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 Udagak Bay of Beaver Inlet, 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 Udagak Bay 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 Udagak Bay of Beaver Inlet, Alaska

October 1998

Total Maximum Daily Load for

Settleable Solid Residues

in the Waters of

Udagak Bay of Beaver Inlet, Alaska

TMDL AT A GLANCE:

Water Quality-limited?	Yes
Hydrologic Unit Code:	30102
Standard of Concern:	Residues in marine waters
Designated Use Affected:	Growth and propagation of fish, shellfish, other aquatic life and wildlife
Environmental Indicator:	2.4 acre deposit of settleable solid seafood wastes
Source:	Seafood Processing (P/V Northern Victor)
Loading Capacity:	400,000 lbs of settleable solid seafood wastes per year assuming no authorized zone of deposit
Wasteload Allocation:	360,000 lbs of settleable solid seafood wastes per year
Margin of Safety:	40,000 lbs of settleable solid seafood wastes per year
Remedial Action to Date:	Anchor on swinging anchor line in water of 100-115 ft depth; meal reduction of a significant portion of waste solids; collection and transport of fish gurry to deep water more than one mile from shore by a support vessel
Monitoring to Date:	Dive surveys, annual since 1991
Proposed Future Actions:	Re-issuance of NPDES permit with limitations on settleable solids, requirements for appropriate management practices, and monitoring; possible remediation of existing waste pile.

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 System (NPDES) permits.

The state of Alaska identified Udagak Bay, Beaver Inlet, Unalaska Island (Figure 1) as being water quality-limited for seafood wastes (ADEC 1996,1998). The Alaska Department of Environmental Conservation (ADEC) reviewed monitoring data for Udagak Bay and concluded that seafood processing wastes from the Northern Victor Partnership facility P/V Northern Victor created a waste pile deposit of settleable solid residues measuring at least 2.4 acres in area and 7 feet thick on the seafloor (ADEC 1996; Sound Diving 1997). This waste pile exceeds Alaska's water quality standards for residues. Designated uses for Udagak Bay 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. Udagak Bay 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 Udagak Bay is 400,000 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 40,000 lbs/year. The wasteload allocation (WLA) for settleable solids is 360,000 lbs/year and assumes that the particles size approximate one half (0.5) inch 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 collateral to State authorization of a zone of deposit.

General Background

Udagak Bay is located in Beaver Inlet, Unalaska Island, in the Aleutians West Borough near the west tip of the Alaska Peninsula (Figure 1). The cove itself is approximately 1.75 square miles, or 1,120 acres in area. The land surrounding Udagak Bay is uninhabited.

The P/V Northern Victor (Figure 2) processes fish: cod, halibut, herring, pollock, salmon, and a variety of other fish. It produces fish products, including fish meal. Since 1997 P/V Northern Victor has been supported by a vessel which takes on loads of fish gurry and transports these seafood wastes into deep water more than a mile from shore for disposal while underway.

Climate

The Unalaska area is characterized by a maritime climate. Low-lying fog, overcast skies, rain and drizzle dominate weather conditions. Average annual precipitation is approximately 60 inches, some of which falls as snow. Fog occurs frequently in the summer. Normal summer air temperatures range from 50 degrees Farenheit (F) while normal winter air temperatures range from 25 to 35 degrees F. Moderate to strong winds occur throughout the year (National Weather Service). Wind speed averages about 12 mph across the year, with maximum winds exceeding 40 mph occurring frequently.

Wind is the primary driving force for currents in Udagak Bay. Tidal current comprises a secondary and relatively minor driving force for current conditions in Udagak Bay. Tides are semi-diurnal, with a mean range of 2.2 feet (ft) and a diurnal range of 3.7 ft. Tidal elevations as high as 6.6 ft and as low as -2.7 ft have been recorded in nearby Dutch Harbor.

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)]. Udagak Bay does not support the designated use of growth and propagation of fish, shellfish, other aquatic life, and wildlife.

Parameter of Concern

The Alaska 1994, 1996 and 1998 §303(d) lists identify Udagak Bay as water quality limited due to exceedences of seafood residue deposits from seafood processing. These waste piles have historically measured as much as four acres in area and 14 feet in height.

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, Udagak Bay'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 Udagak Bay, and the subsequent calculations of Udagak Bay's loading capacity and WLA.

One processing facility, P/V Northern Victor (Figure 2), discharges to the receiving waters of Udagak Bay,creating a depositional area of settleable solid seafood wastes on the seafloor beneath and around the vessel (Figure 3). At present the Northern Victor Partnership 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. 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. depth), a one-acre deposit, and a two-acre deposit.

Pollutant Sources

Point Source

The P/V Northern Victor is the only point source and also the only seafood processing facility in Udagak 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 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 1993, the Northern Victor Partnership moved its anchorage from a depth of roughly 80 ft MLLW to 110 ft MLLW. In 1997, the Partnership began using a fish gurry collection, transport and disposal vessel to disperse a significant portion of the P/V Northern Victor's processing wastes in deeper, offshore waters. P/V Northern Victor has an onboard fishmeal reduction capacity, though this capacity is exceeded by its fish processing capacity and excess waste solids are generated.

Other Sources and Natural Sources

There are no other sources of seafood residue in Udagak Bay. Based upon field studies (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

Alaska's 1998 §303(d) list states that past practices of a nearshore floating seafood processor resulted in two waste piles. The most recent dive survey (Sound Diving 1997) shows the waste piles covering a total of 2.4 acres. Since the seafood processor does not have an authorized zone of deposit, this is an exceedance of water quality standards. Dive surveys from 1991 indicate that a reduction has occurred in the depositional area of the original anchorage at 80 ft from a 1992 maximum of 170,500 sq. ft. to a 1997 area of 45,100 sq. ft. and a reduction in the present anchorage at 110 ft from a 1993 maximum of 108,100 sq. ft. to a 1997 area of 60,600 sq. ft.

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 4) 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.

The P/V Northern Victor discharges screened seafood wastewater with settleable solid particulates of approximately one half (0.5) inch width into Udagak Bay at a depth of approximately 33 meters and in average currents of 15 cm/sec or less. The analysis of total maximum yearly load for these conditions is represented by Case 10 in Table 5 (row # 10 of the "floating discharges"). Using this total maximum yearly load as a basis, EPA calculated the loading capacity for settleable solid seafood processing residues in Udagak Bay and the wasteload allocation for the P/V Northern Victor in Udagak Bay.

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 Udagak Bay. See the discussion below.

The loading capacity of Udagak Bay for settleable seafood processing wastes is 400,000 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 1,096 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 water body and/or (2) by establishing allocations that in total are lower than the defined loading capacity. In the case of the Udagak Bay 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 400,000 lbs/year loading capacity, is 40,000 lbs/year. This margin of safety translates into a daily average of 110 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 non-point sources and natural contributions are not a significant source. 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 sources exist, the point source wasteload allocation for the single point source is equal to the loading capacity minus the margin of safety. This yields a wasteload allocation for P/V Northern Victor of 360,000 lbs/year. This translates into an average daily wasteload allocation of 986 lbs/day. (See Table 8.)

Seasonal Variation

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 (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), Udagak Bay 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 Udagak Bay because of the history and precedence of the State's authorization of zones of deposit of one to two acres area. Table 8 shows these alternative scenarios. They show that Northern Victor Partnership could discharge up to:

- 4,000,000 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 3,600,000 lbs/year. A one-acre ZOD would cover approximately 0.1 percent of the bay's seafloor.

- 11,000,000 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 9,900,000 lbs/year. A two-acre ZOD would cover approximately 0.2 percent of the bay';s seafloor.

If the State chooses to issue a ZOD up to two acres for the Northern Victor, 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 Northern Victor Partnership for discharging seafood processing wastes into Udagak Bay. The effluent limit in the permit will comport with the wasteload allocations in this TMDL (Table 8). Prior to issuing the NPDES permit, ADEC will certify that the permit will comply with Alaska'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 waste piles in Udagak Bay that exceed the Alaska Water Quality Standard and any probable ZOD which may be authorized pursuant to an application for a zone of deposit by the Northern Victor Partnership. 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 waste piles in Udagak Bay could naturally decompose and attenuate in approximately 5 to 10 years if no additional wastes are discharged. 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 have raised the question of remediation to expedite attainment of water quality standards with Northern Victor Partnership and the company is considering such remediation

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.

EPA believes that reducing the waste piles from their combined 2.4 acre size to undetectible is feasible and can be accomplished with negligible side effects. Alyeska Seafoods dredged a seafood waste pile 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).

Monitoring

EPA anticipates that the sea floor monitoring program conducted by the Northern Victor Partnership 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 Udagak Bay and to modify the TMDL determination as necessary. EPA will assure that the monitoring reports of the reduction and eventual elimination of the waste pile will be available to members of the public interested in Udagak Bay.

PUBLIC PROCESS

EPA released the draft TMDL for seafood residues in Udagak Bay 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 Udagak Bay,
- 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 one public comment, and no information responding to the above questions.

References

ADEC. 1996. Alaska's 1996 Water Quality Assessment Report: CWA Section 305(b) and Section 303(d) Submittal to the U.S. Environmental Protection Agency. Alaska Department of Environmental Conservation, Watershed Management Program. August 1996.

ADEC. 1998. Alaska CWA §303(d) list. Alaska Department of Environmental Conservation, Watershed Management Program. April 1998.

Aller, R.C., and J.Y. Yingst. 1980. Relationships between microbial distributions and the anaerobic decomposition of organic matter in the surface sediments of Long Island Sound, USA. Mar. Biol. 56:29-42.

Ambrose, R.B., Jr., T.A. Wool, J.P. Connolly, and R.W. Schanz. 1988. WASP4, a hydrodynamic and water quality model -- Model theory, user's manual, and programmer's guide. EPA/600/3-87/039. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Athens, GA.

Aure, J., and A. Stigebrandt. 1990. Quantitative estimates of the eutrophication effects of fish farming on fjords. Aquaculture 90:135-156.

Balzer, W. 1984. Organic matter degradation and biogenic element cycling in a nearshore sediment. Limnol. Oceanogr. 29(6):1231-1246.

EPA. 1982. Revised Section 301(h) technical support document. EPA 430/9-82-011. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

EPA. 1991. Guidance for water quality-based decisions: the TMDL process. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA 440/4-91-001.

Grundmanis, V., and J.W. Murray. 1982. Aerobic respiration in pelagic marine sediments. Geochimica et Cosmochimica Acta 46:1101-1120.

Henrichs, S.M., and A.P. Doyle. 1986. Decomposition of 14C-labeled organic substances in marine sediments. Limnol. Oceanogr. 31(4):765-778.

Jahnke, R.A., S.R. Emerson, and J.W. Murray. 1982. A model of oxygen reduction, denitrification, and organic matter mineralization in marine sediments. Limnol. Oceanogr. 27(4):610-623.

Jones and Stokes. 1993. Environmental Assessment: Deep Sea Fisheries shore plant and the cumulative effects of seafood processing activities in Akutan Harbor, Alaska. Prepared for the U.S. Environmental Protection Agency Region 10, Seattle, WA. June 1993.

Mackin, J.E., and K.T. Swider. 1989. Organic matter decomposition pathways and oxygen consumption in coastal marine sediments. J. Mar. Res. 47:681-716.

NRC. 1990. Managing Troubled Waters: the Role of Marine Environmental Monitoring. National Research Council. National Academy Press, Washington, D.C.

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

Pearson, T.H., I. Stanley, and S.O. Stanley. 1982. Degradation of organic pollutants in nearshore marine sediments. Mar. Environ. Res. 7:195-210.

Sound Diving. 1997. Dive survey of P/V Northern Victor, Udagak Bay- Beaver Inlet, Unalaska Island, Alaska, for January 1997. Sound Diving, 16959 Shore Drive, Seattle, WA 98155. 23 pp.

Stevens, B.G. and J.A. Haaga. 1994. Draft manuscript. Ocean dumping of seafood processing wastes: Comparisons of epibenthic megafauna sampled by submersible in impacted and non-impacted Alaskan bays, and estimation of waste decomposition rate. National Marine Fisheries Service, Kodiak Laboratory, Kodiak, AK.

Tetra Tech. 1993. Water Quality Study in Akutan Harbor, Alaska. Prepared for the U.S. Environmental Protection Agency Region 10, Seattle, WA. September 1993.

Tetra Tech. 1994. Ocean Discharge Criteria Evaluation for the NPDES General Permit for Alaskan seafood processors, Draft report. Prepared for U.S. Environmental Protection Agency, Region 10, Seattle, WA. Tetra Tech, Inc., Redmond, WA.

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 Udagak Bay, Alaska, showing the P/V Northern Victor.

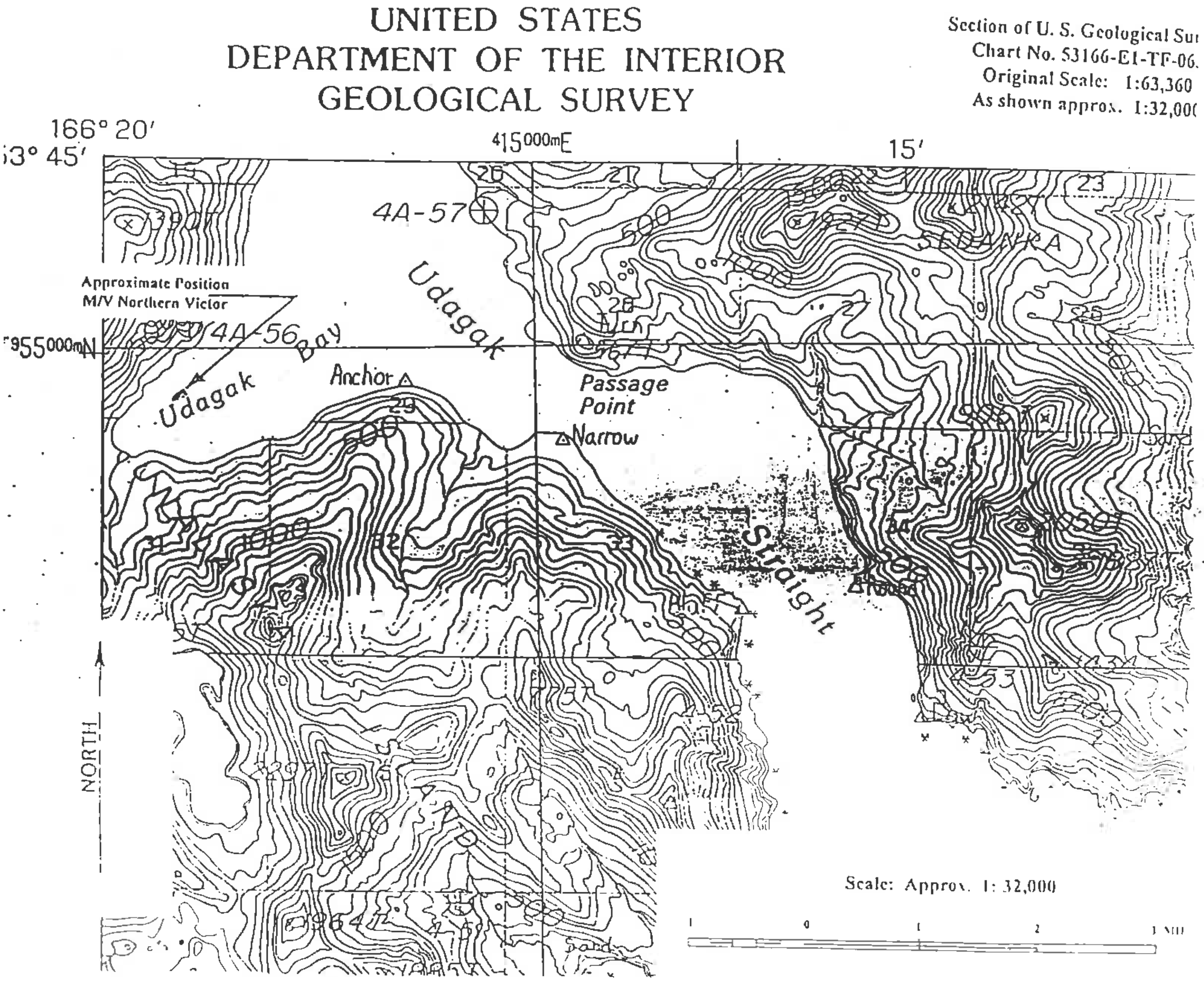
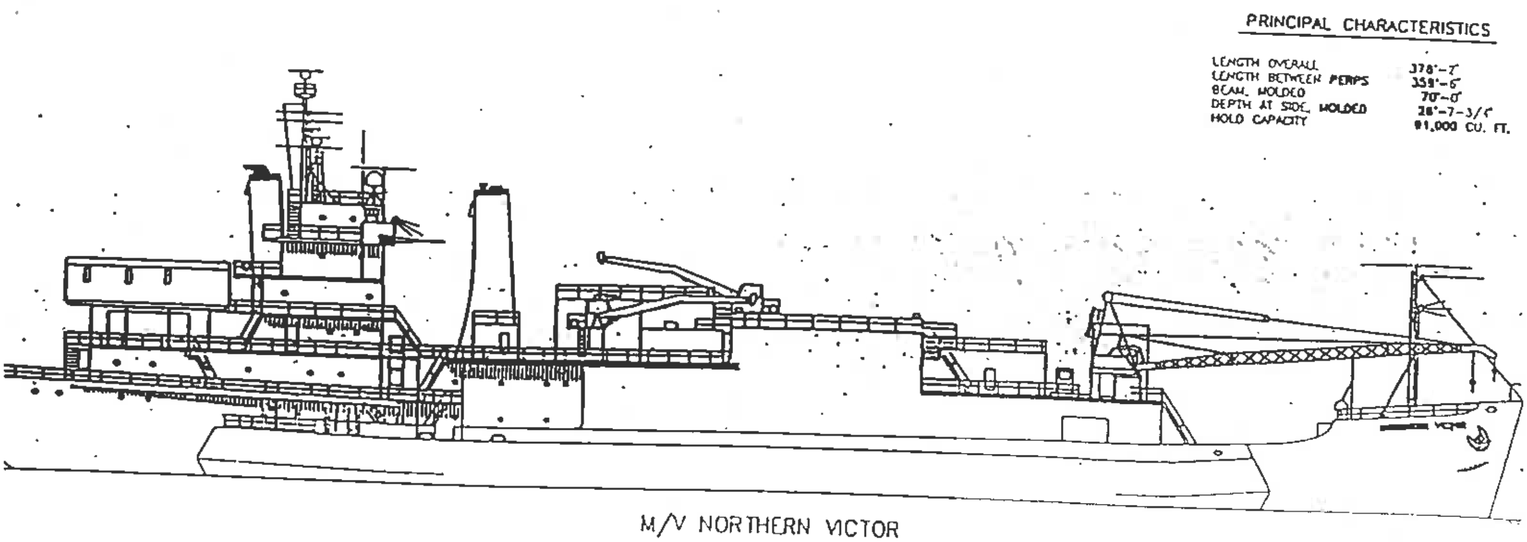


Figure 2. Diagram of P/V Northern Victor.



M/V NORTHERN VICTOR

Figure 3. Diagram of the P/V Northern Victor depicting the approximate location of the two waste piles. Note that the area of the waste piles is over-drawn in proportion to the area bay in order to clearly represent their existence.

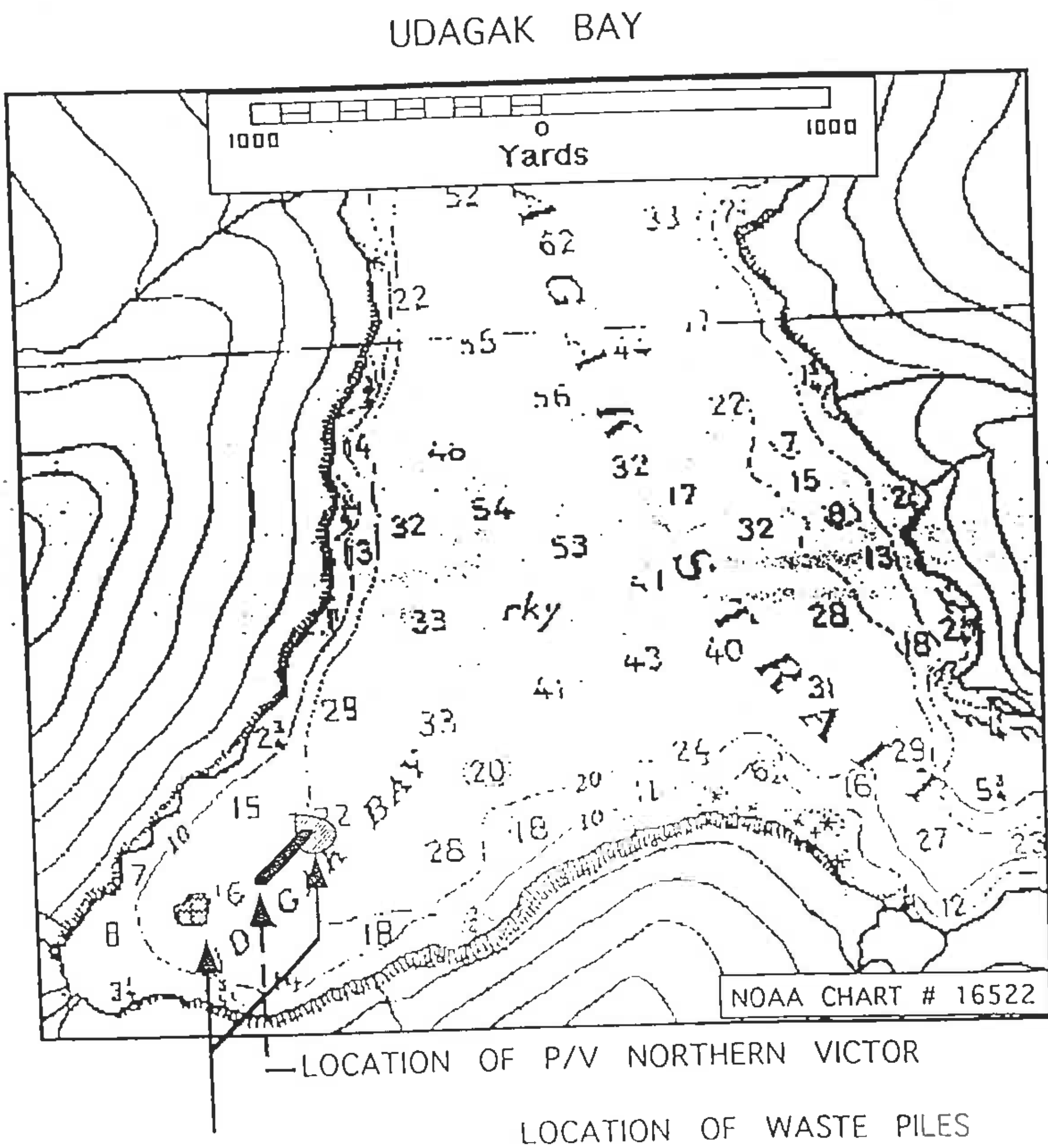


Figure 4. Conceptual model of the fate, transport, persistence, and potential adverse impacts from Alaskan seafood processing waste discharges

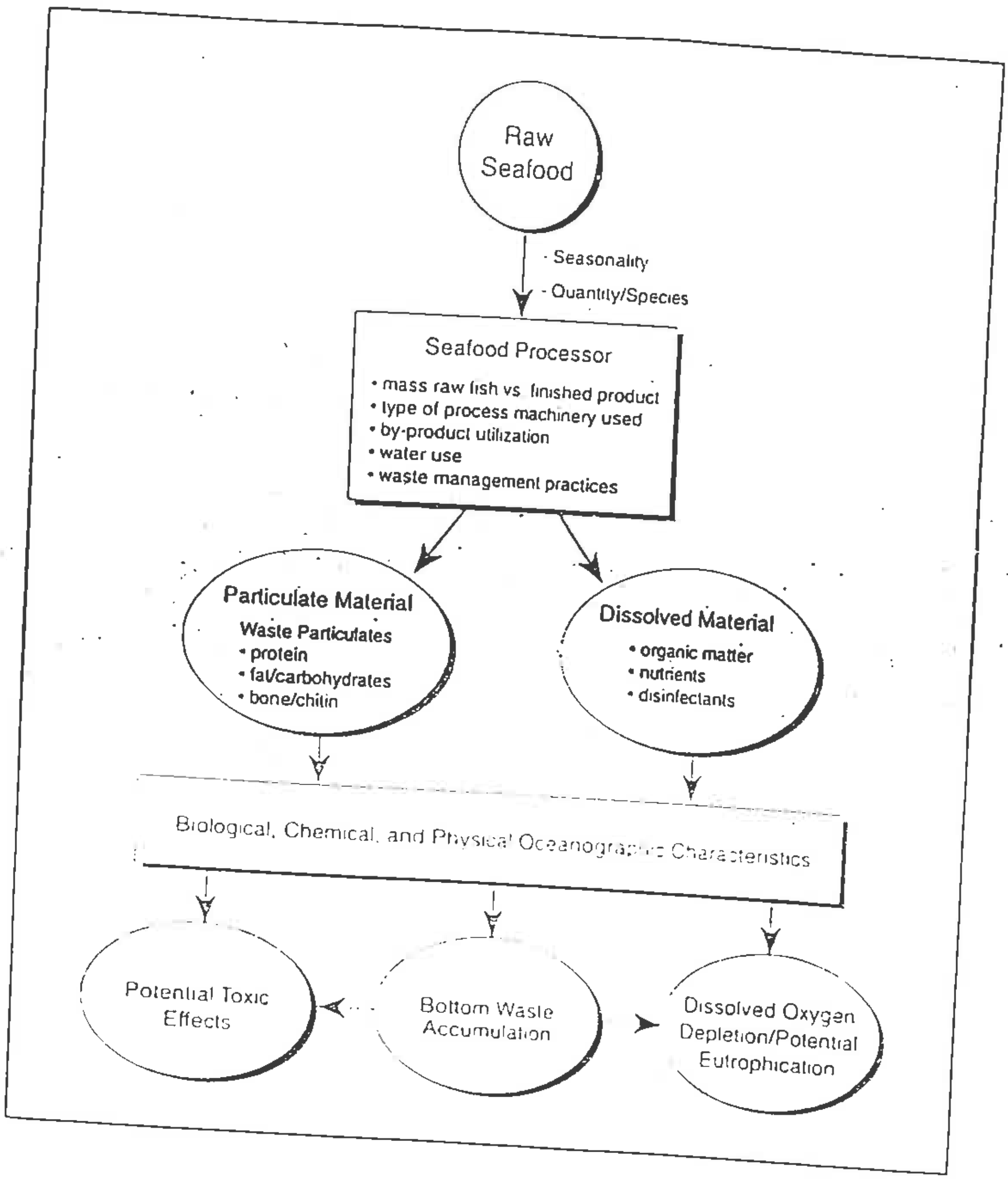


Figure 5. Variable-spaced model grid for WASP5 simulation of seafood waste deposition.

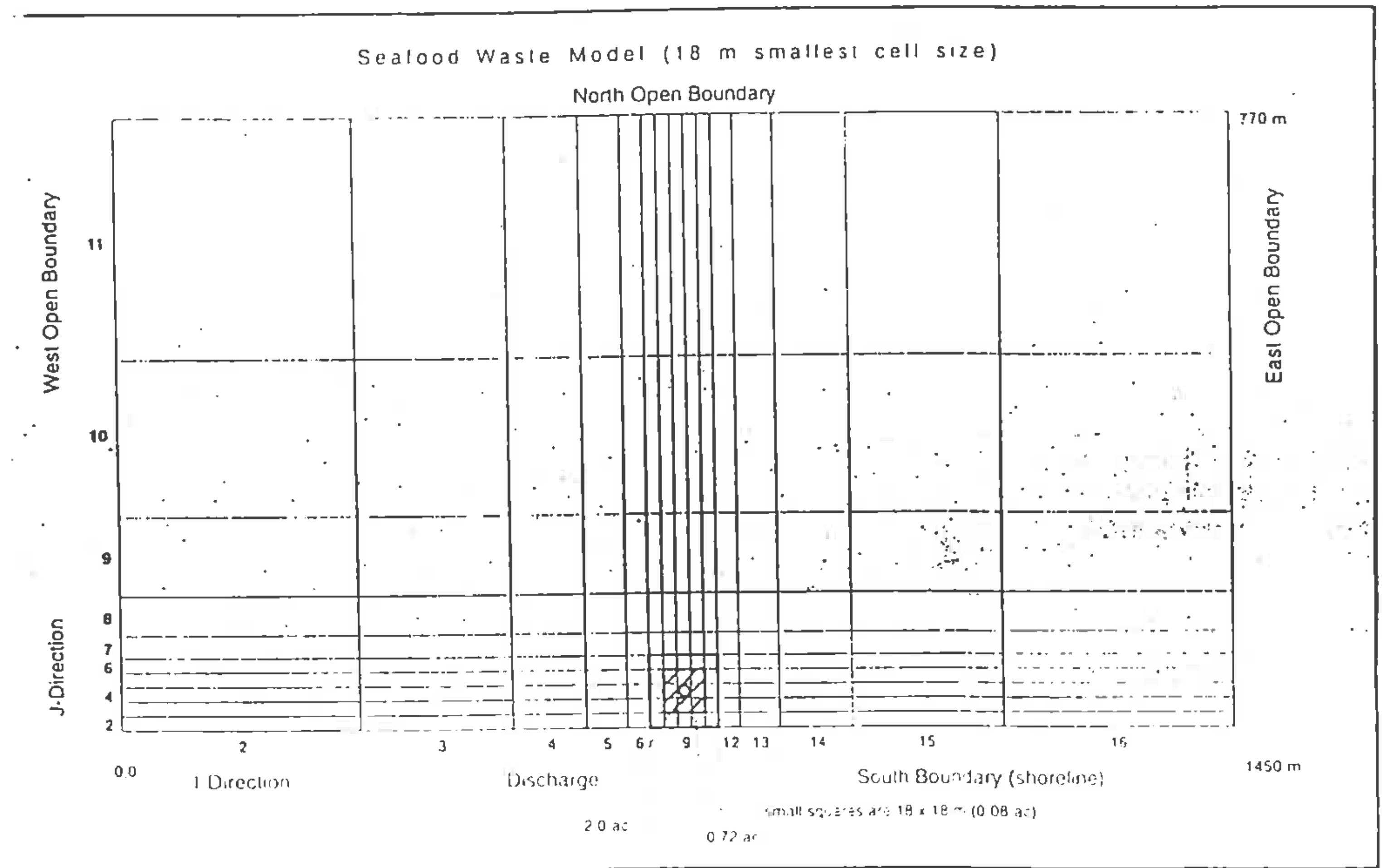


Figure 6. Example of a contoured simulation of seafood waste deposition generated by SURFER™.

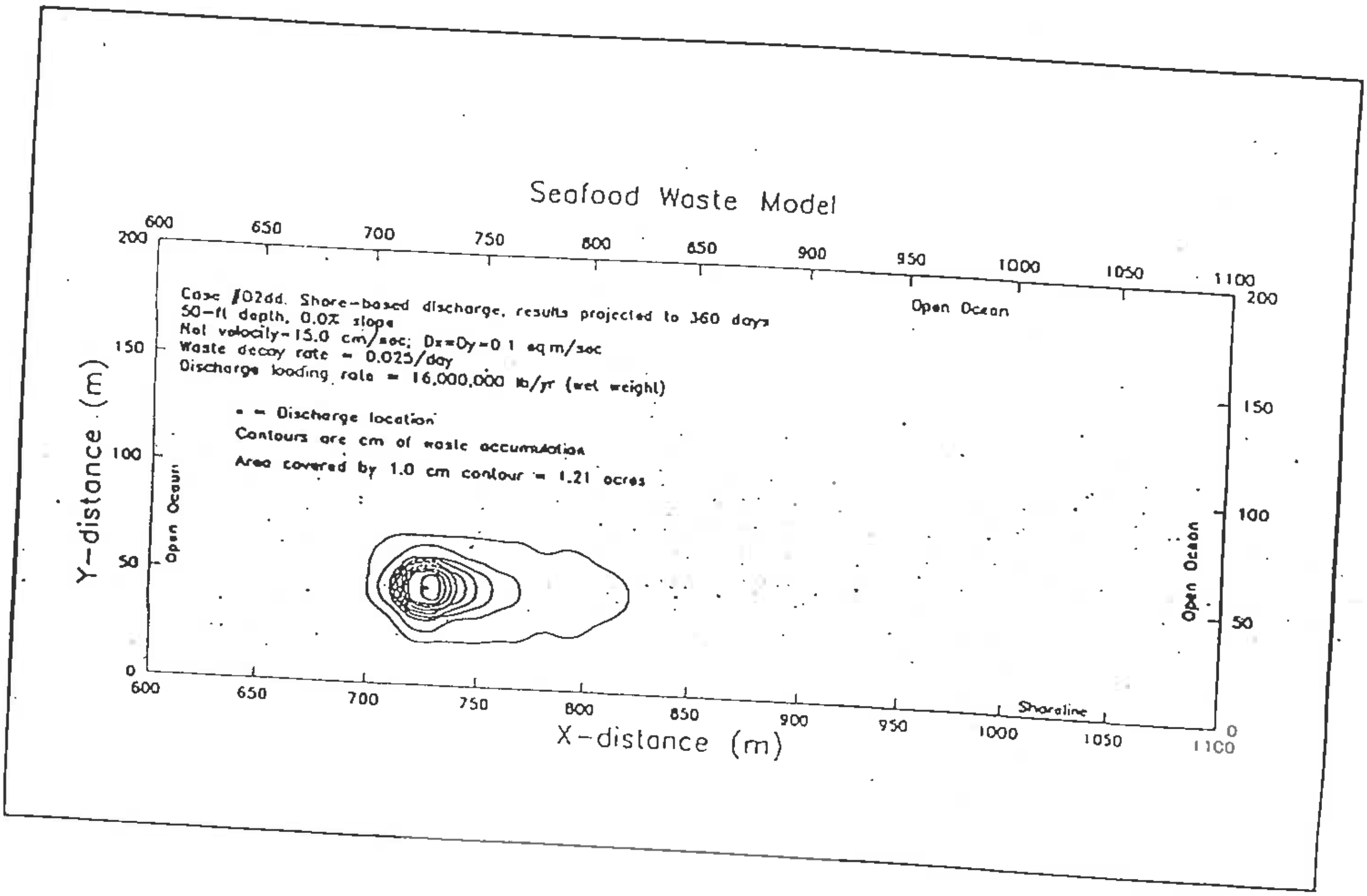


Table 3. Range of sediment decay rate constants for organic material.

(day^{-1})	Degraded Substrate	Measurement Method	Location	Reference
1.6×10^{-6} [a]	Refractory organic material	Benthic chamber, core incubation, pore water	Santa Monica Basin, CA	Jahnke 1990
$< 8.2 \times 10^{-5}$ [a]	Organic material	^{14}C	Resurrection Bay, AK	Henrichs and Doyle 1986
$> 4.1 \times 10^{-4}$ [a]	Labile organic material	Benthic chamber, core incubation, pore water	Santa Monica Basin, CA	Jahnke 1990
1.2×10^{-3} [a]	Organic material	^{14}C	Long Island Sound, NY	Turekian et al 1980
1.7×10^{-3} - 6.0×10^{-3} [a]	Organic material	Pore water nitrogen	North Sea	Billen 1982
2.3×10^{-3} [b]	Refractory algal material	^{35}S	Long Island Sound, NY	Westrich and Berner 1984
2.7×10^{-3} [b]	Refractory organic material	^{35}S	Long Island Sound, NY	Westrich and Berner 1984
2.7×10^{-3} - 8.2×10^{-3} [a]	Refractory algal material	^{14}C	Resurrection Bay, AK	Henrichs and Doyle 1986
1.0×10^{-2} [c]	--	--	--	EPA 1982
2.0×10^{-2} [b]	Labile organic material	^{35}S	Long Island Sound, NY	Westrich and Berner 1984
2.4×10^{-2} [b]	Labile algal material	^{35}S	Long Island Sound, NY	Westrich and Berner 1984
1.4×10^{-1} [a]	Labile algal material	^{14}C	Resurrection Bay, AK	Henrichs and Doyle 1986
Range: 1.6×10^{-6} - 1.4×10^{-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 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 1.52x10^{-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*1.943[illegible]

To convert m/sec to ft/sec multiply m/sec*3.280[illegible]

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 [illegible],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	[illegible],000,000 [illegible],000,000 [illegible],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 15,000,000 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 Udagak Bay and the Northern Victor Partnership's 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 Capacity/365	WLA_y = TMYL*.90	WLA_d = (TMYL*.90)/365
zero	400,000	1,096	360,000	986
one acre	4,000,000	10,959	3,600,000	9,863
two acres	11,000,000	30,137	9,900,000	27,123