste Solids Discharge Rate (lb/yr wet weight)	Maximum Waste Accumulation Depth (cm)	Areal Coverage (acres)	
						S[b]	W[c]
Near-Bottom Shore-Based Discharges							
1	5.0	15.2	0.0	500,000 3,000,000 8,000,000	1.1 15.7 41.7	0.0 1.0 2.0	0.1 0.9 1.4
2	15.0	15.2	0.0	600,000 3,000,000 7,000,000	1.5 7.5 17.6	0.0 1.0 2.1	0.2 0.6 1.5
3	5.0	15.2	12.5	300,000 3,000,000 8,000,000	1.6 15.8 42.1	0.0 1.0 2.0	0.1 0.8 1.4
4	15.0	15.2	12.5	600,000 3,000,000 7,000,000	1.5 7.6 17.7	0.0 1.0 2.1	0.2 0.6 1.3
Near-Surface Floating Discharges in Open Ocean							
7	5.0	15.2	0.0	1,000,000 3,500,000 6,000,000	1.1 4.0 6.8	0.0 1.1 2.0	0.2 0.6 2.1
8	15.0	15.2	0.0	3,000,000 6,000,000 8,500,000	1.3 2.6 3.7	0.0 1.0 2.0	0.5 1.0 1.9
9	5.0	30.5	0.0	2,000,000 5,000,000 8,000,000	1.2 2.9 4.7	0.0 1.0 2.2	0.2 0.6 2.1
10	15.0	30.5	0.0	3,000,000 7,000,000 10,000,000	1.1 2.6 3.7	0.0 1.0 2.0	0.3 1.0 1.5
11	5.0	45.7	0.0	3,000,000 7,000,000 10,000,000	1.2 2.3 3.9	0.0 1.0 2.1	0.2 1.0 1.9
12	15.0	45.7	0.0	9,000,000 16,000,000 20,000,000	1.3 2.3 2.9	0.0 1.0 2.0	0.9 1.9 1.9

[a] Case numbers correspond to the case scenarios outlined in Table 3-5 of the ODCE.

[b] Area coverage of solid waste estimated by SURFER™.

[c] Area coverage of solid waste estimated using WASP output.

Table 8. Assessment of total maximum annual loads, wasteload allocations, average monthly limits on settleable solids, and maximum daily limits on settleable solids for King Cove and the Peter Pan Seafoods' facility located therein under scenarios of no authorized zone of deposit, a one-acre zone of deposit, and a two-acre zone of deposit.

Area of Authorized Zone of Deposit (acres)	Annual Loading Capacity (wet lbs/yr)	Total Maximum Daily Load (wet lbs/day)	Wasteload Allocation, Yearly (wet lbs/yr)	Wasteload Allocation, Daily (wet lbs/day)
Basis	Table 7: Waste Solids Discharge Rates for Case #1	TMDL = Annual Loading Capcity/365	WLA_y = TMYL*.90	WLA_d = TMYL*.90)/365
zero	500,000	1,370	450,000	1,230
one acre	3,000,000	8,220	2,700,000	7,398
two acres	8,000,000	21,918	7,200,000	19,726