U.S. Environmental
Protection Agency
Effluent Guidelines Division
Washington, D.C.

APPENDIX

VOLUME I

SECTION 74
SEAFOOD PROCESSING STUDY
EXECUTIVE SUMMARY

AUGUST 1980

APPENDIX A

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July 14, 1978

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Dear Mr. Denit:

We would like to thank you, Mr. Schatzow, and Mr. Ng for meeting with us and other seafood processing industry representatives on June 16 to discuss EPA's implementation of the Section 74 Seafood Processing Wastes Study. We appreciate your taking time for this meeting which we believe was useful to us and trust that it was useful to you also. Many of the points discussed are summarized below.

It is the belief of the seafood processing industry that under certain conditions the discharge of wastes from seafood processing plants may be beneficial to marine life. Indeed, we believe these wastes can and do contribute to the development of a diversity of beneficial marine life species in the areas where they are discharged.

When the Congress conducted hearings on the amendment of the Water Pollution Control Act, representatives of the seafood processing industry testified and met individually with many congressmen, senators, and their staffs. Seafood processing industry representatives presented the view that where there is sufficient flow and aquatic life, the discharge of seafood processing wastes (which are of themselves non-toxic and non-harmful) should be allowed, in fact encouraged, to promote the development of aquatic resources. Industry representatives also expressed the view that where unreasonable, adverse effects on the environment result from the discharge of such wastes, adequate controls be instituted.

When Congress completed its deliberations on amending the Water Pollution Control Act, the final bill, PL 95-217, the Clean Water Act, contained a requirement for the Environmental Protection Agency to "examine the geographical, hydrological, and biological characteristics of marine waters to determine the effects of seafood processes which dispose of untreated, natural wastes into such waters."

The Conference Report on Section 74 clearly states that the conferees intended that the study include an examination of the "compatibility" of seafood wastes with marine waters. Senator Gravel in the December 15 Congressional Record debate on the Conference Report stated that the focus of the study should be ". . . to determine whether there are grounds for relief from the EPA effluent guidelines for the industry." Senator Gravel also stated in the August 4 Congressional Record that the study ". . . would delve into the question of what organisms or other fish or mammal life feed on the wastes and at what rates of consumption." He further stated that the study ". . . would discuss . . . the flushing effects of tides and currents . . .," and that ". . . the study would be incomplete without a thorough analysis of the plausibility and environmental effect of moving the outfall line to eliminate the problem of accumulation of wastes."

The seafood processing community was pleased that the Congress, by approving the Section 74 Seafood Study, recognized the merits in the industry's views and arguments on compatibility with and bio-enhancement of marine life due to the discharge of seafood processing wastes. Consequently, the industry viewed the requirement for EPA to conduct the seafood processing study as a means of determining once and for all the validity of its claim.

For implementation purposes, the Agency has divided the Congressionally-mandated study into two parts. We have already commented favorably on the undertaking of the market feasibility study for seafood waste reduction in Alaska. This letter is mostly concerned with the effects of the discharge of effluents from seafood processing plants on marine life.

In implementing the second part, according to EPA papers and your comments at our June 16 meeting, the Agency will

. obtain new field data on the water quality effect of "untreated natural wastes" from seafood processing only in Alaska and one control site in Oregon;

. examine technologies to facilitate the use of nutrients in these wastes or to reduce their discharge into the marine environment; and

. conduct a literature review of the discharge of seafood processing wastes.

To implement the above objectives, EPA developed a work plan to be undertaken and completed by private consultants, the University of Alaska, and the Effluent Guidelines and Research and Development segments of EPA. The work plan consists of the following parts:

. A literature search to compile available historical data relating to water quality work both in Alaska and the forty-eight states;

. A detailed assessment of various technologies which may be used in treatment, recovery, or disposal;

. An assessment of the economic feasibility of the manufacture of by-products from seafood processing wastes; and

. Visits to sites in Alaska and one site in Oregon to examine the geological, hydrological, and biological characteristics of the receiving water (the field work will include biological effects on bottom deposits, water column analysis, and scuba diving to observe macro flora and fauna and evidence of accumulation of deposits of seafood wastes).

The Agency has interpreted the term "untreated, natural wastes" to mean only discharges containing gross or ground solids. According to this interpretation, EPA has assumed that new water quality and marine effects data need only be conducted in the Northwest, since all other parts of the country apply a minimum of screening treatment. We do not agree with the Agency's interpretation. We believe that Congress intended screened effluents to be included in the new field work studies.

Contrary to EPA views, we believe that field work should also be done in other areas of the seafood processing industry, namely, bottom fish, sardines, shrimp, and tuna. Field work should be scheduled in Southern California, the center of the United States tuna processing industry; in Louisiana, the center of the United States shrimp canning industry, and in Maine and Massachusetts, the center of the United States sardine and bottom fish industries.

Clearly, the study was to be national in nature. Nothing in the language of Section 74 limits field work to one section of the country. In fact, according to an EPA March 3 memo, EPA was directed by the staffs of Senators Chafee and Gravel ". . . that the study should include coverage of all seafood processing, not just the Alaskan industry."

By failing to institute a thorough work plan for site visits to other areas of the country, new data will not be obtained to demonstrate that bio-enhancement can indeed occur under certain circumstances. Failure to obtain this data may result in arbitrarily stringent regulations requiring "treatment for treatment sake" costing the affected industries many millions of dollars for no environmental benefit and perhaps a loss in marine improvement. If the data are obtained to demonstrate that bio-enhancement does indeed occur, the Congress in evaluating the report might determine at some future date that technology-based standards need not apply to seafood processors under certain specified conditions. This approach was taken by the Congress when it granted municipalities an opportunity to apply for a waiver for secondary treatment requirements based on discharge into marine waters. It was also taken in the Ocean Dumping Act, where seafood wastes are excluded from its provisions.

We acknowledge the below statement from your March 3 memo on the seafood study that under existing law "Regardless of what we do, accomplishment and utilization of any kind of water quality review or assessment is legally inconsistent with Title III of the Act;" however, this statement and a similar one made by Agency representatives during the June 16 meeting does not reflect the intent of the study, which is to provide a report to Congress containing a full cycle thorough review of seafood discharges to determine their compatibility with marine waters.

We believe that the major thrust of the study should be to thoroughly evaluate the industry's claim of the compatbility and bio-enhancement effects of seafood wastes so that Congress can base its future deliberations on this subject with a full understanding of the issues involved. The study should not be based on the premise that the law will remain the same, as your statements suggest.

We disagree with the following statement from your March 3 memo:

> "The request for additional studies in Los Angeles harbor should be a moot point since all tuna canning effluents have been diverted to the local POTW."

This statement again assumes that the existing situation should be continued. We believe that the Agency should conduct new field work in the harbor to determine any changes in marine life that have occurred as a result of the canneries ceasing their discharges. Did the diversity of marine life increase or decrease? What happened to the dissolved oxygen levels? Answers to these questions should be included in the report to Congress. This statement is also contrary to the intent of Congressman Anderson of California who stated in floor debate that "this study should include an assessment of the discharges from such canneries into Los Angeles harbor." (Congressional Record, December 15, 1977.)

We are also concerned that the Agency is failing to complete "full-cycle" studies of the impact of seafood processing wastes on marine waters. In our view, it is inappropriate for the Agency to conduct a one or two day site visit and then claim or assume that this site visit represents typical conditions present at the site at all times. An effective study should begin with sampling prior to seasonal seafood plant start-up, at several times during the processing season, and for a period of time after the plant is no longer in operation. Year-to-year comparisons should also be made.

From information provided to us by EPA, we are very much concerned that too much emphasis is being placed on the collection of data to support past rule-making and future enforcement efforts. On page 8 of the EPA March 3 letter, one of the con statements for conducting no new water quality field work was that "by eliminating new field efforts the Agency may miss water quality data which would assist the regional enforcement efforts." On page 6 of your March 3 memo, one of the pros for conducting more water quality/marine effects studies is "detailed ecological studies may identify more or chronic water quality problems, which may justify more than BAT for some areas in case-by-case permit situations."

Another indication of the Agency's emphasis on rulemaking and enforcement is contained in an EPA summary of the seafood study sent on May 25 to House and Senate Public Works Committees. The summary states that site visits will be made "to problem areas on the Atlantic and Gulf Coasts." Rather than focusing on "problem areas," to which sufficient attention has already been given, we believe the majority of the site visits should be made to "non-problem areas" to determine the beneficial aspects of the discharges and the conditions at these sites that Congress might wish to consider in its future deliberations.

Further evidence of the Agency's intention to use the study in support of rulemaking and enforcement efforts is found in the Agency's April 5, 1978 Research Proposal for Marine effects field work at Yaquina Bay, Oregon. According to this proposal:

> "The principal objective of this project is to assess the detrimental ecological impact, if any exists, of the cannery effluents . . . The regulatory significance is two-fold. First, environmental conditions in Yaquina Bay can serve as a comparison for the effects of cannery effluents from seafood plants in Alaska . . . Second, an analysis of the ecological impact of the Yaquina plants can contribute to the scientific basis for regulatory decisions concerning the need for effluent treatment beyond screening."

Obviously, this research is not objective. Its stated purpose is to find "detrimental" effects and to use the results of the study for increased regulatory requirements.

From the materials presented to industry to date, it does not appear that the Agency has taken any positive steps to determine under what conditions effluents from seafood processing plants may enhance the marine environment.

We were pleased to hear you and Mr. Schatzow comment in the June 16 meeting that the statements referred to above erred in that the referenced documents did not fully explain that compatibility and bio-enhancement effects of seafood wastes on marine waters were indeed being investigated. However, we would appreciate receiving additional assurances from your offices to this effect.

We recognize the limitations that the Agency has with respect to timing and the limited amount of resources available to conduct the study. However, we do not agree that the limited work plan being implemented is sufficient, particularly with respect to demonstrating compatibility of seafood processing wastes with marine waters or their beneficial effects on marine life. Our recommendation is that the Agency develop a more complete work plan, along the lines suggested by seafood processing industry representatives on January 27, 1978, and request additional time and resources from Congress to implement it.

In conclusion, we believe the Agency is failing to carry out the Congressional intent of the Section 74 Seafood Processing Study. We respectfully request that the program be redirected to focus on the beneficial aspects of the disposal of seafood processing wastes and that the rulemaking and enforcement aspects of the Agency's regulatory programs be separated from the seafood study.

Representatives of the seafood processing industry stand ready to assist the Agency to develop a more balanced and appropriate work plan. We wish to participate if at all possible.

Sincerely,

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FINAL REPORT TO ENVIRONMENTAL PROTECTION AGENCY

Impact of Seafood Cannery Waste on the Benthic Biota and Adjacent Waters at Dutch Harbor, Alaska

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1 April 1979

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DISCLAIMER

FORWARD

TABLE OF CONTENTS

DISCLAIMER NOTICE ii

FOREWARD iii

LIST OF TABLES vi

LIST OF FIGURES. vii

ACKNOWLEDGEMENTS ix

ABSTRACT x

1. INTRODUCTION 1
   General Background 1
   Previous Work. 1
   Objectives 4

2. CONCLUSIONS. 6

3. RECOMMENDATIONS 9

4. METHODS. 10
   Sampling 10
   Hydrography. 10
   Dissolved Oxygen Analysis. 10
   Nutrient Analysis. 14
      Ammonia 14
      Orthosilic Acid 14
      Nitrate, Nitrite, Nitrite 14
      Orthophosphate 14
   Sulfide. 15
   Sediment Total Organic Carbon. 15
   Sediment Size Analysis 15
   Benthic Biological Samples 16
   Numerical Analysis 16
   Diversity. 19
   Trophic Structure. 20

5. HYDROGRAPHY, CHEMISTRY AND GEOLOGY 22
   Introduction 22
   Results. 23
   Discussion 70
      Hydrography 70
      Water Chemistry 88
      Geology 92

6. BENTHIC BIOLOGICAL STUDIES 93
   Introduction 93
   Results. 95
      General 95
      Analysis of Stations from Field and Television Observations. 95
      Numerical Analysis. 98

TABLE OF CONTENTS
(Continued)

Discussion 109
Sampling Efficiency of the van Veen Grab. 109
Analysis Based on Field and Television Observatiion . .109
Numerical Analysis - General. 117
Numerical Analysis - Data From Grab Samples 118
Combined Analysis Based on Field and Television Observations and Numerical Analysis 119

7. GENERAL DISCUSSION 122

REFERENCES 125

APPENDIX A - Summary of All Species Data for Stations Analyzed in the Laboratory. 131

APPENDIX B - Taxon Codes and Species Names used in the Cluster Analyses Described in this Report . . .187

APPENDIX C - Features of Stations Samples in the Vicinity of Dutch Harbor, Alaska 190

APPENDIX D - Dominant Species at Stations within Station Groups. 203

LIST OF TABLES

Table 1. Station data for cruise of R/V *ACONA* in the vicinity of Dutch Harbor, Alaska 13

Table 2. Dissolved oxygen and nutrient data: DUT-01A. 52

Table 3. Dissolved oxygen and nutrient data: DUT-02 53

Table 4. Dissolved oxygen and nutrient data: DUT-00 54

Table 5. Dissolved oxygen and nutrient data: HEL-1. 55

Table 6. Dissolved oxygen and nutrient data: HEL-2. 56

Table 7. Dissolved oxygen and nutrient data: 3E 57

Table 8. Dissolved oxygen and nutrient data: HEL-3A 58

Table 9. Dissolved oxygen and nutrient data: HEL-3. 59

Table 10. Dissolved oxygen and nutrient data: HEL-7. 60

Table 11. Dissolved oxygen and nutrient data: HEL-6. 61

Table 12. Dissolved oxygen and nutrient data: HEL-4. 62

Table 13. Water column chemistry: Total soluble sulfide concentrations (µg at /ℓ) 82

Table 14. Sediment grain size parameters. 83

Table 15. Sediment texture. 84

Table 16. Summer distribution of nutrients in surface shelf waters and bottom basin waters. 91

Table 17. Station groups formed by cluster analysis of *ln* transformed abundance data. 100

Table 18. Species groups formed by cluster analysis of *ln* transformed abundance data. 101

Table 19. Station group - Species group coincidence table formed by cluster analysis of transformed abundance data 106

Table 20. Diversity and species richness of station groups formed by a cluster analysis of *ln* transformed data. 107

Table 21. Station groups formed by cluster analysis of *ln* transformed and untransformed abundance data. 111

Table 22. Feeding and motility classes of common benthic invertebrates from Dutch Harbor 112

LIST OF FIGURES

Figure 1. Map of Dutch Harbor and vicinity showing location of processing plants. 2

Figure 2. Hydrographic water chemistry, sedimentological, and biological sampling grid 5

Figure 3. Stations occupied for hydrographic measurements. 11

Figure 4. Biological stations with taxonomic data based on laboratory analysis. Stations used in cluster analysis 12

Figure 5. Grain size analysis for sediments from three stations in the Dutch Harbor area 17

Figure 6. Hydrography and vertical profiles: DUT-01A. 24

Figure 7. Hydrography and vertical profiles: DUT-02 25

Figure 8. Hydrography and vertical profiles: DUT-00 26

Figure 9. Hydrography and vertical profiles: DUT-05 27

Figure 10. Hydrography and vertical profiles: HEL-1. 28

Figure 11. Hydrography and vertical profiles: HEL-2. 29

Figure 12. Hydrography and vertical profiles: 3E 30

Figure 13. Hydrography and vertical profiles: HEL-3A 31

Figure 14. Hydrography and vertical profiles: HEL-3. 32

Figure 15. Hydrography and vertical profiles: HEL-7. 33

Figure 16. Hydrography and vertical profiles: 7C 34

Figure 17. Hydrography and vertical profiles: HEL-6A 35

Figure 18. Hydrography and vertical profiles: HEL-6. 36

Figure 19. Hydrography and vertical profiles: DUT-0A 37

Figure 20. Hydrography and vertical profiles: DUT-00 38

Figure 21. Hydrography and vertical profiles: DUT-0B 39

Figure 22. Hydrography and vertical profiles: HEL-1. 40

Figure 23. Hydrography and vertical profiles: 3H 41

Figure 24. Hydrography and vertical profiles: 3AG. 42

Figure 25. Hydrography and vertical profiles: 3G 43

Figure 26. Hydrography and vertical profiles: 3BF. 44

Figure 27. Hydrography and vertical profiles: 3DE. 45

Figure 28. Hydrography and vertical profiles: HEL-4. 46

Figure 29. Hydrography and vertical profiles: 4A 47

Figure 30. Longitudinal temperature profiles. 48

LIST OF FIGURES
(Continued)

Figure 31. Longitudinal salinity profiles 49

Figure 32. Longitudinal density profiles. 50

Figure 33. Short term temperature and salinity changes at Stations HEL-1 and DUT-00. T = temperature, S = salinity 51

Figure 34. Longitudinal oxygen profiles 63

Figure 35. Longitudinal phosphate profiles. 64

Figure 36. Longitudinal ammonia profiles. 65

Figure 37. Longitudinal nitrite profiles. 66

Figure 38. Longitudinal nitrate profiles. 67

Figure 39. Longitudinal NO profiles 68

Figure 40. Longitudinal silicate profiles 69

Figure 41. Vertical nutrient profiles: DUT-00. 71

Figure 42. Vertical nutrient profiles: DUT-01A 72

Figure 43. Vertical nutrient profiles: DUT-02. 73

Figure 44. Vertical nutrient profiles: HEL-1 74

Figure 45. Vertical nutrient profiles: HEL-2 75

Figure 46. Vertical nutrient profiles: HEL-3 76

Figure 47. Vertical nutrient profiles: HEL-3A. 77

Figure 48. Vertical nutrient profiles: 3E. 78

Figure 49. Vertical nutrient profiles: HEL-4 79

Figure 50. Vertical nutrient profiles: HEL-6 80

Figure 51. Vertical nutrient profiles: HEL-7 81

Figure 52. Grain size mean distributions of surficial sediments < 1mm (Ø). 85

Figure 53. Grain size standard deviation (sorting) distributions sediments < 1mm (Ø). 86

Figure 54. Organic carbon contents of surficial sediment (%). 87

Figure 55. Longitudinal sulfide distribution. 89

Figure 56. Dendrogram produced by cluster analysis using *ln* transformed numbers of individuals per m^2. 99

Figure 57. Dendrogram produced by cluster analysis using number of individuals per m^2 110

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ABSTRACT

The objective of the study reported here was to examine the marine environment in the vicinity of Dutch Harbor with emphasis on areas which had formerly, or were presently receiving seafood processing wastes. Over a period of 24 hours in June 1978, an inventory of dominant infaunal species was made together with sedimentological measurements at certain stations. Water column measurements included hydrography and nutrient chemistry. In a complementary program visible waste circulation and the *in situ* fauna was observed *via* underwater television.

A variety of coastal environments were identified in the vicinity of Dutch Harbor. North (NE and NW) of Amaknak Island is a dynamic region facing the Bering Sea and blanketed with coarse grained, well-sorted sediment. The head of Unalaska Bay (which itself appears to be relatively quiet at depth) lies immediately south of a shallow sill structure between Hog and Amaknak Islands separating it from the active region northwards. Net water movement (at least in the summer) appears to be southwards through the channel, and south of this sill the relatively carbon-rich surficial sediment is finer grained and poorly sorted. A number of stations in this latter region (between Hog and Amaknak Island) show accumulations of plant debris, and it is here that the bulk of the shellfish processing waste is currently being dumped. Because of the apparently restricted bottom circulation here, this waste material is not well dispersed and a localized patch of anoxic water was observed here.

The sea bottom at the point of discharge of processing wastes where debris is accumulating, and in areas immediately adjacent to that point, are always anaerobic and reducing environment. No infaunal or epifaunal organisms can be expected to survive such conditions, and none were observed in this study. Variable conditions exist at stations near the waste outfalls on the west side of Amaknak Island depending on their distance from outfalls, the presence or absence of plant material, their location in the channel between Hog and Amaknak Islands where water movement is reduced, and their proximity to the shallow sill between Hog and Amaknak Islands where well-mixed water is found. The interpretation of the effects of processing wastes are complicated by the presence of algal accumulations

at Stations 3D, 3H, 3AG, 3BF, and 7B (on the far side of Unalaska Bay). Stress on the benthic system on the west side of Amaknak Island must be common whenever plant (marine and terrestrial) material accumulates on the bottom. The additional input of processing wastes to such a stressed system can be expected to further alter the benthic infauna.

Processing wastes were formerly discharged directly into Dutch Harbor proper which, with Iliuliuk Bay, comprises one of the two physically restricted coastal basins. The bottom of Dutch Harbor-Iliuliuk Bay is composed of fine grain, poorly sorted sediment relatively enriched in organic carbon. The other, and much deeper, basin is the adjacent Captains Bay. At the time of year sampled (June) the spring phytoplankton bloom was apparently complete in this region and the water within the basins was well stratified and isolated from the adjacent shelf waters. Nitrate was depleted at the surface and there were strong positive gradients for, in particular, ammonia, phosphate and silica to the bottom, due to regeneration at depth and in the surface sediments. Because of the active biological consumption of oxygen and lack of advective influx of new water, dissolved oxygen concentrations at the base of the water column in Dutch Harbor proper were less than 5 ml/ℓ. However, a high oxygen consumption rate (assuming isolation of the basin water at approximately the same time of year) is not conspicuously different from that observed a decade previously, at which time the additional organic loading due to processing waste was much higher. It appears that oxygen depletion continues through the summer and that anoxic conditions occur in late summer-fall at depth, persisting until new shelf water flushes the system at some unknown period during the winter. This cycle appears to be annual and is apparently a natural consequence of local productivity and terrestrial carbon input. The infaunal composition within the Dutch Harbor-Iliuliuk Bay basin reflects a biologically stressed system. The anoxic conditions that normally occur seasonally within the basin at depth contribute to the depauperate conditions present there. However, additional stresses to this system by way of plant debris and/or processing wastes would be expected to increase the oxygen demand by the benthos and result in a further reduction of infaunal species present. It is obvious that the future deposition of processing wastes in this basin would be ecologically unsound.

A qualitative assessment of the conditions within the study area in conjunction with numerical analysis of grab data have clarified the relationship of benthic infauna to seafood processing waste discharge in the Dutch Harbor area. The numerical analysis delineated seven station groups, and 41 species groups associated with the station groups. An assessment of the relationships of station and species groups, as delineated by the numerical analysis, strengthens the qualitative assessment of each station made by television and direct observation of grab material on shipboard.

Processing wastes accumulating on the shallow shelf on the west side of Amaknak Island are responsible for severe anoxic and reducing conditions on the bottom, at the site of, and immediately adjacent to effluent piles. No benthic infaunal organisms are surviving under or close to the waste accumulations. However, the negative effects of these wastes are dissipated within relatively short distances from the accumulated deposits; i.e. healthy infaunal populations occur within a few hundred meters of these deposits. Thus, based on the very restricted areas on and around the accumulated shellfish waste piles that are affected biologically, it is apparent that existing water currents are not providing sufficient energy for adequate dispersal of wastes. Although processing wastes are not presently impacting broad areas near outfalls, accumulated wastes adjacent to Amaknak Island may eventually cover much of the nearshore bottom with serious sanitary and ecological problems to be expected.

SECTION 1
INTRODUCTION

GENERAL BACKGROUND

The oceanographic impact of effluents discharged from seafood canning operations has been only superficially examined in a few locations in Alaska. The primary impact of such activity is, as added organic waste, largely in particulate form. Since this is typically discharged into shallow coastal regions of restricted circulation, the additional oxygen demand may be such as to overload the system and create local areas of low oxygen content, anoxic sediments, and even anoxic conditions in the water column. Only certain microorganisms can exist in the absence of free oxygen, and the reduced sulfur compounds which are the primary product of marine anaerobic metabolism are generally toxic to higher organisms. Recognizing that seafood wastes may have the potential for either enriching the marine environment or for causing environmental problems, the U.S. Congress has required EPA to further investigate seafood waste discharges.

Dutch Harbor is an ideal locality for continuing research on these problems. The following are the major factors:

1) A number of processing facilities exist in a limited area as shown in Figure 1.

2) A number of morphologically distinct oceanographic environments are involved including both restricted basins and open shelf regions.

3) The waste discharge sites have been changed in recent years so that we have a region which formerly received waste, but no longer does, and a new area of recent impact.

4) The processing facilities are not presently screening to remove solids so that, in general, higher levels of degradable organic waste are discharged into the confined local waters than would be usual in other regions of the United States.

PREVIOUS WORK

EPA investigations in the Dutch Harbor area in 1975, 1976 and 1977 determined that many of the seafood outfalls were in violation of the provisions of their discharge permits. The major findings of the EPA studies

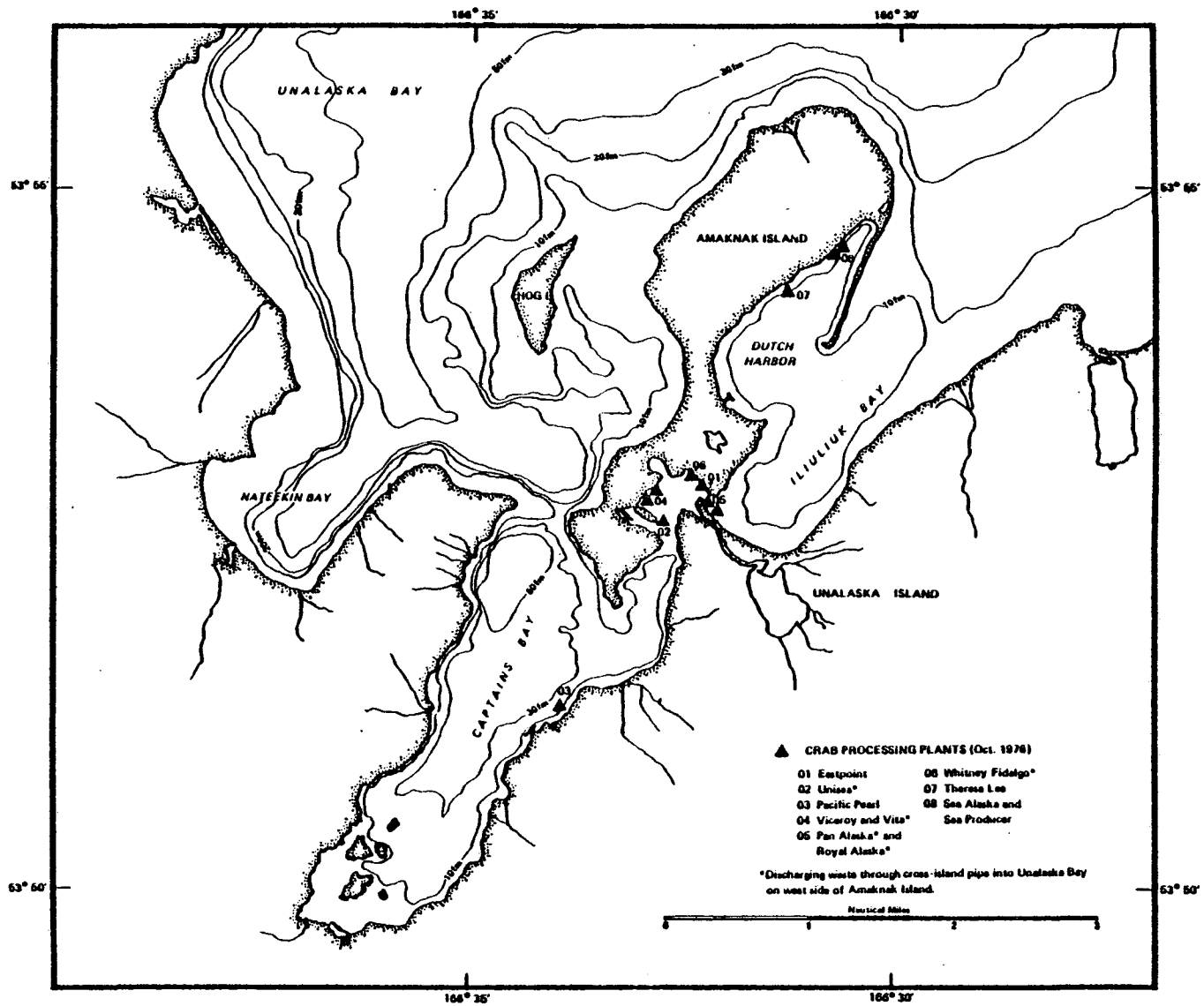

Figure 1. Map of Dutch Harbor and vicinity, showing location of processing plants.

were (1) water quality conditions were degraded due to seafood processing operations. Specifically, low dissolved oxygen (DO) values were found in Iliuliuk Bay, Dutch Harbor, Captain's Bay and near the old submarine repair dock. The low DO values in Captain's Bay were attributed to natural conditions, but in the other areas the primary factor was found to be the seafood wastes with the lowest DO value 0.0 mg/l near the submarine dock, (2) seafood wastes were accumulating, causing buildup of anaerobic, black, organic material. The water movement around the outfall locations was insufficient to remove the wastes, (3) benthic fauna near the outfalls consisted primarily of pollution-tolerant polychaete worms. In many of the areas examined infaunal species were smothered by the waste accumulations, and (4) H_2S concentrations greatly exceeded the 0.002 mg/l concentration reported to constitute a hazard for marine life (Stewart and Tangerone, 1977; Karna, 1978).

There have been no systematic investigations of the oceanographic consequences of the seafood disposal practices in Dutch Harbor. However, a preliminary investigation in the Dutch Harbor area by Colonell and Reeburgh (1978) determined vertical profiles for the major chemical parameters at a number of stations for two observation periods only in September and October. Current meter data were also obtained at this time to determine the major circulation patterns prevalent (at this time of year) seaward of Amaknak Island in Unalaska Bay.

The chemical data showed that, whereas the water chemistry in Unalaska Bay appeared to be "normal", the bottom waters of both Dutch Harbor and Iliuliuk Bay were anoxic at this time of year. This work is of considerable significance since:

1) It is not known whether these conditions are directly induced by the local industrial activity or are natural. Scan Bay, on the western side of Unalaska Island contains anoxic bottom waters at certain times of the year, under natural conditions.

2) In either case, this environment is well suited to an examination of the chemical gradients resulting from removal of oxygen. In particular, the distribution of NH_3-N, PO_4, and SiO_2 are of considerable interest and significance. The magnitude of such atypical nutrient contents in the water column will be a function of the length of time the water remains anoxic; Colonell and Reeburgh (*op cit*) believe that winter storms

restore oxic conditions but nothing definitive is known of this seasonality. However, even if anoxic conditions in the water column are transient, it is likely that long-term overloading of the oxidative capacity of the sediments adjacent to present or past outfalls has resulted in continuous anoxic conditions here, and nutrient profiles immediately adjacent to the sediments may possibly demonstrate a quasi steady state flux of, e.g., phosphate and ammonia from the sediments.

We are unaware of a previous quantitative investigation of the benthic fauna in the vicinity of Dutch Harbor, although benthic studies on the southeastern Bering Sea shelf are reported in Feder (1977), Feder *et al.* (1978), and Feder *et al.* (In press, a and b).

OBJECTIVE

The objective of the study was to examine the marine environment in the vicinity of Dutch Harbor with emphasis on areas which had formerly, or were presently, receiving seafood processing waste. The following activities were part of the investigation.

1) Water column hydrography and chemistry on the grid shown in Figure 2 consisting of temperature and salinity, dissolved oxygen, dissolved sulfide, and the nutrients: nitrate, nitrite, ammonia, silicate and phosphate.

2) Analysis of substrate samples at grab stations for size analysis and total organic carbon.

3) Visual observations of the sediment-water boundary using underwater television.

4) An analysis of benthic infaunal invertebrates at stations adjacent to seafood processing plants and at unpolluted sites in Dutch Harbor and vicinity.

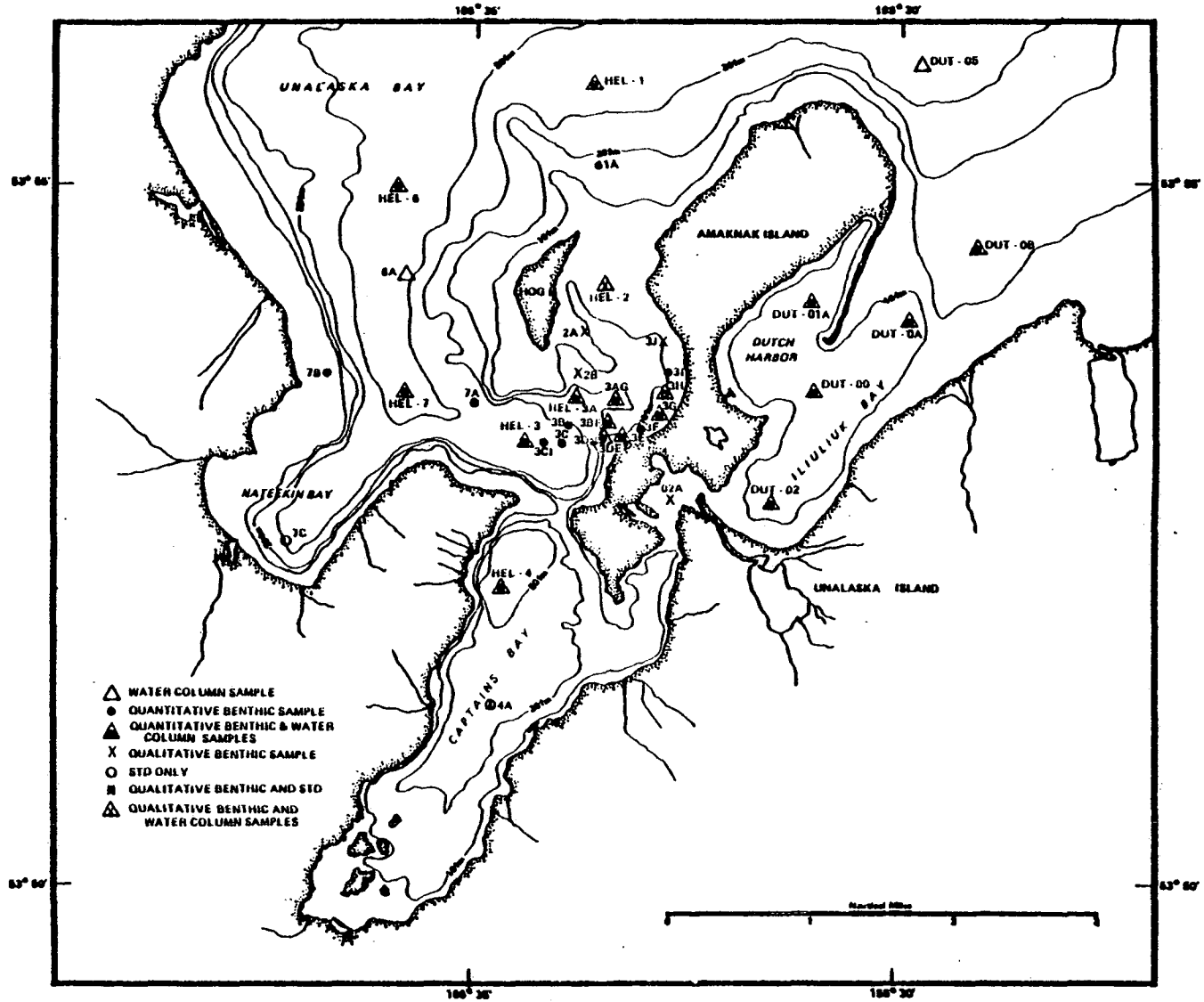

Figure 2. Hydrographic water chemistry, sedimentological, and biological sampling grid.

SECTION 2
CONCLUSIONS

1. A variety of coastal environments occur in the vicinity of Dutch Harbor. North of Amaknak Island is a dynamic region facing the Bering Sea. The head of Unalaska Bay, immediately south of a shallow sill between Hog and Amaknak Islands, is relatively quiet at depth. Dutch Harbor proper and Iliuliuk Bay comprises one of two physically restricted coastal basins. The other, and deeper, basin is the adjacent Captain's Bay.

2. The two basins appear to be advectively isolated through the summer-early fall period. Biological activity reduces the oxygen at the bottom. In Dutch Harbor-Iliuliuk Bay, presumably because it is shallower, and this activity ultimately leads to anoxia in the Fall. This annual oxic-anoxic cycle is natural. Increased organic loading, resulting from accumulating plant debris or processing wastes, will accelerate the oxygen consumption rate and create anoxic conditions earlier in the season (and for longer periods depending on the time of renewal).

3. At the time of year sampled, the basin waters were well stratified and there were strong vertical gradients for the various nitrogen species. The relatively low N/P ratio at depth in Dutch Harbor probably indicates enhanced bottom water concentrations of phosphate as is commonly found where the underlying sediments are anoxic to, or close to, the interface.

4. The sediments in the basins are fine grained and poorly sorted, and have relatively high organic contents. Sediments north and southeast of Amaknak Island are coarser and well sorted, reflecting the dynamic environment there. The latter situation also applies to the shallow region between the islands north of Stations 2A and 2B to 3I.

5. It is probable that the sediments in regions of high organic loading are anoxic to very close to the sediment-water interface. There is an indication of an excess flux of phosphate into the base of the water column over that given by stoichiometric regeneration. This is probably due to transport in solution in association with ferrous iron.

6. Accumulations

   a. There is evidence of multi-year accumulations of processing wastes and natural plant debris on the shallow shelf on the west side of Amaknak Island. Processing wastes do not disperse very far from waste outfall sites, and are not found in the trough between Amaknak and Hog Islands.

   b. Sulfide was present in the sediment at all stations at or adjacent to processing waste outfalls and in regions of accumulation of plant debris. A black anaerobic bottom was present at all of the above stations. Total mortality of infaunal organisms occurred in these regions. Soluble sulfide was locally present in the water column at 21 and 26 m at Station 3DE. Sulfide concentration at this station increased an order of magnitude with a 5 m increase in depth.

   c. Anoxic conditions and a very reduced infauna occurred in the Dutch Harbor-Iliuliuk Bay basin, a region formerly used as a waste disposal site. These conditions are to be expected here if anoxic conditions occur in the water column on a seasonal basis.

7. Benthic Biological Conditions

   a. Benthic infaunal organisms were either smothered by the fresh processing wastes or killed by the decrease in oxygen or the severe reducing conditions within or close to waste piles.

   b. The negative effects of processing wastes on the infauna dissipated over a relatively short distance from the accumulated deposits since the weak currents present near waste outfalls are unable to transport the material far from the point of discharge.

8. Major site — specific characteristics that determine the measured effects

   a. Circulation patterns. The two basins and the trough between Hog and Amaknak Island (immediately south of a shallow sill) receive little "flushing action", and may become anoxic

naturally. Hence, these areas are particularly sensitive to increased organic loading (e.g. seafood wastes and/or plant debris).

b. Outfall locations. Currently, as in the past, wastes are discharged into an area with limited circulation. The present outfall location although "open" is relatively quiescent at depth, and contributes to the problems detected in this study.

c. Amounts of waste discharged. It is apparent that processing wastes are accumulating adjacent to outfalls off Amaknak Island and that the existing water currents there do not provide sufficient energy for adequate dispersal of the wastes. Although processing wastes are not presently impacting broad areas near outfalls, it is probable that accumulated wastes adjacent to Amaknak Island will eventually cover much of the nearshore bottom. Potentially serious ecological and sanitary problems may occur here.

SECTION 3
RECOMMENDATIONS

1. Additional studies are needed to (a) determine periods and mechanisms of flushing over a seasonal cycle in the Dutch Harbor basin and the trough between Amaknak and Hog Islands, (b) determine water column and longshore primary productivity, and terrestrial carbon input to the shallow marine system in the Dutch Harbor area to permit computation of a carbon-oxygen consumption mass balance, and (c) examine basin sediments in the context of overlying cycling oxic/anoxic water.

2. Development of a seasonal annual program designed to monitor the marine systems adjacent to processing waste outfalls is essential.

3. Current seafood waste disposal practices should be improved so that gross solids are either removed or dispersed by discharging effluent into areas of well-mixed waters. Further study of potential disposal sites will be needed to ensure that processing wastes are not flushed back into less dynamic waters where they will accumulate, e.g. the trough between Hog and Amaknak Islands, and the Dutch Harbor-Iliuliuk Bay basin.

SECTION 4
METHODS

SAMPLING

The station grids shown in Figures 2, 3 and 4 were sampled onboard the R/V *Acona*, 11-12 June 1978. Station descriptive data are included in Table 1.

Water samples for salinity, dissolved oxygen and nutrients were collected using Go-flo Niskin bottles at the stations listed in Table 1.

Splits from the van Veen grabs were taken for size analysis and carbon analysis.

HYDROGRAPHY

Temperature and salinity were obtained *via* STD with discrete Nansen bottle calibrations.

The Institute of Marine Science employs a Plessey Enviromental Systems 9040 STD system (S.N. 5341) for vertical profiling of temperature and salinity. During a cast, S, T, and D are sampled five times per second and are recorded digitally on magnetic tape and on analog chart paper. The analog trace is for backup and field use; the magnetic tape is processed to yield high quality data.

The STD system is capable of high precision but relatively less accuracy unless field corrected using Nansen bottles for discrete samples. When thusly corrected, the accuracy is dependent on standard techniques for determining temperature and salinity. The generally accepted accuracy for temperature using deep sea reversing thermometer is within ± 0.02°C and that for salinity using a bench salinometer is within ± 0.02°/$_{oo}$.

The STD system is recalibrated every two years against standards traceable to NBS (National Bureau of Standards). Field corrections are determined separately for each cruise based on discrete samples. Thermometers are calibrated at least every two years and the bench salinometers are calibrated on an irregular basis. Records of field corrections are kept to monitor STD function.

DISSOLVED OXYGEN ANALYSIS

The dissolved oxygen contents of discrete water samples are determined using the Chesapeake Bay Institution microburet modification of the Winkler

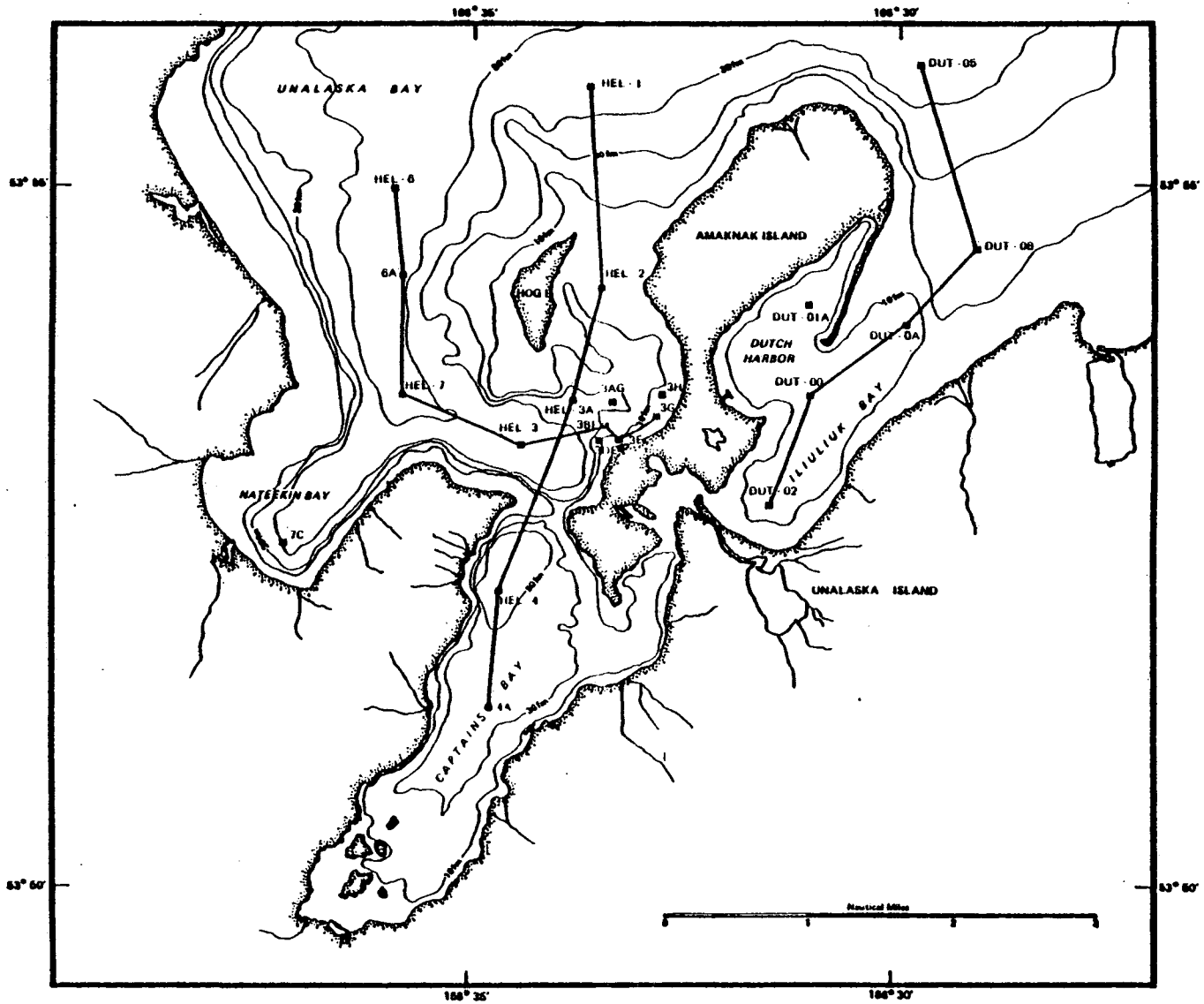

Figure 3. Stations occupied for hydrographic measurements.

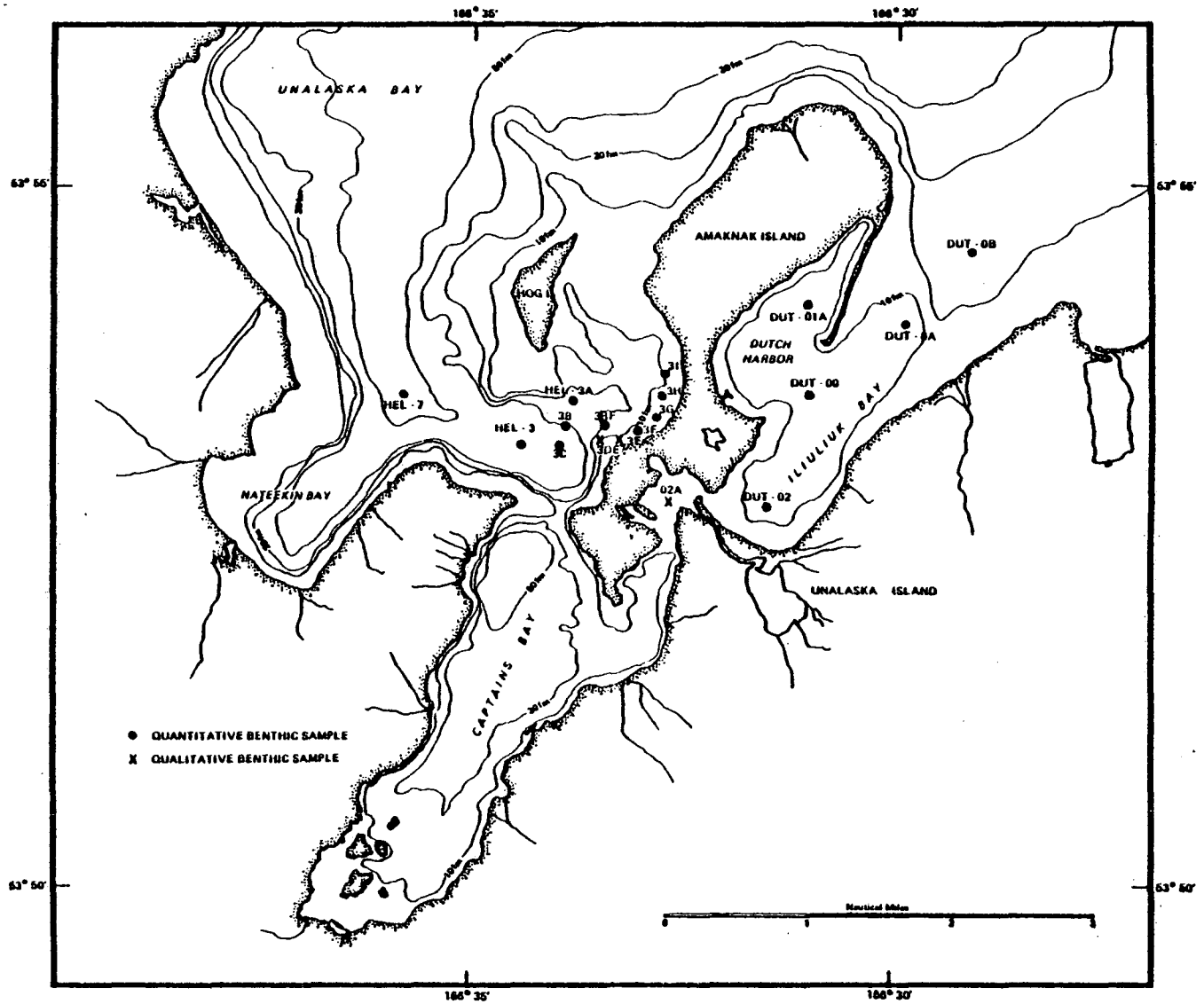

Figure 4. Biological stations with taxonomic data based on laboratory analysis. Stations used in cluster analysis.

TABLE 1. STATION DATA FOR CRUISE OF R/V *ACONA*, 11-12 JUNE 1978 IN THE VICINITY OF DUTCH HARBOR, ALASKA. HYDROGRAPHIC, WATER CHEMISTRY, SEDIMENTOLOGICAL AND BIOLOGICAL STATIONS. HC = HYDROGRAPHIC AND CHEMISTRY STATION; B = BIOLOGICAL STATION; S = SEDIMENTOLOGICAL

Station Name	Ship Operation	Latitude	Longitude	Depth (m)
DUT-01A	HC, B[1]	53°55.2'	166°31.15'	28
DUT-02	HC, B[1]	53°52.8'	166°31.2'	30
DUT-00	HC, B[1]	53°53.5'	166°30.8'	34
DUT-05	HC	55°55.7'	166°29.97'	55
HEL-1	HC, B	53°56.0'	166°34.0'	80
1A	B, S	53°55.3'	166°33.7'	46
HEL-2	HC, B	53°54.6'	166°33.5'	15
3E	HC, B, S	53°52.55'	166°33.45'	16
3F	B[1]	53°53.2'	166°33.65'	51
3G	HC, B[1], S	53°53.18'	166°33.3'	31
3H	HC, B[1], S	53°53.72'	166°32.5'	34
3I	B[1], S	53°53.94'	166°32.95'	32
3J	B	53°54.33'	166°33.6'	14
2A	B	53°54.25'	166°33.3'	14
2B	B	53°53.87'	166°33.36'	14
HEL-3A	HC, B[1], S	53°53.5'	166°33.21'	40
3B	B[1], S	53°53.35'	166°34.0'	51
3D	B	53°52.95'	166°33.7'	57
3C	B[1]	53°53.04'	166°33.9'	68
3C1	B, S	53°53.1'	166°34.1'	48
HEL-3	HC, B[1], S	53°53.2'	166°34.25'	49
7A	B	53°53.4'	166°35.1'	80
HEL-7	HC, B[1]	53°53.6'	166°35.8'	98
7B	B	53°53.8'	166°36.6'	51
7C	HC	53°52.6'	166°37.15'	62
6A	HC	53°54.45'	166°35.97'	117
HEL-6	HC, B, S	53°55.2'	166°35.9'	132
02A	B,S	53°52.65'	166°32.65'	28
DUT-0A	HC, B[1], S	53°54.1'	166°29.18'	29
DUT-0B	HC, B[1], S	53°54.44'	166°28.97'	22
HEL-1	HC, B	53°56.0'	166°34.0'	76
3AG	HC, B, S	53°53.44'	166°33.32'	38
3BF	HC, B[1], S	53°53.27'	166°33.4'	58
3DE	HC, B, S	53°52.9'	166°33.4'	26
HEL-4	HC, B	53°52.2'	166°34.4'	95
4A	HC, B	53°51.3'	166°34.97'	78

[1]Station for which biological data available for the cluster analysis included in this report.

titration (Carpenter, 1965). Samples are drawn from the Nansen bottles into calibrated BOD-type bottles in the usual fashion. One ml each of 3M $MnCl_2$ and the Na OH/Na I (8M and 4M respectively) are added to preserve the oxygen contents. Analysis consists of acidification with 10N H_2SO_4 and titration against 0.2M sodium thiosulfate using a Gilmont micropipet-buret. Standardization is against KIO_3. The precision of this method is about ± 0.05 ml O_2/ℓ (see discussion by Carritt and Carpenter, 1966).

NUTRIENT ANALYSIS

Nutrients are determined using Technicon®[1] Autoanalyzer® procedures based on the manual methods of Murphy and Riley (1962) for reactive phosphorus and Armstrong *et al.* (1967) for dissolved silicon, nitrite. Ammonia is measured by the pheno-hypochlorite method of Koroleff (1970), as adapted by Slawyk and MacIsaac (1972).

Ammonia: Ammonia is determined by the Berthelot reaction in which hypochlorous acid and phenol react with ammonia in aqueous alkaline solution to form indophenol blue, an intensely blue chromophore with an absorption maximum at 537 nm.

Orthosilic Acid: Orthosilic acid is determined by its reaction with molybolate in aqueous acidic solution to form silicomolybdic acid. In this procedure stannous chloride is used to reduce silicomolybdite acid to the heteropoly acid which has an absorption maximum at 820 nm.

Nitrate, Nitrite, Nitrite: Nitrite is determined by the Greiss reaction in which sulfanilamide and N-(1-naphthyl) ethylenidiamine dihydrochloride (NNED) reacts with nitrite in aqueous acidic solution to form an intensely pink diazo dye with an absorption maximum at 570 nm. Nitrate, after it is reduced to nitrite by passage through a column containing copperized cadmium filings, is determined in an identical manner. Thus, the sum of nitrate plus nitrite is determined in the nitrate procedure.

Orthophosphate: Phosphate is determined as phosphomolybdic acid which in its reduced form in the presence of antimony has an absorption maximum at $\sim$ 880 nm.

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[1] Copyright notation

SULFIDE

Soluble water column sulfide was determined by the method described by Strickland and Parsons (1968) as modified by Cline (1969). This involves formation of methylene blue from dimethyl p-phenylene diamine and is an application to marine water of a well established colorimetric procedure.

SEDIMENT TOTAL ORGANIC CARBON

Sediment samples for total organic carbon analysis were collected by van Veen Grab and frozen shipboard. In the laboratory aliquots were freeze-dried, rough weighed to approximately 2 g and treated with 1N HCl for four hours in a water bath at 60°C to destroy inorganic carbonate. After filtering through a 0.45 µm glass fiber filter (Gelman AE®), the mud was dried at 60°C overnight. Triplicate samples were then weighed into crucibles along with metal accelerators and analyzed in a Leco® carbon analyser. The instrument was calibrated with high and low carbon standards as prescribed by the furnace manufacturers. (High: 0.892 %c/g; low: 0.062 %c/g). The data included in this report are, unfortunately, still preliminary and subject to revision.

SEDIMENT SIZE ANALYSIS

Two complementary techniques have been used for the sediment grain size analysis. The size fraction larger than 4 ϕ (62.5 µm) was dried and passed through a battery of sieves of decreasing 0.5 ϕ mesh using a Ro-tap® shaker. After shaking the sediment on each screen was transferred to pre-weighed beakers for determination of the amount of material in each size class.

The less than 4 ϕ fraction was transferred to 1 ℓ volumetric cylinders in a 27°C water bath. Aliquots were extracted by pipette at different times and depths according to standard technique based on Stokes Law assuming a density of 2.65 in this case Calgon® (2.5 g/ℓ) was used as a dispersant to present flocculation.

The above general analytical scheme was prefaced by a peroxide treatment to destroy organic matter. This particular batch of samples--particularly those from adjacent to the cannery outfalls--contained large amounts of fish remains in addition to native organic material so that a 50% H_2O_2 digestive solution was employed and treatment was continued for several days. Samples from near the outfall sites also contained very large amounts of refractory biogenic material: crustacean carapaces, fish bones, etc. Because this material would have severely biased the sediment size spectrum analysis it was resolved to arbitrarily discard all material which did not pass a 1 mm (0 ϕ) screen. This unusual procedural modification must be borne in mind if these data should be compared with those from elsewhere.

Size class data were plotted in the normal way to give cumulative curves and the statistical parameters computed according to the methods of Folk (1968). Representative curves are given in Figure 5.

BENTHIC BIOLOGICAL SAMPLES

A van Veen grab was used to take five replicate samples at each station selected. At several stations only 1-2 replicates were taken. Samples were washed on a 1.0 mm mesh screen, fixed in 10% buffered formalin and subsequently examined at the Marine Sorting Center, Institute of Marine Science, Seward.

NUMERICAL ANALYSIS

Site groups and species assemblages were identified using cluster analysis. Stations used in the analysis are presented in Figure 4. Cluster analysis can be divided into three basic steps.

1. Calculation of a measure of similarity or dissimilarity between entities to be classified.
2. Sorting through a matrix of similarity coefficients to arrange the entities in a hierarchy or dendrogram.
3. Recognition of classes within the hierarchy.

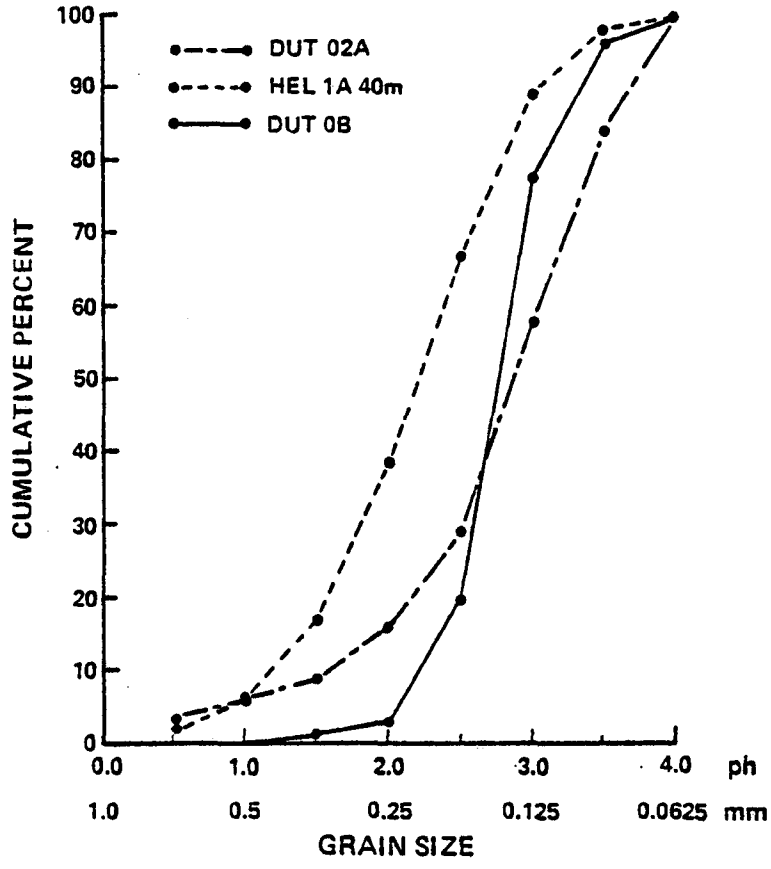


Figure 5. Grain size analysis for sediments from three stations in the Dutch Harbor area.

Data reduction prior to calculation of similarity coefficients consisted of elimination of taxa that could not be identified to genus and taxa that occurred at a single station in low numbers.

The coefficient used to calculate similarity matrices for cluster analysis routines was the Czekanowski coefficient[1]

Czekanowski Coefficient

$$Cs_{1,2} = \frac{2W}{A + B}$$ where A = the sum of the measures of attributes of entity one

B = the sum of the measures of attributes of entity two

W = the sum of the lesser measures of attributes shared by entities one and two.

The Czekanowski coefficient has been used effectively in marine benthic studies by Field and MacFarlane (1968), Field (1969, 1970 and 1971), Day *et al.* (1971), Stephenson and Williams (1971), and Stephenson *et al.* (1972). This coefficient emphasizes the effect of dominant species on the classification, and is often used with some form of transformation. The Czekanowski coefficient was used to calculate similarity matrices for normal cluster analysis (with sites as the entities to be classified and species as their attributes) and inverse cluster analysis (with species as entities and sites as attributes) using both untransformed and natural logarithm transformed abundance data (individuals/m^2). The natural logarithm transformation, $Y = ln(X+1)$, reduces the influence that dominant species have on the similarity determination.

Dendrograms were constructed from the similarity matrices using a group-average agglomerative hierarchical cluster analysis (Lance and Williams, 1966). An an aid in the interpretation of dendrograms formed by cluster analyses, two-way coincidence tables comparing site groups formed by normal analysis and species groups formed by inverse analysis were constructed (Stephenson *et al.*, 1972). In each table the original species x

[1]The Czekanowski coefficient is synonymous with the Motyka (Mueller-Dombois and Ellenberg, 1974), and Bray-Curtis (Clifford and Stephenson, 1975) coefficients.

sites data matrix was rearranged (based on the results of both normal and inverse analysis) so that the sites or species with the highest similarities were adjacent to each other.

DIVERSITY

Species diversity can be thought of as a measurable attribute of a collection or a natural assemblage of species, and consists of two components: the number of species or "species richness" and the relative abundance of each species or "evenness". The two most widely used measures of diversity which include species richness and evenness are the Brillouin (1962) and Shannon (Shannon and Weaver, 1963) information measures of diversity (Nybakken, 1978). There is still disagreement on the applicability of these indices, and the results are often difficult to interpret (Sager and Hasler, 1969; Hurlbert, 1971; Fager, 1972; Peet, 1974; Pielou, 1966a, b). Pielou (1966a,b, 1977) has outlined some of the conditions under which these indices are appropriate.

The Shannon Function

$$H' = -\sum_i p_i \log p_i \text{ where } p_i = \frac{n_i}{N}$$

where n_i = number of individuals in the i^{th} species

N = total number of individuals

assumes that a random sample has been taken from an infinitely large population whereas the Brillouin function

$$H = \frac{1}{N} \log \frac{N!}{n_1! n_2! \cdots n_s!}$$

is appropriate only if the entire population has been sampled. Thus, if we wish to estimate the diversity of the fauna at a sampling site the Shannon function is appropriate. The Brillouin function is merely a measure of the diversity of the five grab samples taken at each site, and makes no predictions about the diversity of the benthic community that the samples were drawn from. The evenness of samples taken at each site can be calculated using the Brillouin measure of evenness, $J = H/H_{maximum}$,

where H = Brillouin diversity function. $H_{maximum}$, the maximum possible diversity for a given number of species, occurs if all species are equally common and is calculated as:

$$H_{maximum} = \frac{1}{N} \log \frac{N!}{\{[N/s]!\}^{s-r}\{([N/s]+1)!\}^{r}}$$

where [N/s] = the integer part of N/s
s = number of species in the censused community
r = N - s[N/s]

Theoretically the evenness component of the Shannon function can be calculated from the following:

$$J' = \frac{H'}{\log s^*}$$ where H' = Shannon diversity function
s* = the total number of species in the randomly sampled community

However, s* is seldom known for benthic infaunal communities. Therefore, the evenness component of the Shannon diversity index was not calculated (for a discussion see Pielou, 1977). Both the Shannon and Brillouin diversity indices were calculated in the present study (see discussions in Loya, 1972 and Nybakken, 1978). Species richness (Margalef, 1958) was calculated as

$$SR = \frac{(S-1)}{\ln N}$$ where S = the number of species
N = the total number of individuals

The Simpson index (Simpson, 1949) was also calculated to enable comparison of the dominance structure.

TROPHIC STRUCTURE

The feeding method used by each of the common species collected was recorded. Species were classified into 5 feeding classes: suspension feeders (SF), deposit feeders (DF), predators (P), scavengers (S) and other (O). All species utilized for the determination of trophic structure were assigned to feeding classes based on the literature (MacGinitie and MacGinitie, 1949; Morton, 1958; Fretter and Graham, 1962; Jørgensen,

1974; Barnes, 1974; Trueman, 1975; Yonge and Thompson, 1976; Jumars and Fauchald, 1977; Feder and Matheke, in press) and personal observations. Since species are distributed along a continuum of feeding types and many organisms utilize several feeding modes, it is often difficult to place a species in a specific class. For example, protobranch molluscs, generally regarded as deposit feeders, may also utilize particles in suspension (Stasek, 1965; Stanley, 1970). However, since these molluscs probably obtain most of their nutritional requirements from the sediment, we classified them as deposit feeders. It is even more difficult to make a distinction between scavengers and deposit feeders, as for example, some of the larger polychaetes and amphipods that can ingest larger food particles as well as small detrital fragments. If these organisms were motile, and able to operate efficiently as scavengers, as well as incorporate sediment in their diet, they were classified as both scavengers and deposit feeders. Species whose feeding behavior was unknown, or uncertain, were classified as "other". The percentage of individuals belonging to each feeding classification was calculated for each site group. Where a species was assigned to two feeding classes we arbitrarily assigned one half of the individuals of that species to each class. Species were also classified into three classes of motility: sessile, discretely motile (generally sessile but capable of movement to escape unfavorable environmental conditions), and motile (after Jumars and Fauchald, 1977). The percentage of individuals belonging to each motility class was also calculated for each station group.

SECTION 5

HYDROGRAPHY, WATER CHEMISTRY AND SEDIMENTOLOGY

INTRODUCTION

In this section we consider the hydrography, and limited aspects of the marine chemistry and sedimentology of the region shown in Figure 1. The principal physiographic features here are: an indentation (Unalaska Bay) of the Bering Sea shelf; two shallow and physically isolated basins (Captains Bay and the combined Dutch Harbor-Iliuliuk Bay area, hereafter simply referred to as "Dutch Harbor"); and a shallow channel between Hog and Amaknak Islands. This area borders the southern Bering Sea. Colonell and Reeburgh (1978) have discussed the summer wind regime here which appears to be of major importance to local water movements. This is noted further briefly below.

The overall objective of this section of the project has been to describe oceanographic conditions with particular reference to those areas which were the major disposal sites of seafood processing wastes (mainly Dutch Harbor), and the region on the west coast of Amaknak Island where most of the processing material is currently discharged.

Alaska has countless examples of semi-restricted bodies of coastal and estuarine water - fjords, lagoons etc. - that have been seasonally well studied. In general, because of physical restrictions on the force exchange of water, the bottom waters in these environments become oxygen deficient at certain times of the year. Whether true anoxic conditions occur within the water column depends, however, on localized characteristics such as the geometry of the basin, the below surface depth of the confining barrier, and the seasonal density of the source water. In the fjords of south central and southeast Alaska, all the inlets studied to date flush at least annually (Heggie and Burrell, 1977). By way of contrast certain Aleutian bays do go anoxic in the summer: Scan Bay - a neighbor of Dutch Harbor - is the best studied to date (Hattori *et al.*, 1978). Unalaska Bay and the region west of Amaknak Island have relatively unrestricted access to the Bering Sea, and this precludes anything other than strictly local oxygen deficiency.

Two immediate problems associated with this project appeared to be whether Dutch Harbor proper (and possibly also Captains Bay) might naturally

go anoxic at certain times of the year. Clearly, enhanced anthropogenic organic loading within Dutch Harbor would exacerbate any such tendency but might not, *per se*, be the direct cause of bottom water anoxia. Secondly, what was the oceanographic regime in the Hog-Amaknak Island channel in relation to the existing and projected rate of industrial perturbation there.

Oceanographic conditions here are strongly seasonal. If, for example, a regular pattern of stagnation were to occur in the basins, flushing would be a function of the annual regional meteorological conditions. A detailed description and understanding of this would then require year-round, and probably, multi-year observation, and this has not been possible to date.

RESULTS

We have obtained data for two days during June (1978) only. Some comparison may be made with the June 1977 data of Brickell and Goering (1970) and the October (1977) data of Colonell and Reeburgh (1978). However considerable additional data at other times of the year are an urgent need.

Hydrographic measurements were taken at the stations shown in Figures 2 and 3, and listed in Table 1. These data are tabulated, and vertical profiles are plotted, in Figures 6-29. Grain size data from stations DUT-02A, DUT-0B, and HEL-1 are included in Figure 5. To better illustrate the hydrography in this region, horizontal profiles for temperature, salinity and density along the tract lines shown in Figure 3 are presented as Figures 30-32. The upper profile, from stations HEL-6 to 3G, is illustrative of open shelf conditions up to the near shore region adjacent to the present site of maximum processing waste dumping. (It should be noted that the slight basin structure shown is an artifact related to the curvation of the profile line; these are <u>not</u> closed basins as in the two lower profiles.) The center profile is again from the open shelf across the shallow region between Amaknak and Hog Islands, over the sill into Captains Bay. The lower profile is basically Dutch Harbor proper and the shelf seaward of this. Short-term temperature and salinity changes at stations HEL-1 and DUT-00 are included in Figure 33.

Dissolved oxygen and nutrient data for the water column are listed in Tables 2-12. Figures 34-40 show profiles (along the same lines discussed

*Note: Continuation of text on page 70

AC CRUISE 261 CONSECUTIVE STATION NO. 55. DUT001A 11/ 6/78
10.0 HOURS GMT

LATITUDE = 53 55.2N LONGITUDE = 166 31.2W SONIC DEPTH = 28 M

1-DIGIT WEATHER CODE IS (X3) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED,
VISIBILITY --- ( ) ---NOT RECORDED

	DIRECTION	SPEED
WIND	195 - 194 DEGR	5 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY =	10.0 DEGR C.	BAROMETRIC PR.	=1019.8 MB
-WET =	DEGR C.	TRANSPARENCY =	M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.90	30.962	24.17	0.
1.0	7.90	30.998	24.19	0.004
5.0	7.94	31.272	24.40	0.018
10.0	7.59	31.724	24.81	0.035
15.0	5.81	32.251	25.45	0.050
20.0	5.13	32.421	25.66	0.062

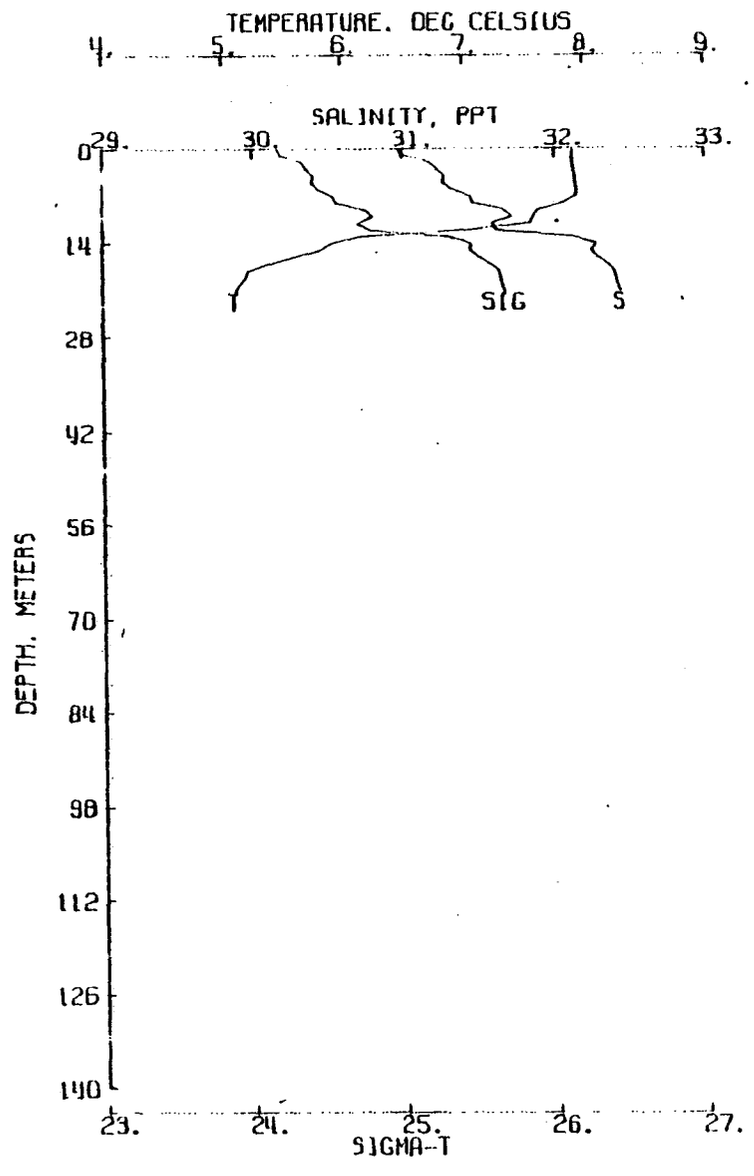


Figure 6. Hydrography and vertical profiles: DUT-01A.

AC CRUISE 261 CONSECUTIVE STATION NO. 56. DUT002 11/ 6/78
11.6 HOURS GMT

LATITUDE = 53 52.8N LONGITUDE = 166 31.2W SONIC DEPTH = 30 M

1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- ( ) ---NOT RECORDED

	DIRECTION	SPEED
WIND	175 - 194 DEGR	5 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY =	9.4 DEGR C.	BAROMETRIC PR.	=1019.2 MB
-WET =	DEGR C.	TRANSPARENCY =	M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.93	30.516	23.81	0.
1.0	7.92	30.357	23.69	0.004
5.0	7.72	31.387	24.52	0.020
10.0	7.24	31.762	24.88	0.036
15.0	6.03	32.306	25.46	0.050
20.0	5.22	32.391	25.63	0.062
25.0	4.92	32.461	25.71	0.074

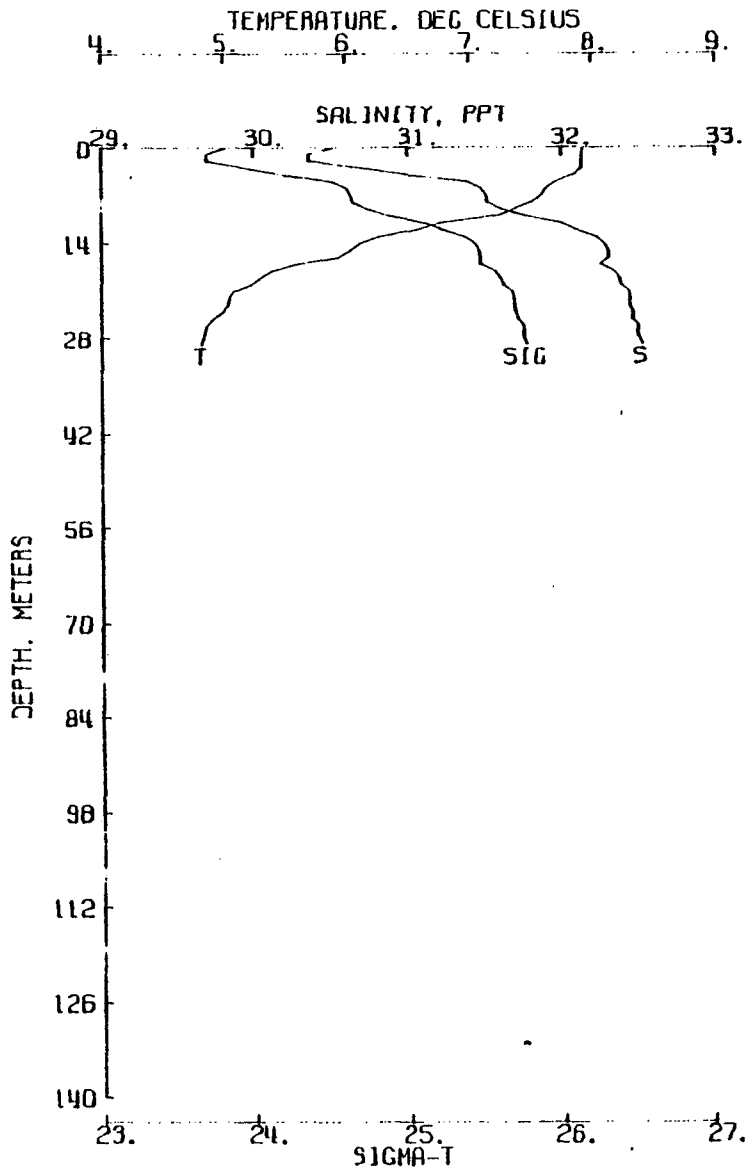


Figure 7. Hydrography and vertical profiles: DUT-02.

AC CRUISE 261 CONSECUTIVE STATION NO. 57. DUT000 11/ 6/78
13.0 HOURS GMT

LATITUDE = 53 53.5N LONGITUDE = 166 30.8W SONIC DEPTH = 34 M

1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- ( ) ---NOT RECORDED

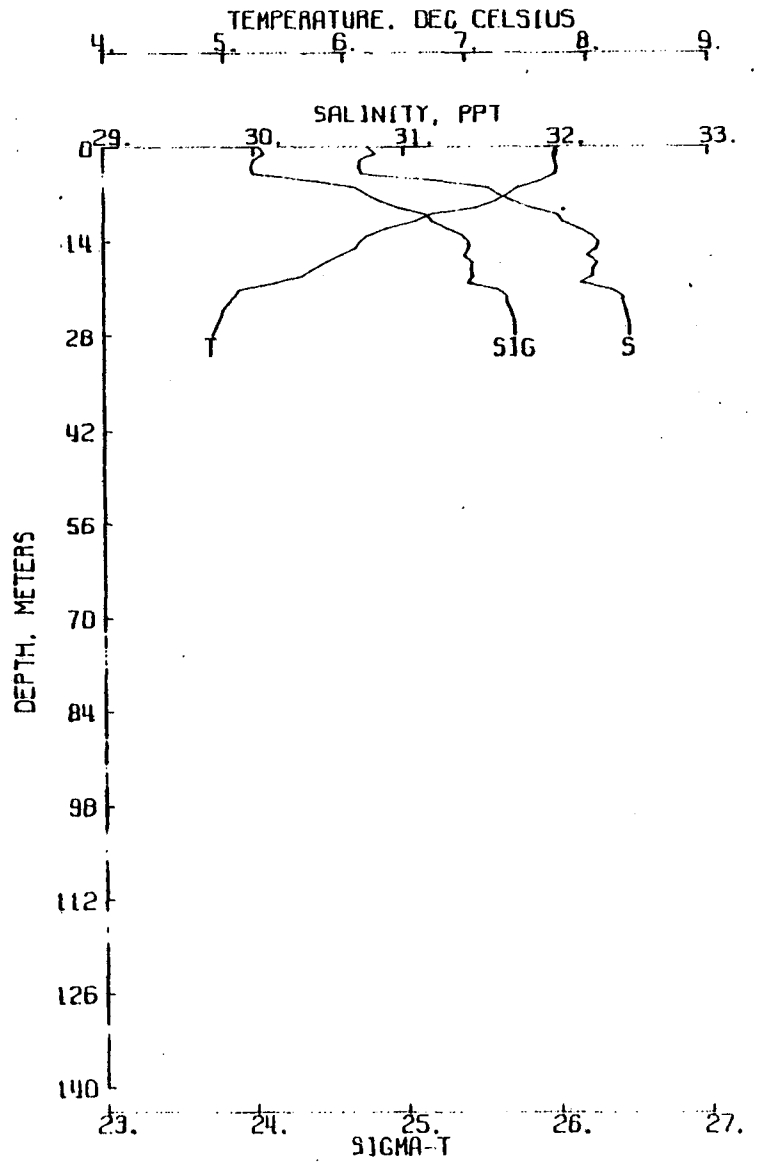
	DIRECTION	SPEED
WIND	185 - 194 DEGR	10 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY =	7.2 DEGR C.	BAROMETRIC PR. =	1018.3 MB
-WET =	DEGR C.	TRANSPARENCY =	M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.75	30.763	24.03	0.
1.0	7.73	30.814	24.07	0.004
5.0	7.63	31.211	24.40	0.019
10.0	6.73	32.011	25.14	0.035
15.0	6.10	32.265	25.42	0.049
20.0	5.42	32.161	25.42	0.061
25.0	4.97	32.468	25.71	0.073

Figure 8. Hydrography and vertical profiles: DUT-00.



AC CRUISE 261 CONSECUTIVE STATION NO. 58. DUT005 11/ 6/78
14.7 HOURS GMT

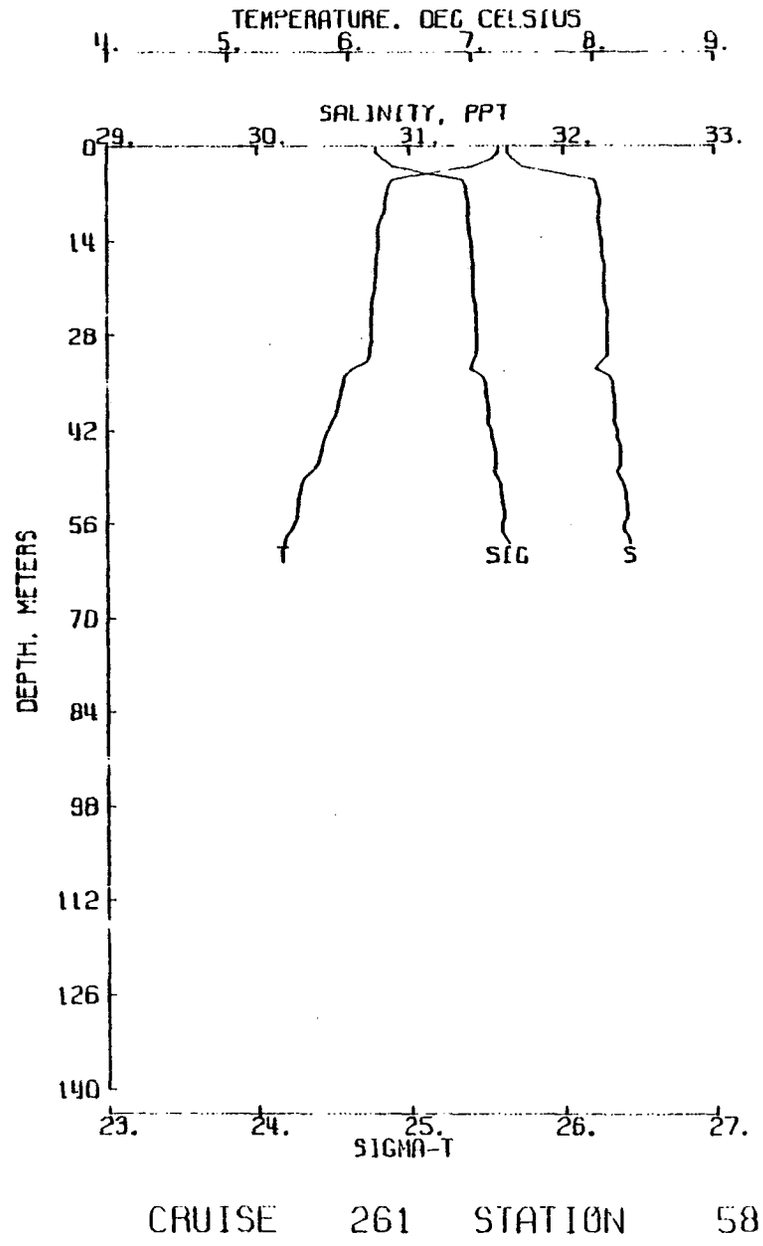
LATITUDE = 55 55.7N LONGITUDE = 166 30.0W SONIC DEPTH = 55 M

1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (7) ---7/8
VISIBILITY --- (7) ---10-20 KM

	DIRECTION	SPEED		
WIND	115 - 124 DEGR	7 KNOTS		
	DIRECTION	HEIGHT	PERIOD	
SEA	115 - 124 DEGR	0.2 M.	SECS	
SWELL	- DEGR	M.	SECS	
TEMPERATURES -DRY =	9.3 DEGR C.	BAROMETRIC PR.	=1017.3 MB	
-WET =	DEGR C.	TRANSPARENCY =	M	

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.23	31.636	24.79	0.
1.0	7.23	31.636	24.79	0.003
5.0	6.35	32.215	25.35	0.015
10.0	6.28	32.238	25.38	0.028
15.0	6.24	32.263	25.40	0.041
20.0	6.22	32.273	25.42	0.054
25.0	6.18	32.292	25.43	0.067
30.0	6.18	32.293	25.44	0.080
35.0	5.95	32.331	25.49	0.093
40.0	5.88	32.339	25.51	0.105
45.0	5.76	32.379	25.55	0.118
50.0	5.61	32.402	25.59	0.130

Figure 9. Hydrography and vertical profiles: DUT-05.



AC CRUISE 261 CONSECUTIVE STATION NO. 59. HEL001 11/ 6/78
15.0 HOURS GMT

LATITUDE = 53 56.0N LONGITUDE = 166 34.0W SONIC DEPTH = 80 M

1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (7) ---7/8
VISIBILITY --- (7) ---10-20 KM

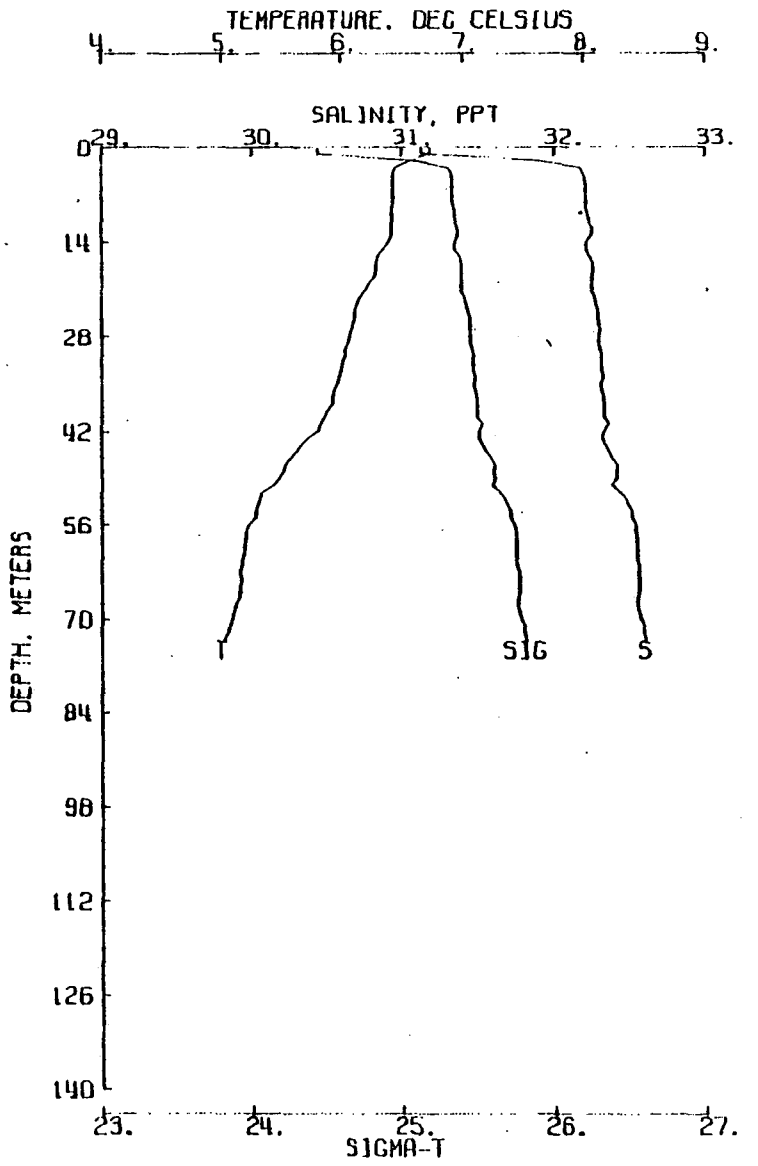
	DIRECTION	SPEED
WIND	175 - 184 DEGR	10 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	175 - 184 DEGR	0.5 M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY = 7.4 DEGR C. BAROMETRIC PR. =1017.1 MB
-WET = DEGR C. TRANSPARENCY = M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	6.74	31.128	24.45	0.
1.0	6.74	31.128	24.45	0.003
5.0	6.43	32.208	25.34	0.015
10.0	6.42	32.226	25.35	0.028
15.0	6.34	32.209	25.35	0.041
20.0	6.23	32.246	25.39	0.054
25.0	6.11	32.298	25.45	0.067
30.0	6.03	32.310	25.47	0.080
35.0	5.97	32.311	25.48	0.093
40.0	5.85	32.329	25.50	0.105
45.0	5.62	32.366	25.56	0.117
50.0	5.42	32.373	25.59	0.130
60.0	5.17	32.548	25.75	0.153
70.0	5.07	32.571	25.78	0.175

Figure 10. Hydrography and vertical profiles: HEL-1.



AC CRUISE 261 CONSECUTIVE STATION NO. 60. HEL002 11/ 6/78
17.7 HOURS GMT

LATITUDE = 53 54.6N LONGITUDE = 166 33.5W SONIC DEPTH = 14 M

1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (3) ---3/8 TOTAL
VISIBILITY --- (7) ---10-20 KM

	DIRECTION	SPEED
WIND	165 - 174 DEGR	15 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	165 - 174 DEGR	0.3 M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY = 7.8 DEGR C. BAROMETRIC PR. =1015.6 MB
-WET = DEGR C. TRANSPARENCY = M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.40	29.837	23.35	0.
1.0	7.40	29.837	23.35	0.005
5.0	7.37	30.850	24.15	0.022

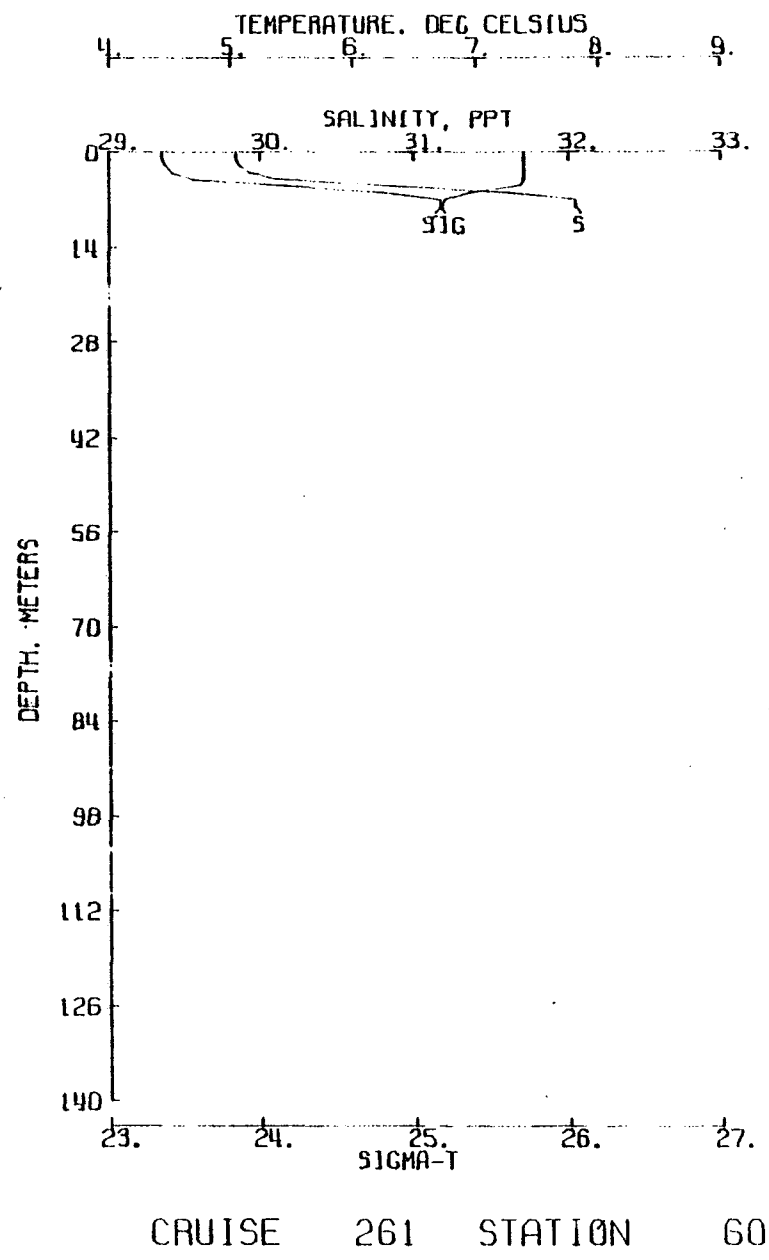


Figure 11. Hydrography and vertical profiles: HEL-2.

AC CRUISE 261 CONSECUTIVE STATION NO. 61. 03E 11/ 6/78
19.3 HOURS GMT

LATITUDE = 53 52.8N LONGITUDE = 166 33.4W SONIC DEPTH = 16 M

1-DIGIT WEATHER CODE IS (X?) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- (4) ---STRATOCUMULUS
CLOUD AMOUNT --- (9) ---8/8 TOTAL
VISIBILITY --- (7) ---10-20 KM

	DIRECTION	SPEED
WIND	135 - 144 DEGR	20 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEG?	M.	SECS

TEMPERATURES -DRY = 8.3 DEGR C. BAROMETRIC PR. =1014.9 MB
-WET = DEGR C. TRANSPARENCY = M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.18	30.136	23.61	0.
1.0	7.18	30.136	23.61	0.004
5.0	6.60	32.074	25.21	0.018

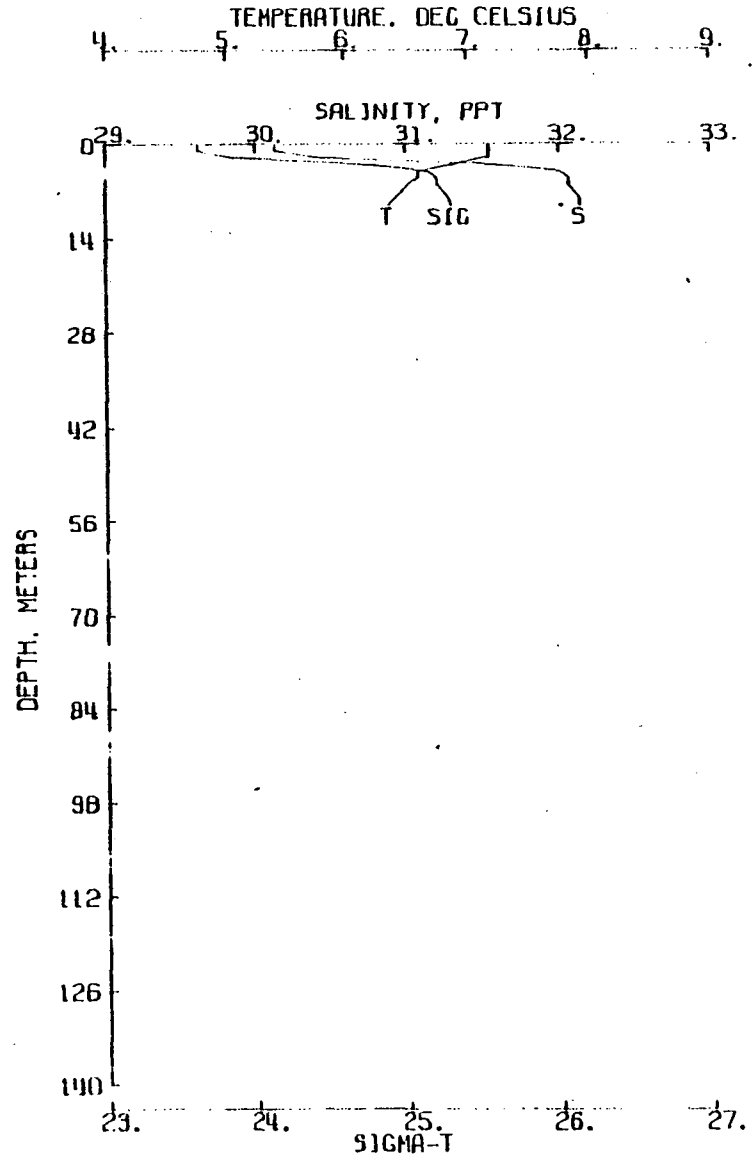


Figure 12. Hydrography and vertical profiles: 3E.

AC CRUISE 261 CONSECUTIVE STATION NO. 71. HEL03A 127 6778
2.8 HOURS GMT

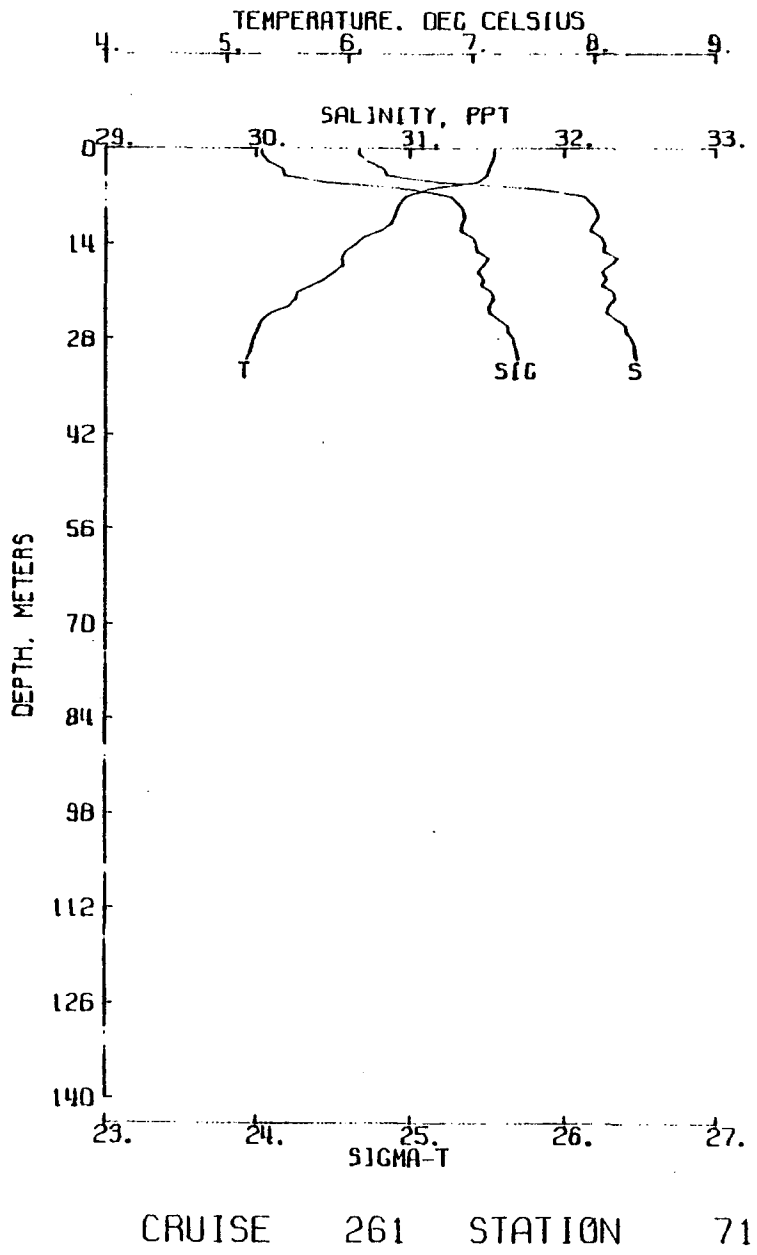
LATITUDE = 53 53.5N LONGITUDE = 166 33.2W SONIC DEPTH = 40 M

1-DIGIT WEATHER CODE IS (x7) AND INDICATES RAIN
CLOUD TYPE --- (7) ---STRATUS
CLOUD AMOUNT --- (8) ---8/8 TOTAL
VISIBILITY --- (7) ---10-20 KM

	DIRECTION	SPEED		
WIND	165 - 174 DEGR	14 KNOTS		
	DIRECTION	HEIGHT	PERIOD	
SEA	165 - 174 DEGR	0.2 M.	SECS	
SWELL	- DEGR	M.	SECS	
TEMPERATURES -DRY =	10.0 DEGR C.	BAROMETRIC PR. =	1008.9 MB	
-WET =	DEGR C.	TRANSPARENCY =	M	

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.18	30.671	24.03	0.
1.0	7.18	30.671	24.03	0.004
5.0	7.05	31.194	24.46	0.019
10.0	6.37	32.221	25.36	0.033
15.0	5.97	32.261	25.44	0.046
20.0	5.69	32.251	25.46	0.059
25.0	5.30	32.349	25.58	0.071
30.0	5.19	32.468	25.69	0.083

Figure 13. Hydrography and vertical profiles: HEL-3A.



AC CRUISE 261 CONSECUTIVE STATION NO. 76. HEL 03 12/ 6/78
8.0 HOURS GMT

LATITUDE = 53 53.2N LONGITUDE = 166 34.3W SONIC DEPTH = 49 M

1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- ( ) ---NOT RECORDED

	DIRECTION	SPEED
WIND	175 - 184 DEGR	5 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY =	10.6 DEGR C.	BAROMETRIC PR. =	1008.0 MB
-WET =	DEGR C.	TRANSPARENCY =	M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.28	30.570	23.94	0.
1.0	7.28	30.570	23.94	0.004
5.0	6.58	31.964	25.13	0.017
10.0	6.03	32.283	25.45	0.031
15.0	5.76	32.289	25.48	0.043
20.0	5.45	32.371	25.58	0.056
25.0	5.26	32.405	25.63	0.068
30.0	5.26	32.478	25.69	0.079
35.0	5.17	32.525	25.74	0.091
40.0	5.09	32.582	25.79	0.102

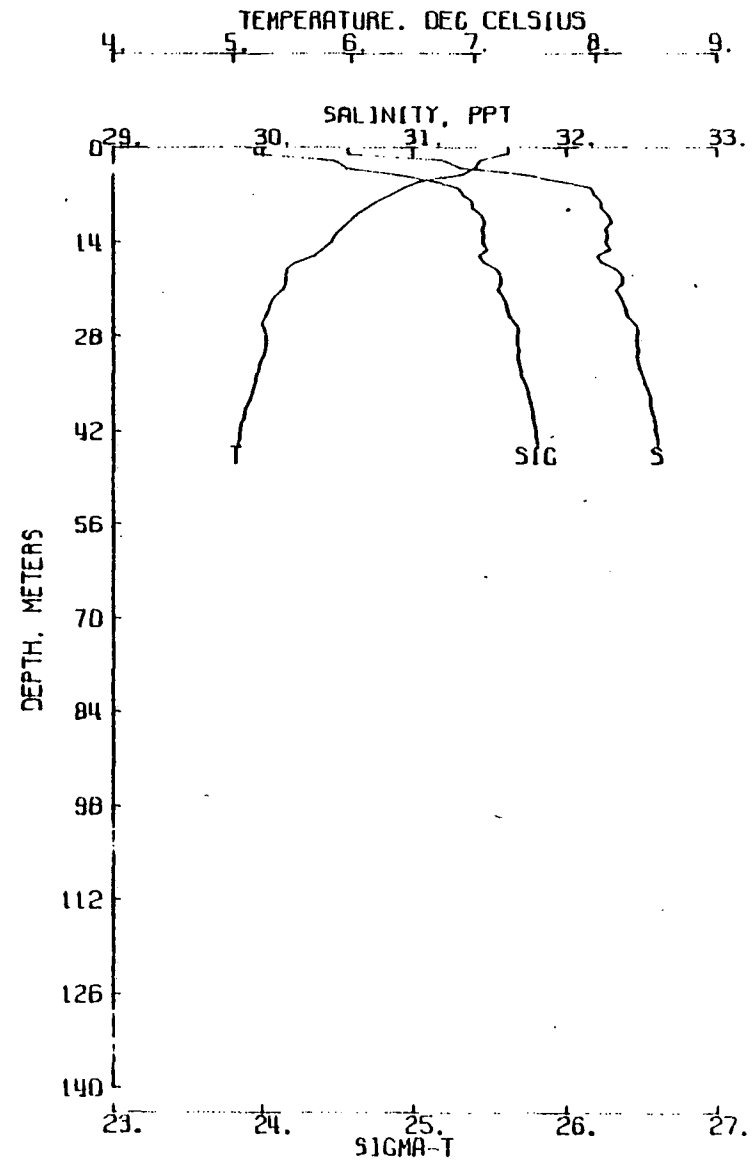


Figure 14. Hydrography and vertical profiles: HEL-3.

AC CRUISE 261 CONSECUTIVE STATION NO. 78, HEL 07 12/ 6/78
10.8 HOURS GMT

LATITUDE = 53 53.6N LONGITUDE = 166 35.8W SONIC DEPTH = 98 M

1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED,
VISIBILITY --- ( ) ---NOT RECORDED

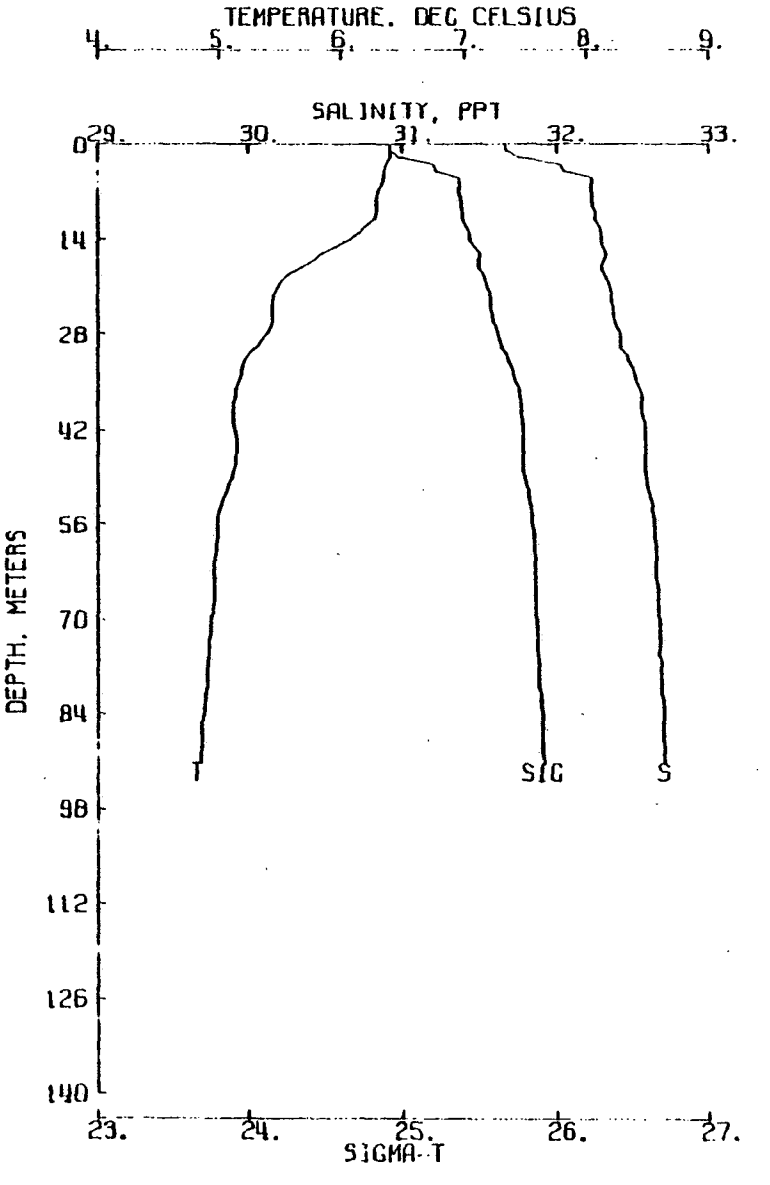
	DIRECTION	SPEED
WIND	215 - 224 DEGR	15 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	215 - 224 DEGR	0.3 M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY = 6.9 DEGR C. BAROMETRIC PR. =1009.6 MB
-WET = DEGR C. TRANSPARENCY = M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	6.41	31.676	24.92	0.
1.0	6.41	31.676	24.92	0.003
5.0	6.34	32.236	25.37	0.014
10.0	6.28	32.261	25.40	0.027
15.0	5.96	32.303	25.47	0.040
20.0	5.50	32.336	25.55	0.053
25.0	5.43	32.375	25.59	0.065
30.0	5.30	32.427	25.64	0.077
35.0	5.16	32.528	25.74	0.088
40.0	5.12	32.568	25.78	0.100
45.0	5.14	32.578	25.78	0.111
50.0	5.08	32.598	25.80	0.122
60.0	4.97	32.651	25.86	0.144
70.0	4.93	32.670	25.88	0.165
75.0	4.92	32.664	25.87	0.176
80.0	4.90	32.688	25.90	0.187
90.0	4.85	32.703	25.91	0.208

Figure 15. Hydrography and vertical profiles: HEL-7.



AC CRUISE 261 CONSECUTIVE STATION NO. 80. 7C 12/ 6/78
14.4 HOURS GMT

LATITUDE = 53 52.6N LONGITUDE = 166 37.2W SONIC DEPTH = 62 M

1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (6) ---6/8
VISIBILITY --- (6) ---4-10 KM

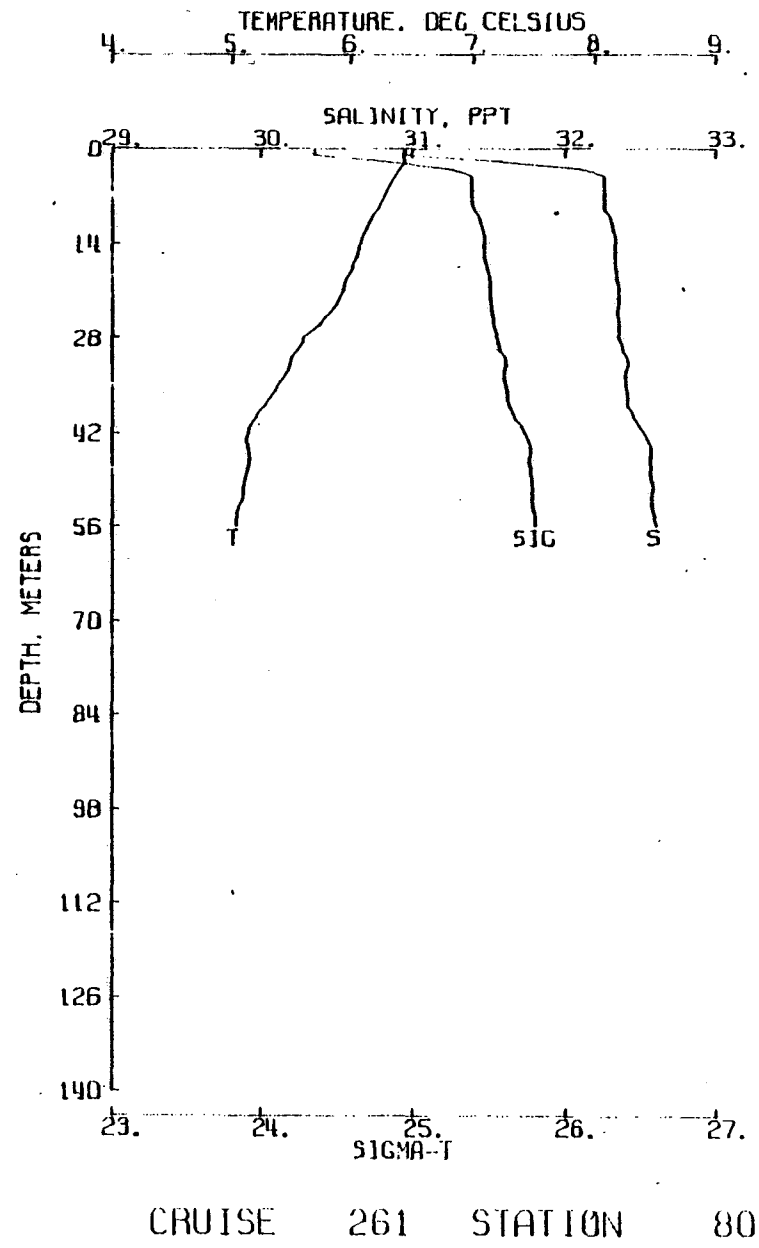
	DIRECTION	SPEED
WIND	- DEGR	KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES	-DRY = 9.4 DEGR C.	BAROMETRIC PR.	=1009.9 MB
	-WET = DEGR C.	TRANSPARENCY =	M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	6.43	30.955	24.35	0.
1.0	6.43	30.955	24.35	0.004
5.0	6.34	32.261	25.39	0.015
10.0	6.17	32.293	25.44	0.028
15.0	6.06	32.329	25.48	0.041
20.0	5.95	32.351	25.51	0.053
25.0	5.77	32.366	25.53	0.066
30.0	5.56	32.388	25.58	0.078
35.0	5.39	32.397	25.61	0.090
40.0	5.19	32.452	25.68	0.102
45.0	5.15	32.568	25.77	0.113
50.0	5.09	32.579	25.79	0.124

Figure 16. Hydrography and vertical profiles: 7C.



AC CRUISE 261 CONSECUTIVE STATION NO. 81. HEL 6A 12/ 6/78
14.8 HOURS GMT

LATITUDE = 51 54.4N LONGITUDE = 166 36.0W SONIC DEPTH = 117 M

1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- (7) ---STRATUS
CLOUD AMOUNT --- (6) ---6/8
VISIBILITY --- (7) ---10-20 KM

	DIRECTION	SPEED
WIND	- DEGR	KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY = 7.8 DEGR C. BAROMETRIC PR. =1009.7 MB
-WET = DEGR C. TRANSPARENCY = M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	6.47	31.853	25.05	0.
1.0	6.47	31.853	25.05	0.003
5.0	6.42	32.122	25.27	0.014
10.0	6.19	32.265	25.41	0.027
15.0	5.93	32.254	25.43	0.040
20.0	5.55	32.398	25.59	0.053
25.0	5.51	32.350	25.56	0.065
30.0	5.33	32.415	25.63	0.077
35.0	5.12	32.547	25.76	0.088
40.0	5.06	32.596	25.80	0.099
45.0	5.04	32.609	25.82	0.110
50.0	5.00	32.632	25.84	0.121
60.0	4.96	32.653	25.86	0.143
70.0	4.93	32.668	25.88	0.165
75.0	4.91	32.668	25.88	0.175
80.0	4.88	32.684	25.89	0.186
90.0	4.87	32.697	25.91	0.207
100.0	4.85	32.709	25.92	0.228

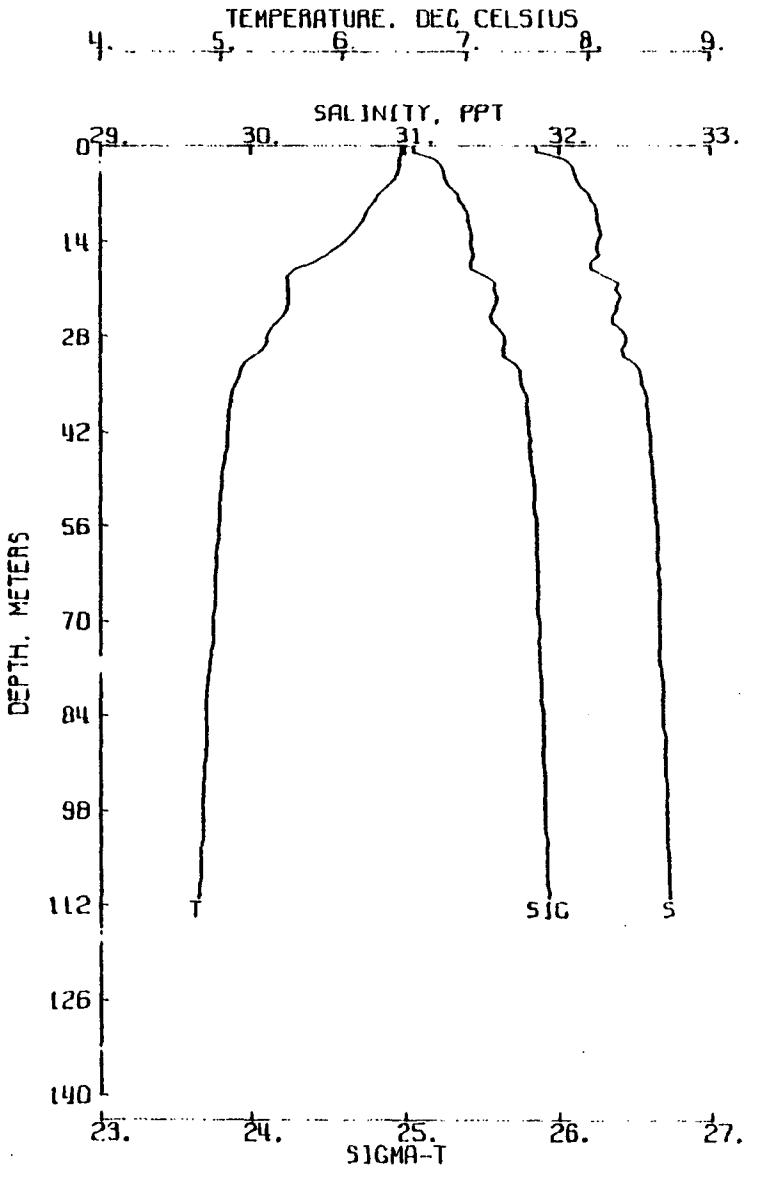


Figure 17. Hydrography and vertical profiles: HEL-6A.

AC CRUISE 261 CONSECUTIVE STATION NO. 82. HEL 06 12/ 6/78
15.4 HOURS GMT

LATITUDE = 51 55.2N LONGITUDE = 166 35.9W SONIC DEPTH = 132 M

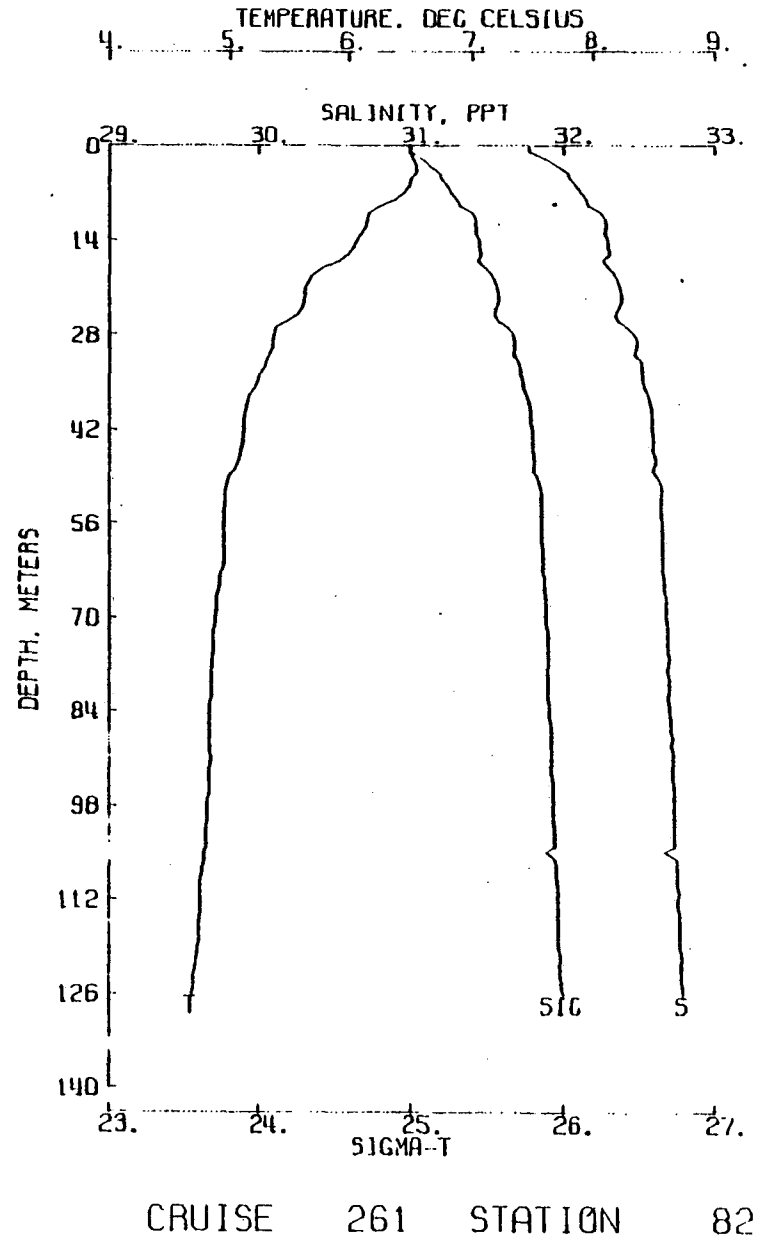
1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- (7) ---STRATUS
CLOUD AMOUNT --- (6) ---6/8
VISIBILITY --- (7) ---10-20 KM

	DIRECTION		HEIGHT	PERIOD
WIND	-	DEGR	KNOTS	
SEA	0 - 0	DEGR	M.	SECS
SWELL	-	DEGR	M.	SECS

TEMPERATURES -DRY = 7.4 DEGR C. BAROMETRIC PR. =1009.9 MB
-WET = DEGR C. TRANSPARENCY = M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	6.51	31.780	24.99	0.
1.0	6.51	31.780	24.99	0.003
5.0	6.50	32.051	25.21	0.014
10.0	6.15	32.248	25.40	0.028
15.0	6.02	32.292	25.45	0.041
20.0	5.67	32.362	25.55	0.053
25.0	5.56	32.344	25.55	0.066
30.0	5.36	32.479	25.68	0.077
35.0	5.23	32.531	25.73	0.089
40.0	5.12	32.563	25.79	0.100
45.0	5.09	32.585	25.79	0.111
50.0	4.98	32.637	25.85	0.122
60.0	4.94	32.656	25.87	0.144
70.0	4.88	32.680	25.89	0.165
75.0	4.85	32.689	25.90	0.176
80.0	4.85	32.693	25.91	0.187
90.0	4.84	32.719	25.93	0.208
100.0	4.81	32.733	25.94	0.229
125.0	4.69	32.786	25.99	0.280

Figure 18. Hydrography and vertical profiles: HEL-6.



AC CRUISE 261 CONSECUTIVE STATION NO. 84, DUT OA 12/ 6/78
21.8 HOURS GMT

LATITUDE = 54 54.1N LONGITUDE = 166 29.2W SONIC DEPTH = 29 M

1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (7) ---7/8
VISIBILITY --- (4) ---20-50 KM

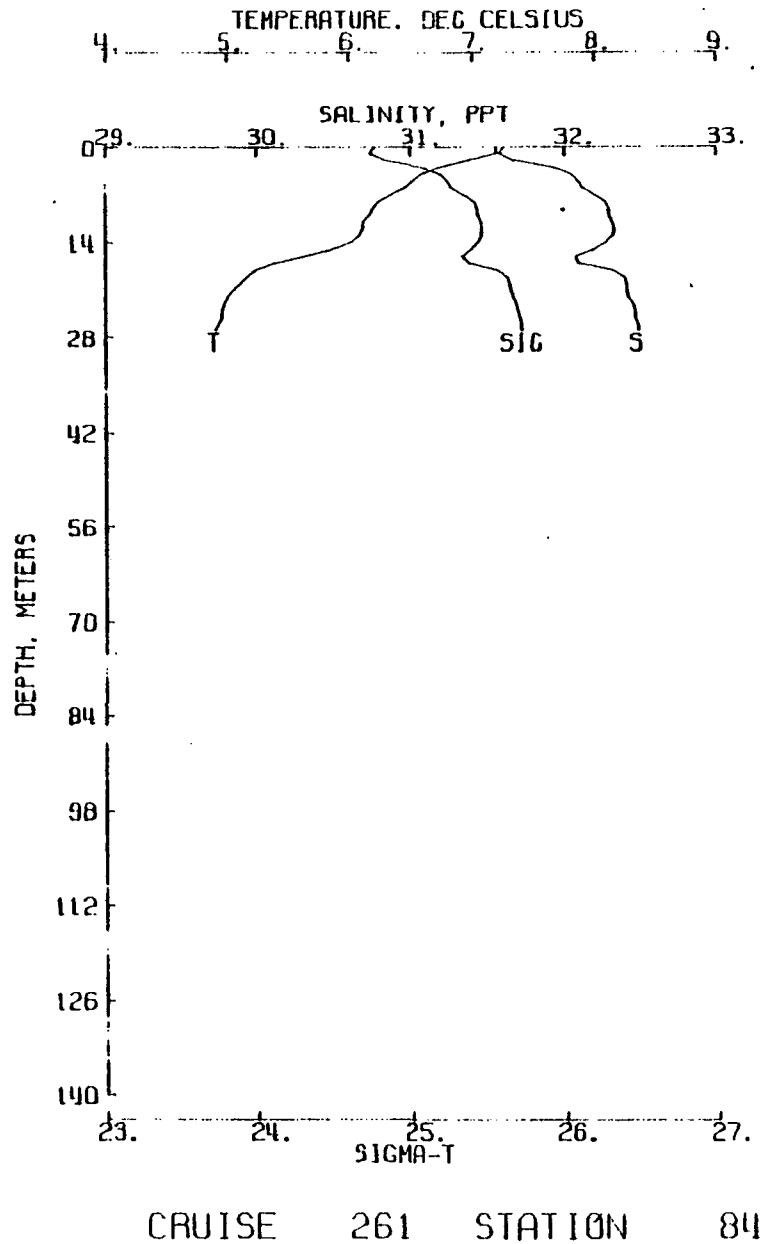
	DIRECTION	SPEED
WIND	205 - 214 DEGR	8 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY =	11.7 DEGR C.	BAROMETRIC PR. =	1009.2 MB	
-WET =	DEGR C.	TRANSPARENCY =	M	

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.20	31.609	24.77	0.
1.0	7.21	31.575	24.74	0.003
5.0	6.52	32.098	25.24	0.015
10.0	6.16	32.293	25.44	0.028
15.0	5.85	32.193	25.40	0.041
20.0	5.11	32.411	25.65	0.053
25.0	4.96	32.472	25.72	0.065

Figure 19. Hydrography and vertical profiles: DUT-0A.



AC CRUISE 261 CONSECUTIVE STATION NO. 85. DUT 00 12/ 6/78
23.0 HOURS GMT

LATITUDE = 53 53.5N LONGITUDE = 166 30.8W SONIC DEPTH = 33 M

1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (6) ---6/8
VISIBILITY --- (8) ---20-50 KM

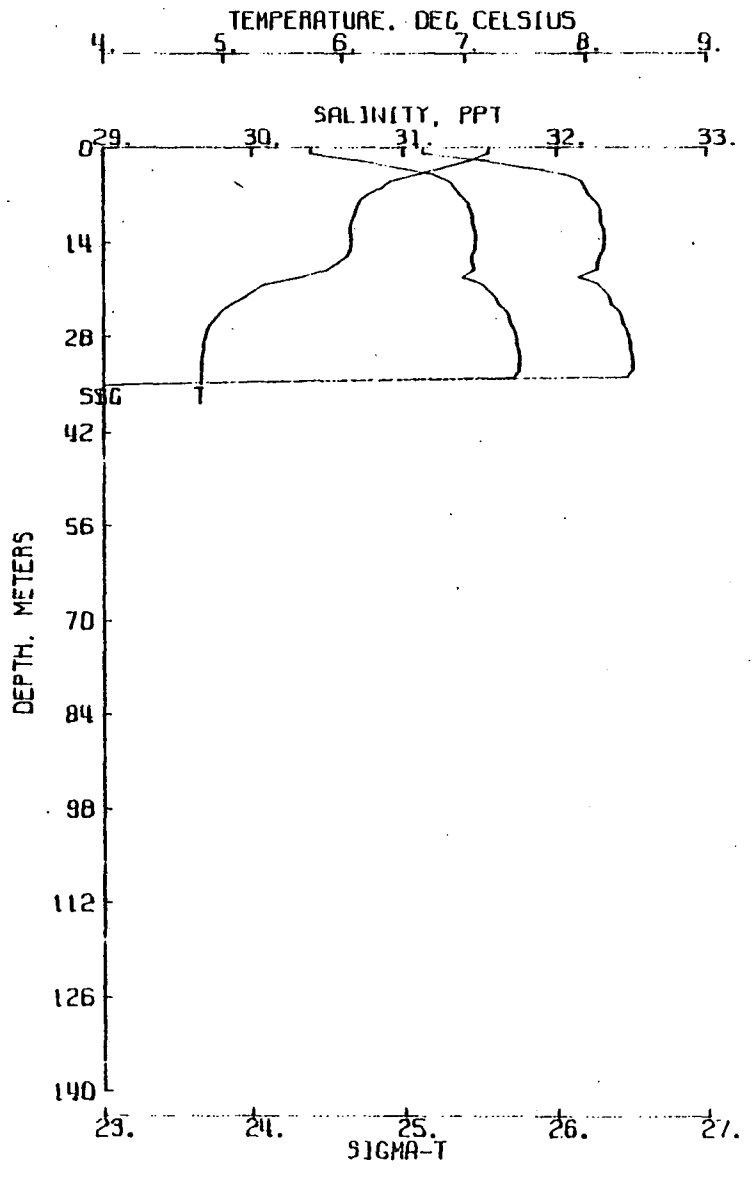
	DIRECTION	SPEED
WIND	185 - 194 DEGR	5 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY = 12.8 DEGR C. BAROMETRIC PR. =1008.9 MB
-WET = DEGR C. TRANSPARENCY = M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.20	31.126	24.39	0.
1.0	7.20	31.126	24.39	0.004
5.0	6.39	32.163	25.31	0.016
10.0	6.10	32.295	25.45	0.029
15.0	6.06	32.307	25.46	0.041
20.0	5.36	32.267	25.51	0.054
25.0	4.94	32.438	25.69	0.066
30.0	4.83	32.492	25.75	0.078
35.0	4.81	27.968	22.17	0.091

Figure 20. Hydrography and vertical profiles: DUT-00.



AC CRUISE 261 CONSECUTIVE STATION NO. 86. DUT OB 13/ 6/78
0.1 HOURS GMT

LATITUDE = 51 54.4N LONGITUDE = 166 29.0W SONIC DEPTH = 22 M

1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (6) ---6/8
VISIBILITY --- (8) ---20-50 KM

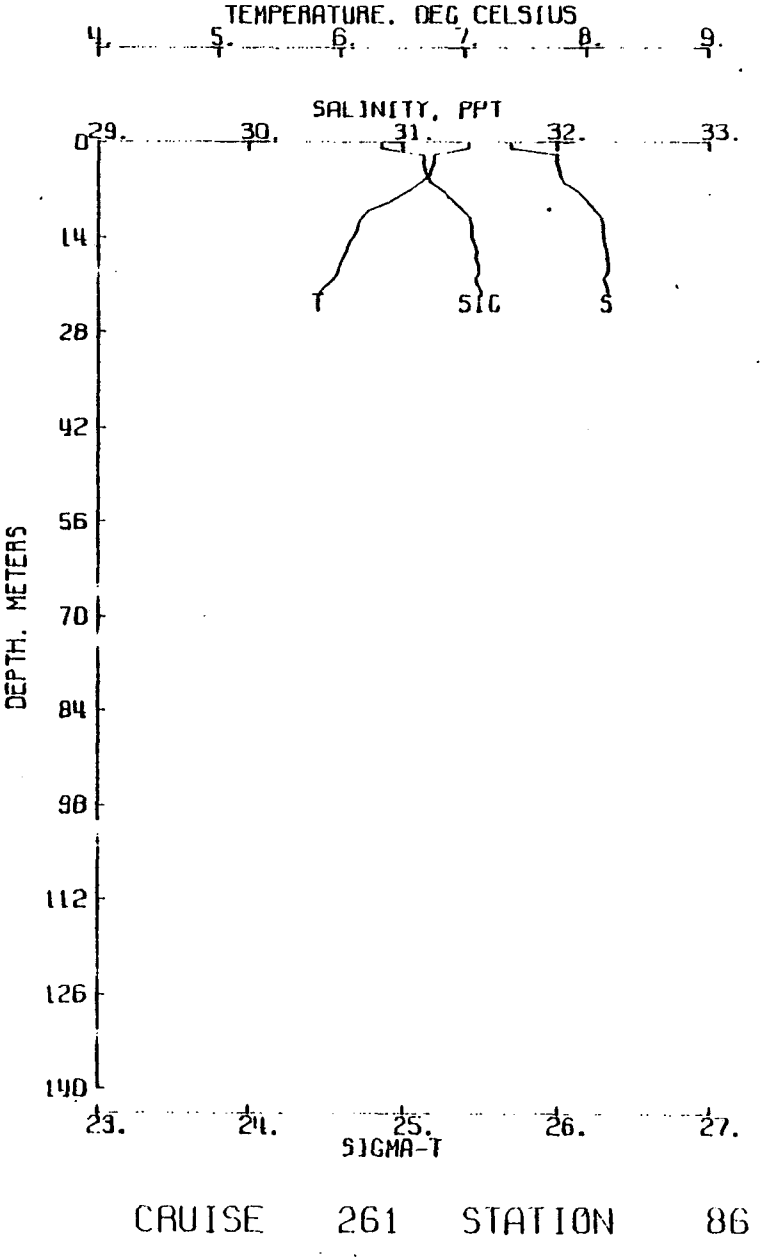
	DIRECTION	SPEED
WIND	185 - 194 DEGR	6 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY =	12.8 DEGR C.	BAROMETRIC PR. =	1008.9 MB
-WET =	DEGR C.	TRANSPARENCY =	M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.04	31.706	24.86	0.
1.0	7.04	31.706	24.86	0.003
5.0	6.72	32.026	25.16	0.015
10.0	6.23	32.247	25.39	0.028
15.0	6.06	32.320	25.47	0.041
20.0	5.94	32.304	25.47	0.053

Figure 21. Hydrography and vertical profiles: DUT-0B.



AC CRUISE 261 CONSECUTIVE STATION NO. 87. HEL 01 13/ 6/78
0.6 HOURS GMT

LATITUDE = 54 56.0N LONGITUDE = 166 34.0W SONIC DEPTH = 79 M

1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (6) ---6/8
VISIBILITY --- (5) ---20-50 KM

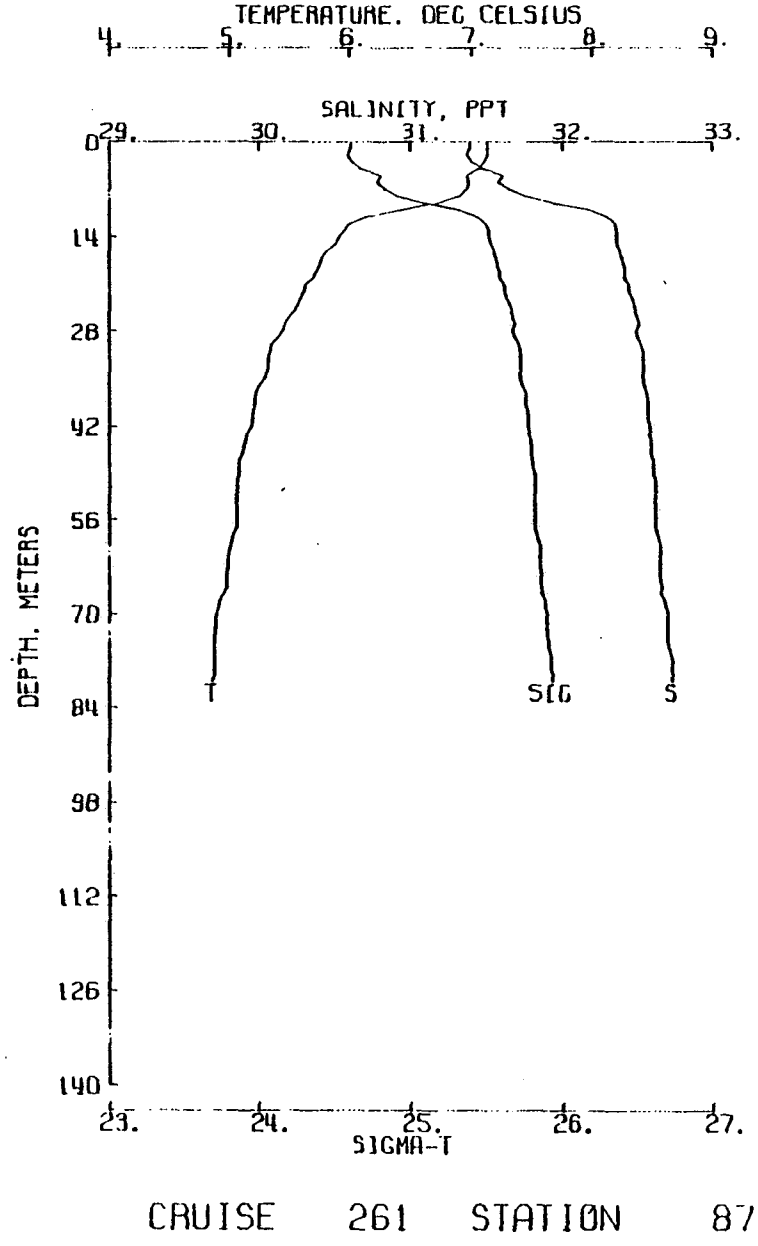
	DIRECTION	SPEED
WIND	195 - 204 DEGR	7 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	195 - 204 DEGR	0.2 M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY =	12.2 DEGR C.	BAROMETRIC PR.	=1008.8 MB
-WET =	DEGR C.	TRANSPARENCY =	M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.13	31.392	24.61	0.
1.0	7.13	31.392	24.61	0.003
5.0	6.96	31.615	24.80	0.017
10.0	6.44	32.179	25.31	0.032
15.0	5.88	32.363	25.53	0.044
20.0	5.69	32.408	25.59	0.057
25.0	5.53	32.492	25.67	0.068
30.0	5.35	32.530	25.72	0.080
35.0	5.29	32.534	25.73	0.091
40.0	5.20	32.570	25.77	0.103
45.0	5.12	32.594	25.80	0.114
50.0	5.07	32.614	25.82	0.125
60.0	5.00	32.647	25.85	0.147
70.0	4.89	32.693	25.90	0.168
75.0	4.87	32.711	25.92	0.179
80.0	4.86	32.730	25.93	0.189

Figure 22. Hydrography and vertical profiles: HEL-1.



AC CRUISE 261 CONSECUTIVE STATION NO. 88, 3H 13/ 6/78
1.2 HOURS GMT

LATITUDE = 53 53.7N LONGITUDE = 166 32.5W SONIC DEPTH = 37 M

1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (7) ---7/8
VISIBILITY --- (8) ---20-50 KM

	DIRECTION	SPEED
WIND	215 - 224 DEGR	7 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	215 - 224 DEGR	0.2 M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY =	12.8 DEGR C.	BAROMETRIC PR.	=1008.5 MB
-WET =	DEGR C.	TRANSPARENCY =	M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.48	30.878	24.16	0.
1.0	7.48	30.868	24.15	0.004
5.0	7.33	31.002	24.27	0.018
10.0	6.12	32.227	25.39	0.033
15.0	5.61	32.298	25.51	0.046
20.0	5.28	32.382	25.61	0.058
25.0	5.23	32.420	25.65	0.070
30.0	5.10	32.494	25.72	0.081
35.0	5.07	32.536	25.76	0.093
40.0	5.04	26.594	21.07	0.110

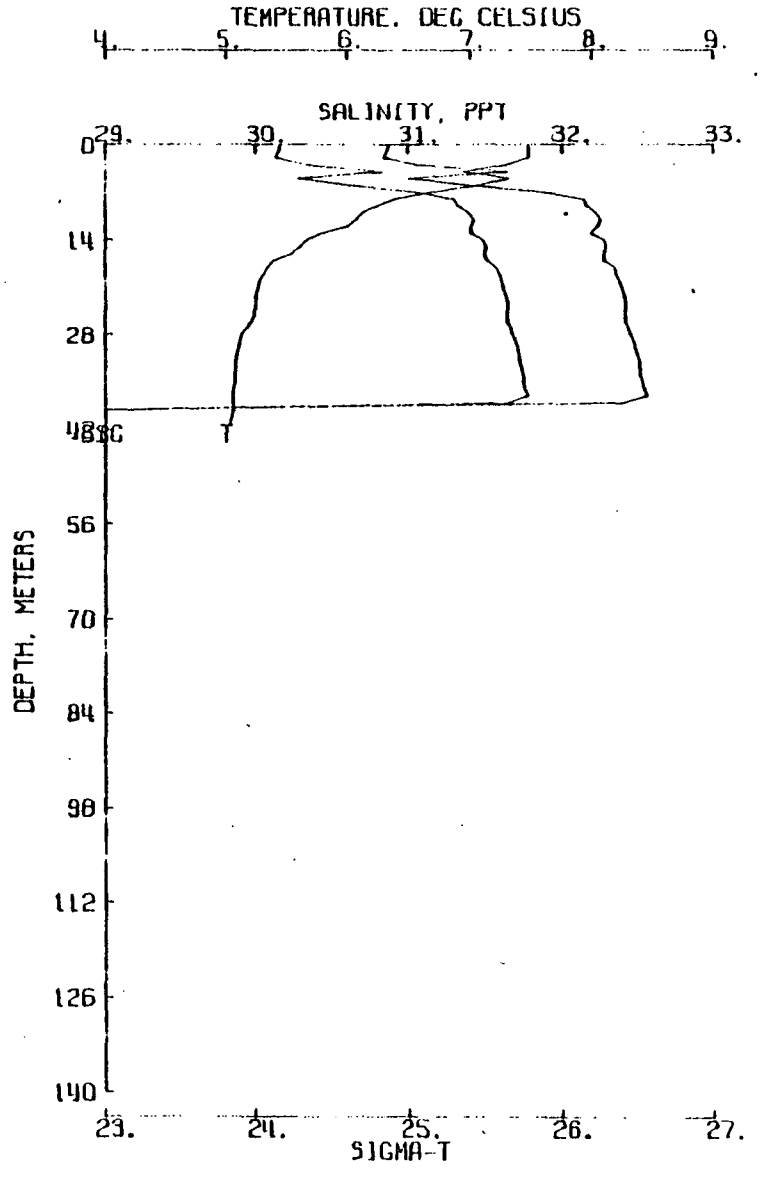


Figure 23. Hydrography and vertical profiles: 3H.

AC CRUISE 261 CONSECUTIVE STATION NO. 89. 3AG 13/ 6/78
1.8 HOURS GMT

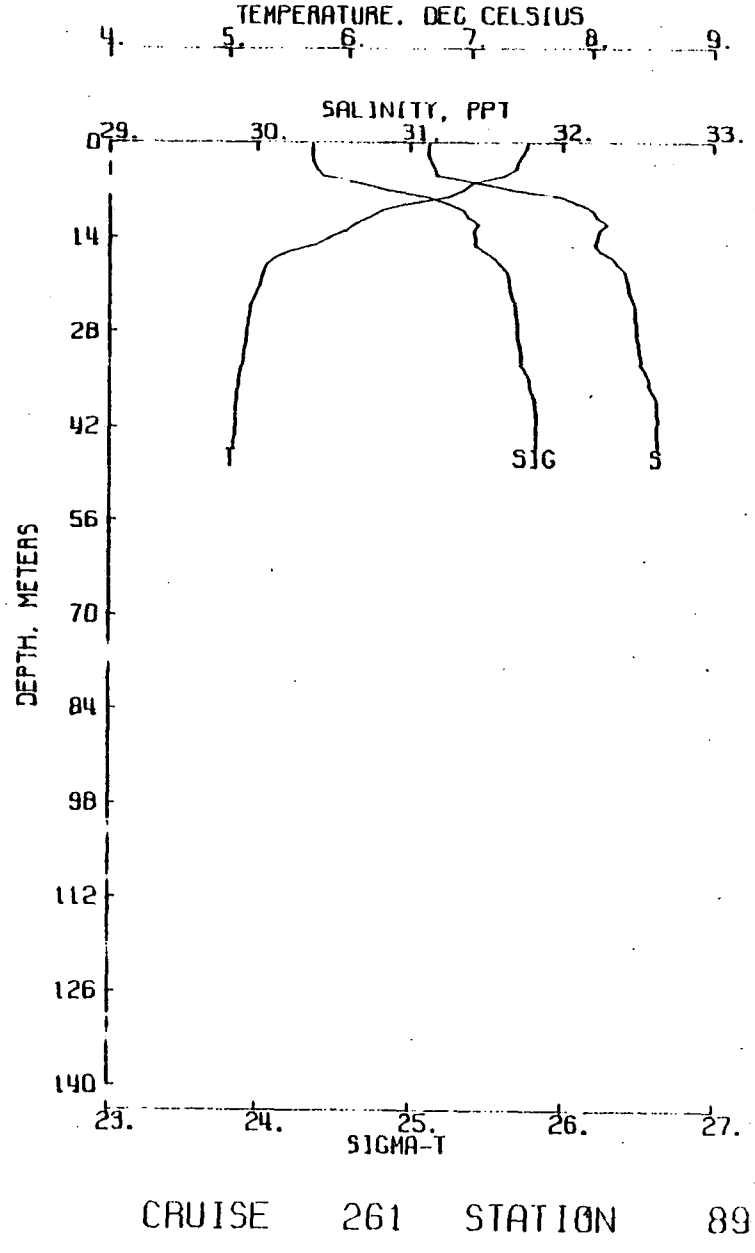
LATITUDE = 53 53.4N LONGITUDE = 166 33.3W SONIC DEPTH = 43 M

1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (7) ---7/8
VISIBILITY --- (8) ---20-50 KM

	DIRECTION	SPEED		
WIND	225 - 234 DEGR	7 KNOTS		
	DIRECTION	HEIGHT	PERIOD	
SEA	215 - 224 DEGR	0.2 M.	SECS	
SWELL	- DEGR	M.	SECS	
TEMPERATURES -DRY =	12.8 DEGR C.	BAROMETRIC PR. =	1008.5 MB	
-WET =	DEGR C.	TRANSPARENCY =	M	

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.46	31.123	24.35	0.
1.0	7.45	31.122	24.35	0.004
5.0	7.26	31.180	24.42	0.018
10.0	6.29	32.200	25.35	0.033
15.0	5.72	32.218	25.43	0.046
20.0	5.27	32.426	25.65	0.058
25.0	5.17	32.478	25.70	0.070
30.0	5.13	32.496	25.72	0.081
35.0	5.08	32.575	25.79	0.093
40.0	5.04	32.621	25.83	0.104
45.0	5.03	32.626	25.83	0.115

Figure 24. Hydrography and vertical profiles: 3AG.



AC CRUISE 261 CONSECUTIVE STATION NO. 90. 3G 13/ 6/78
2.7 HOURS GMT

LATITUDE = 53 53.5N LONGITUDE = 166 33.3W SONIC DEPTH = 32 M

1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (7) ---7/8
VISIBILITY --- (8) ---20-50 KM

	DIRECTION	SPEED
WIND	215 - 224 DEGR	5 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY = 12.8 DEGR C. BAROMETRIC PR. =1008.4 MB
-WET = DEGR C. TRANSPARENCY = M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.52	31.016	24.26	0.
1.0	7.51	30.992	24.24	0.004
5.0	7.41	31.005	24.27	0.018
10.0	6.17	32.180	25.35	0.034
15.0	5.54	32.322	25.53	0.047
20.0	5.22	32.448	25.67	0.059
25.0	5.13	32.506	25.73	0.070
30.0	5.09	32.547	25.76	0.082

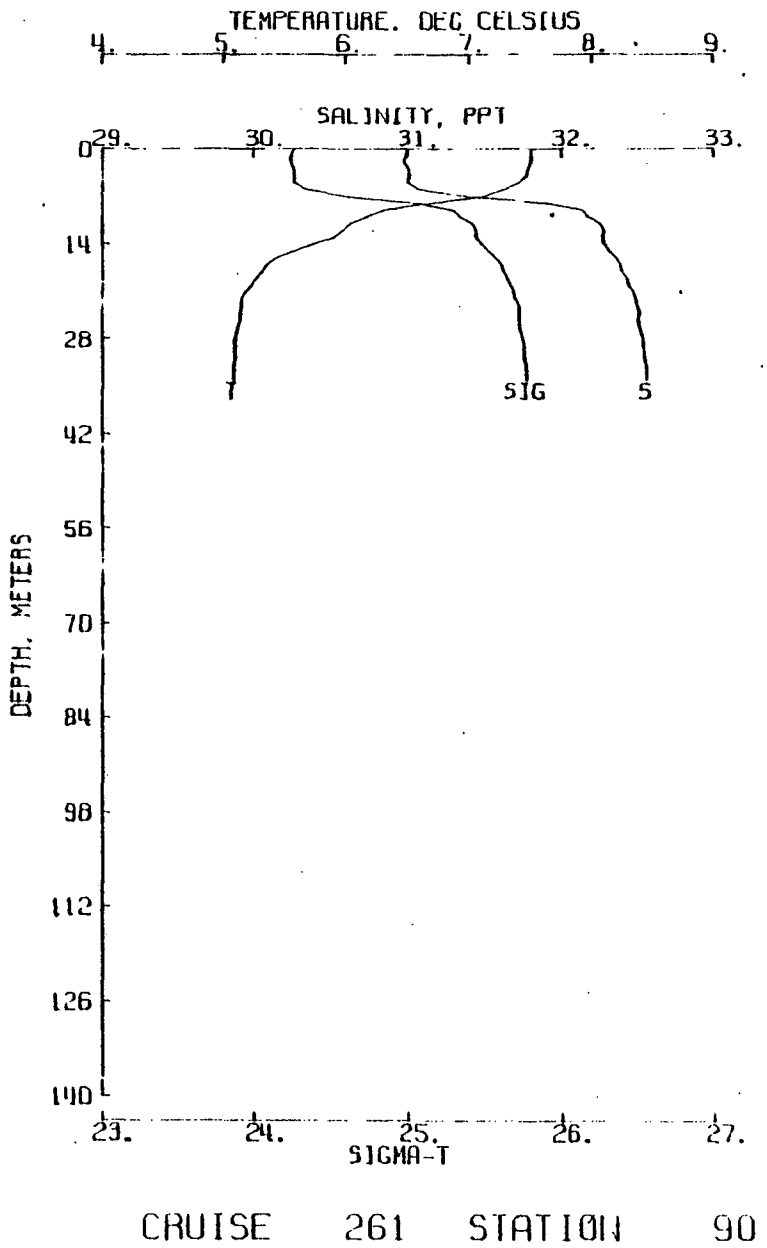


Figure 25. Hydrography and vertical profiles: 3G.

AC CRUISE 261 CONSECUTIVE STATION NO. 91, 3BF 13/ 6/78
3.1 HOURS GMT

LATITUDE = 53 53.3N LONGITUDE = 166 33.4W SONIC DEPTH = 58 M

1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (7) ---7/8
VISIBILITY --- (9) ---20-50 KM

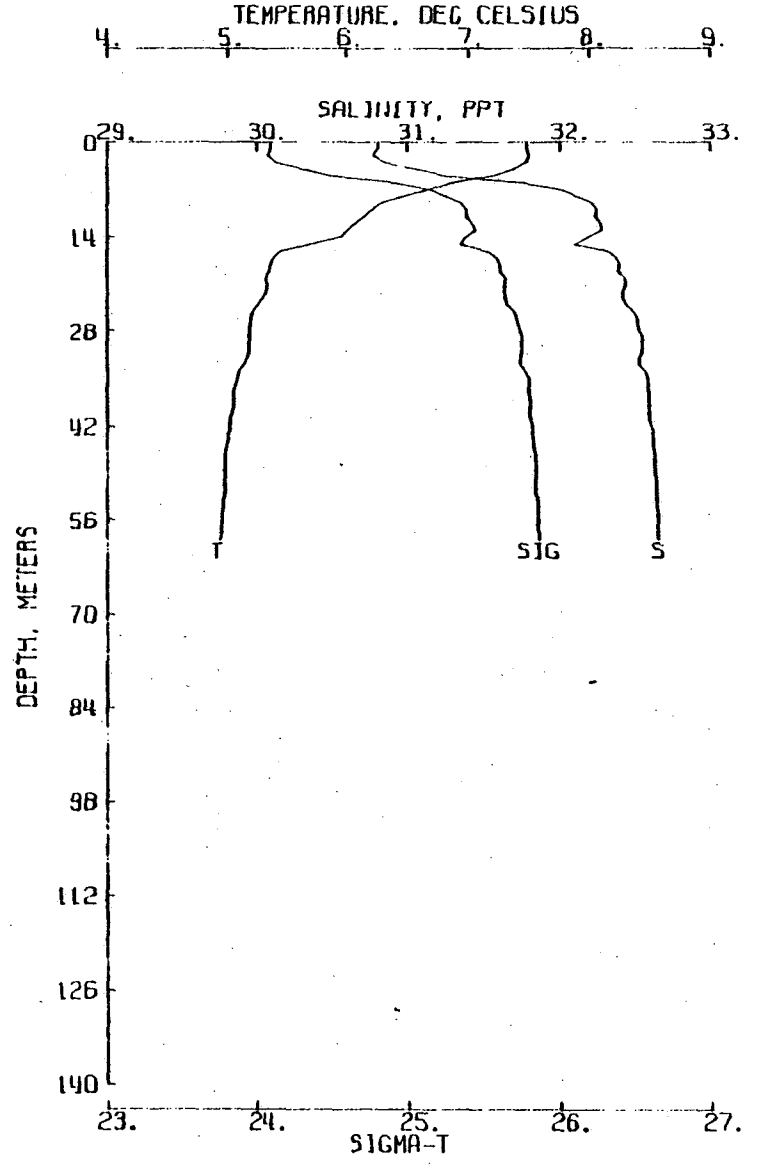
	DIRECTION	SPEED
WIND	255 - 264 DEGR	12 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	255 - 264 DEGR	0.3 M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY =	12.2 DEGR C.	BAROMETRIC PR. =	1008.5 MB
-WET =	DEGR C.	TRANSPARENCY =	M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.49	30.800	24.09	0.
1.0	7.49	30.800	24.09	0.004
5.0	7.21	31.261	24.49	0.019
10.0	6.21	32.251	25.40	0.033
15.0	5.69	32.100	25.34	0.046
20.0	5.32	32.428	25.64	0.058
25.0	5.21	32.485	25.70	0.070
30.0	5.17	32.551	25.76	0.081
35.0	5.07	32.583	25.79	0.093
40.0	5.03	32.590	25.80	0.104
45.0	4.99	32.622	25.83	0.115
50.0	4.97	32.637	25.85	0.126

Figure 26. Hydrography and vertical profiles: 3BF.



AC CRUISE 261 CONSECUTIVE STATION NO. 92 3DE 13/ 6/78
4.2 HOURS GMT

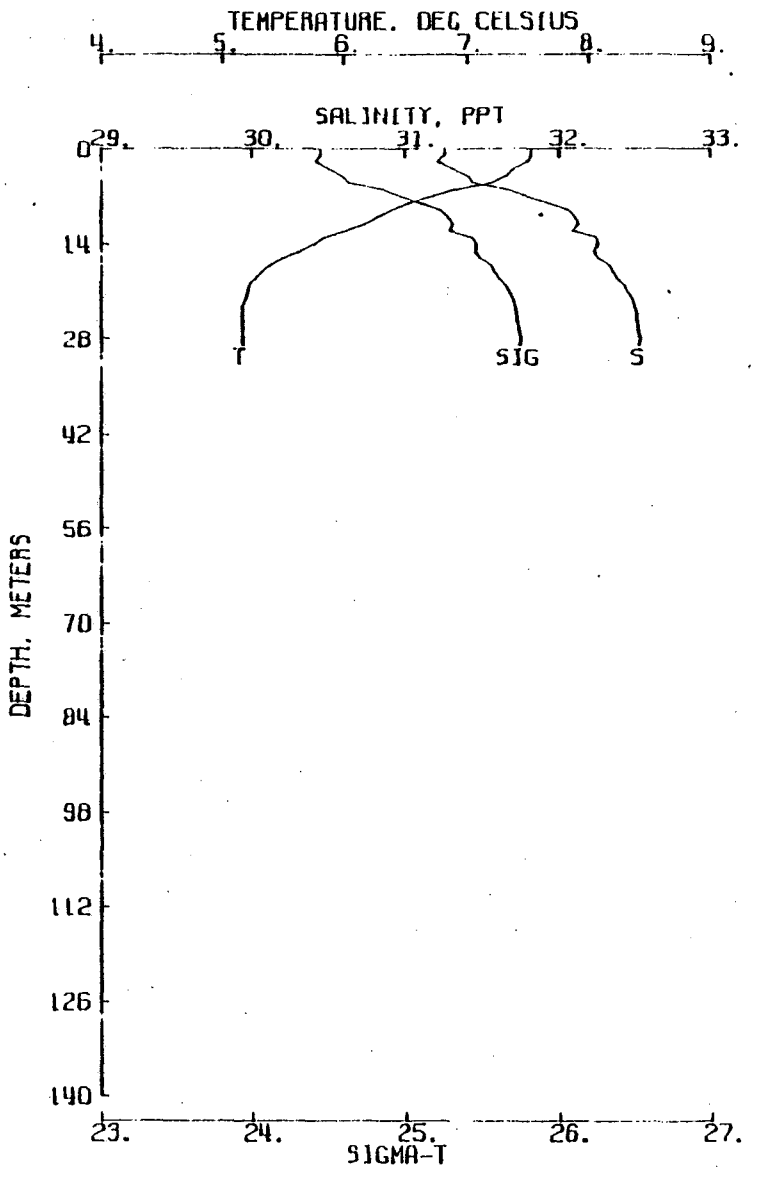
LATITUDE = 53 52.9N LONGITUDE = 166 33.4W SONIC DEPTH = 26 M

1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (8) ---8/8 TOTAL
VISIBILITY --- (7) ---10-20 KM

	DIRECTION	SPEED		
WIND	225 - 234 DEGR	10 KNOTS		
	DIRECTION	HEIGHT	PERIOD	
SEA	0 - 0 DEGR	M.	SECS	
SWELL	- DEGR	M.	SECS	
TEMPERATURES -DRY =	9.4 DEGR C.	BAROMETRIC PR. =	1008.5 MB	
-WET =	DEGR C.	TRANSPARENCY =	M	

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.53	31.258	24.45	0.
1.0	7.53	31.258	24.45	0.003
5.0	7.21	31.437	24.63	0.017
10.0	6.28	32.109	25.28	0.032
15.0	5.64	32.226	25.45	0.045
20.0	5.23	32.433	25.66	0.057
25.0	5.16	32.519	25.73	0.069

Figure 27. Hydrography and vertical profiles: 3DE.



AC CRUISE 261 CONSECUTIVE STATION NO. 93, HEL 04 13/ 6/78
4.7 HOURS GMT

LATITUDE = 53 52.2N LONGITUDE = 166 34.4W SONIC DEPTH = 95 M

1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (7) ---7/8
VISIBILITY --- (7) ---10-20 KM

	DIRECTION	SPEED
WIND	205 - 214 DEGR	KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY =	10.0 DEGR C.	BAROMETRIC PR. =	1008.1 MB
-WET =	DEGR C.	TRANSPARENCY =	M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	7.18	31.663	24.81	0.
1.0	7.18	31.663	24.81	0.003
5.0	6.92	31.569	24.77	0.016
10.0	6.23	32.160	25.33	0.030
15.0	6.04	32.185	25.37	0.043
20.0	5.26	32.284	25.54	0.056
25.0	4.86	32.299	25.59	0.068
30.0	4.76	32.373	25.66	0.080
35.0	4.46	32.313	25.64	0.092
40.0	4.31	32.411	25.74	0.103
45.0	4.28	32.417	25.75	0.114
50.0	4.22	32.416	25.75	0.126
60.0	4.22	32.422	25.75	0.148
70.0	4.25	32.449	25.77	0.171
75.0	4.26	32.454	25.78	0.182
80.0	4.28	32.449	25.77	0.193
90.0	4.32	32.472	25.78	0.216

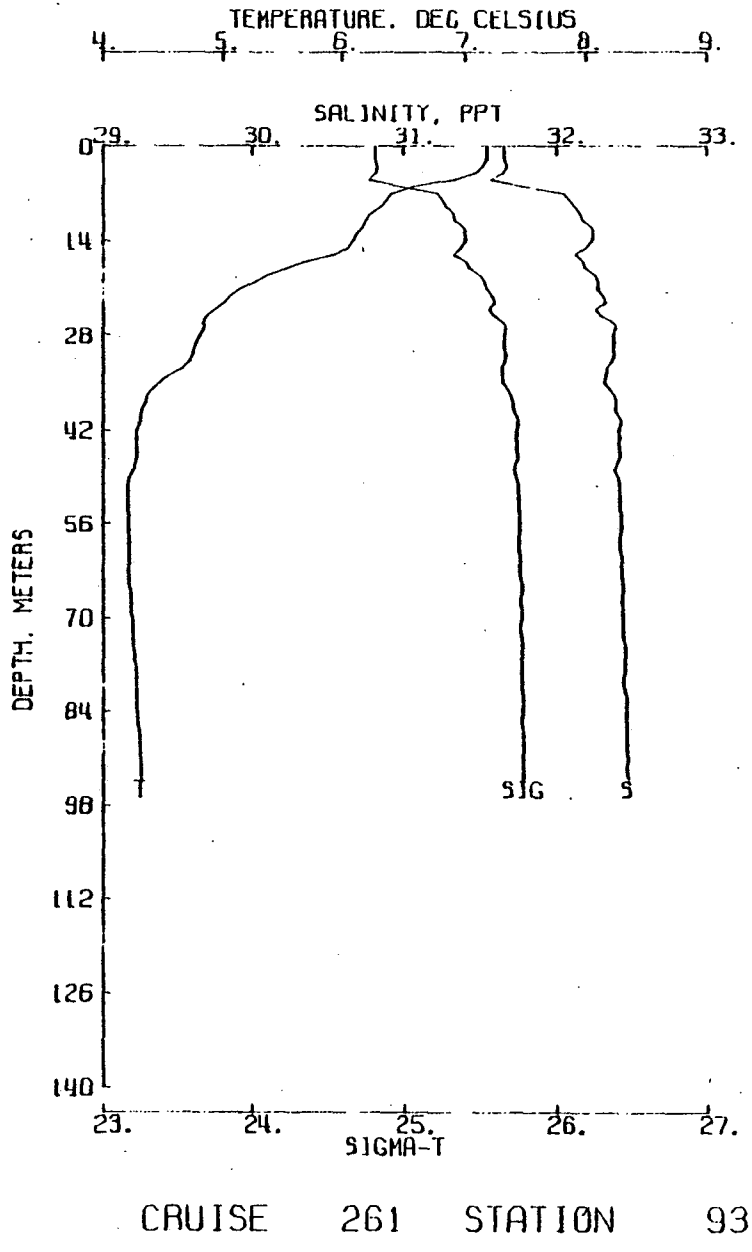


Figure 28. Hydrography and vertical profiles: HEL-4.

AC CRUISE 261 CONSECUTIVE STATION NO. 94. 4A 13/ 6/78
6.1 HOURS GMT

LATITUDE = 53 51.3N LONGITUDE = 166 35.0W SONIC DEPTH = 78 M

1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (7) ---7/8
VISIBILITY --- (7) ---10-20 KM

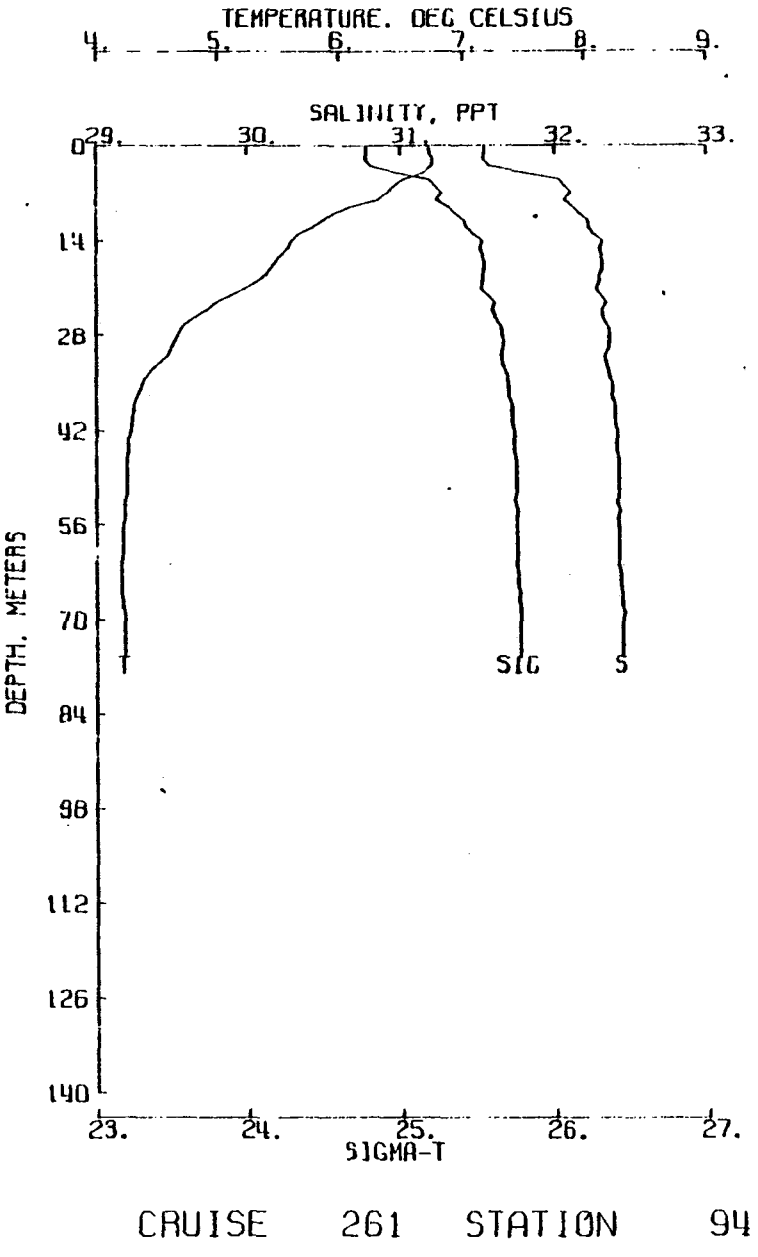
	DIRECTION	SPEED
WIND	205 - 214 DEGR	7 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY =	10.0 DEGR C.	BAROMETRIC PR. =	1008.0 MB
-WET =	DEGR C.	TRANSPARENCY =	M

DEPTH METERS	TEMPERATURE DEG C	SALINITY PPT	SIGMA-T	DELTA-D DYN M
0.	6.73	31.544	24.78	0.
1.0	6.73	31.544	24.78	0.003
5.0	6.52	32.026	25.18	0.016
10.0	5.96	32.169	25.36	0.029
15.0	5.57	32.291	25.51	0.042
20.0	5.32	32.292	25.54	0.054
25.0	4.83	32.320	25.61	0.066
30.0	4.61	32.351	25.66	0.078
35.0	4.39	32.383	25.71	0.090
40.0	4.30	32.402	25.73	0.101
45.0	4.26	32.412	25.74	0.113
50.0	4.25	32.417	25.75	0.124
60.0	4.22	32.418	25.75	0.147
70.0	4.24	32.448	25.77	0.169
75.0	4.24	32.445	25.77	0.180

Figure 29. Hydrography and vertical profiles: 4A.



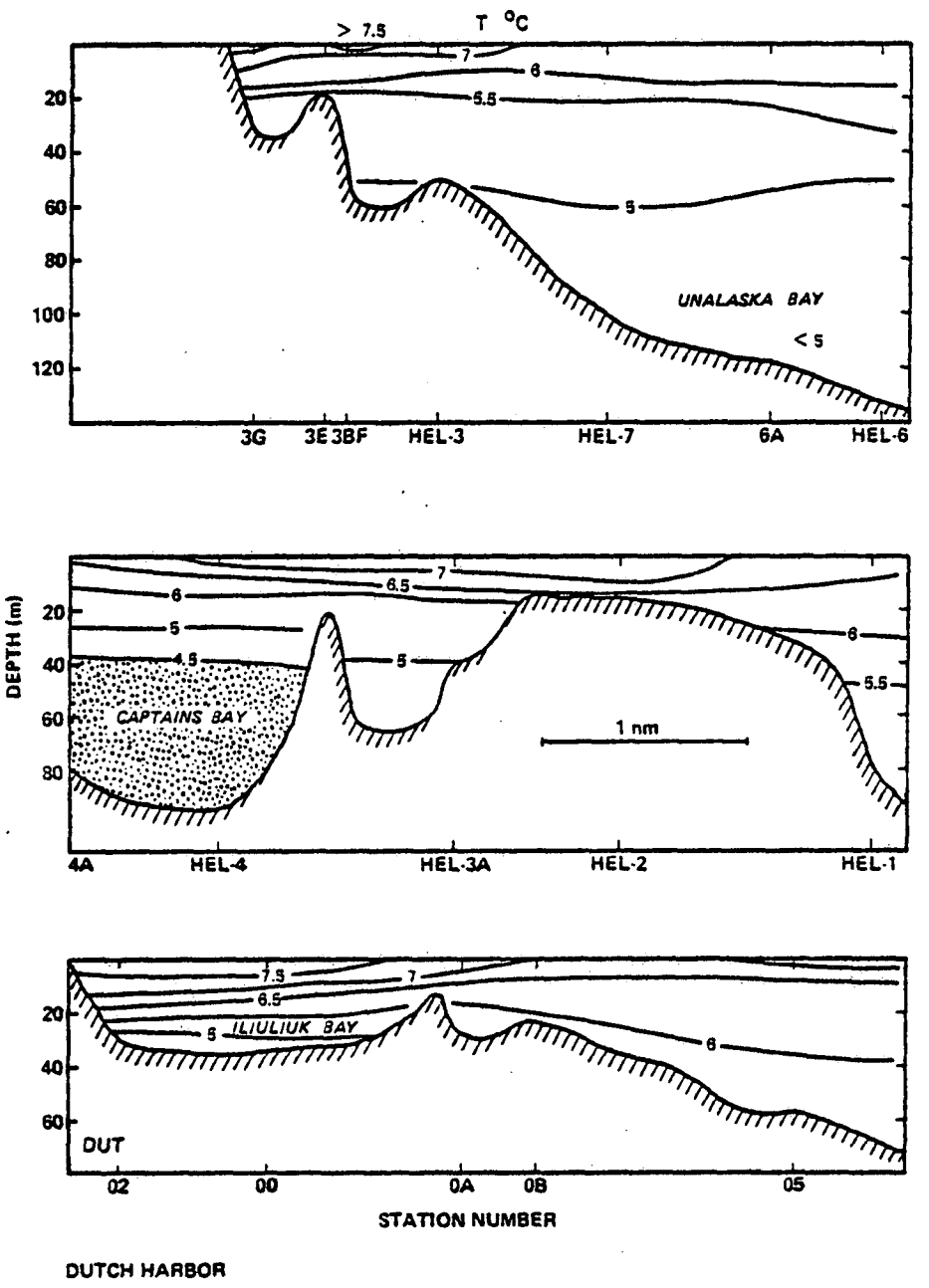


Figure 30. Longitudinal temperature profiles.

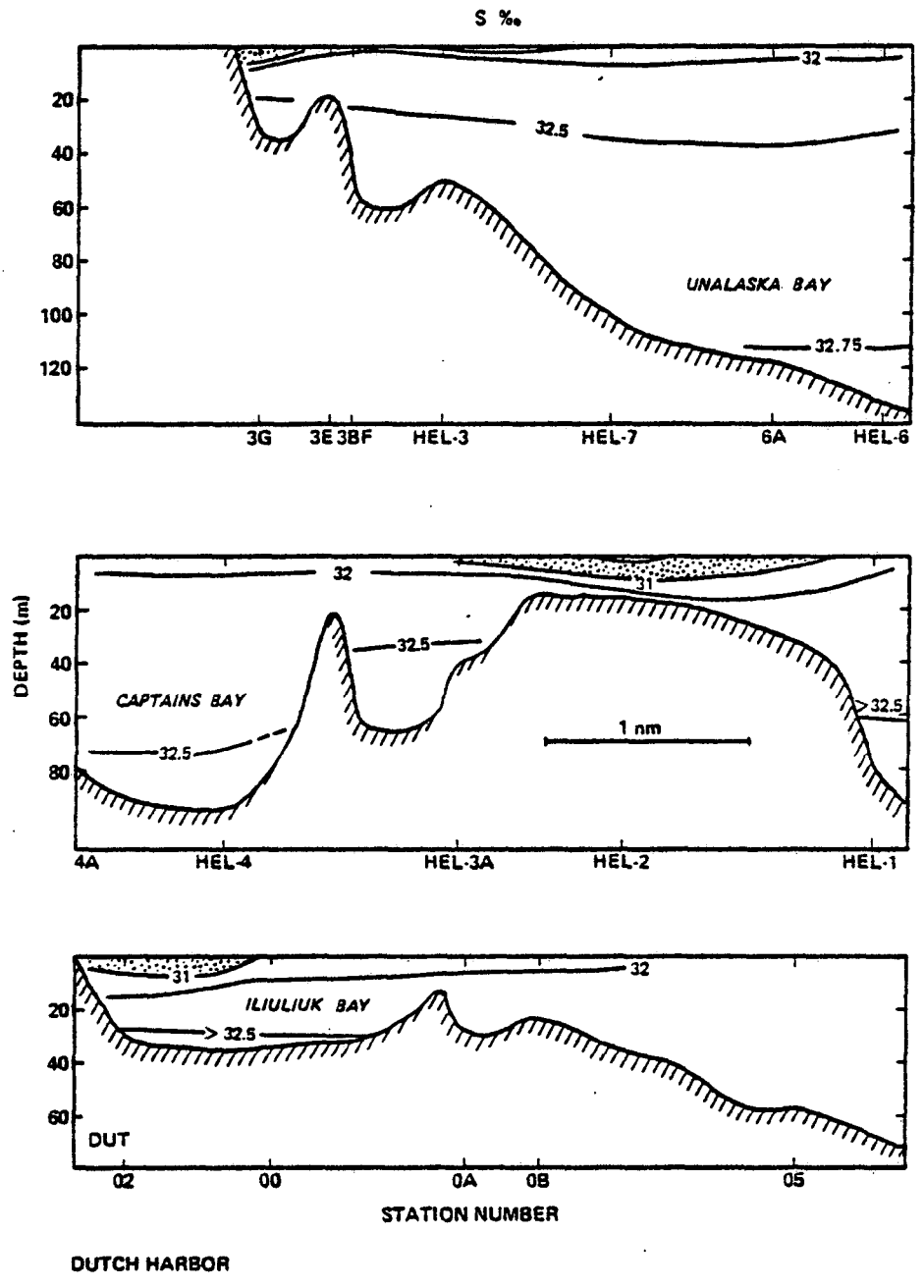


Figure 31. Longitudinal salinity profiles.

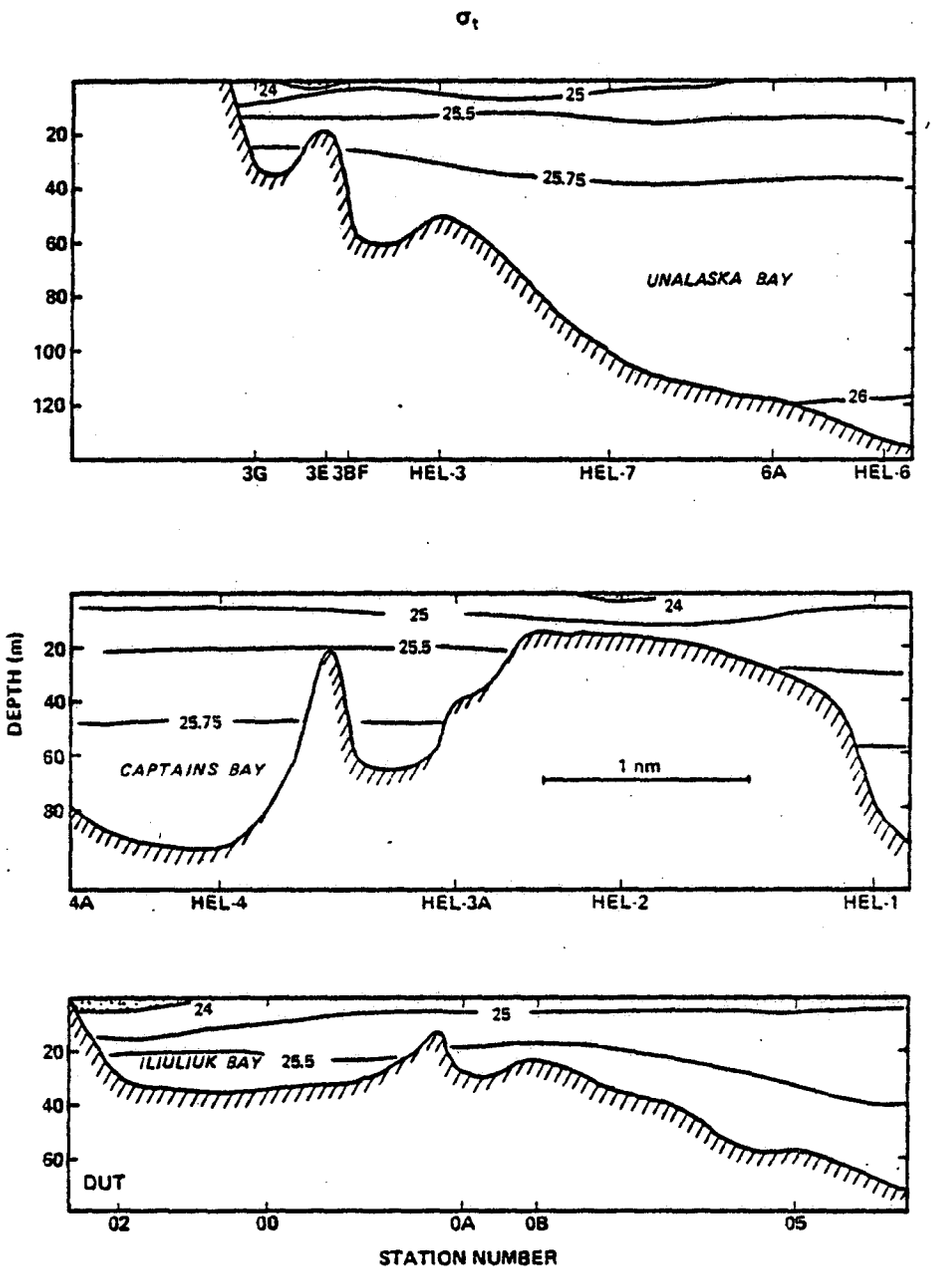


Figure 32. Longitudinal density profiles.

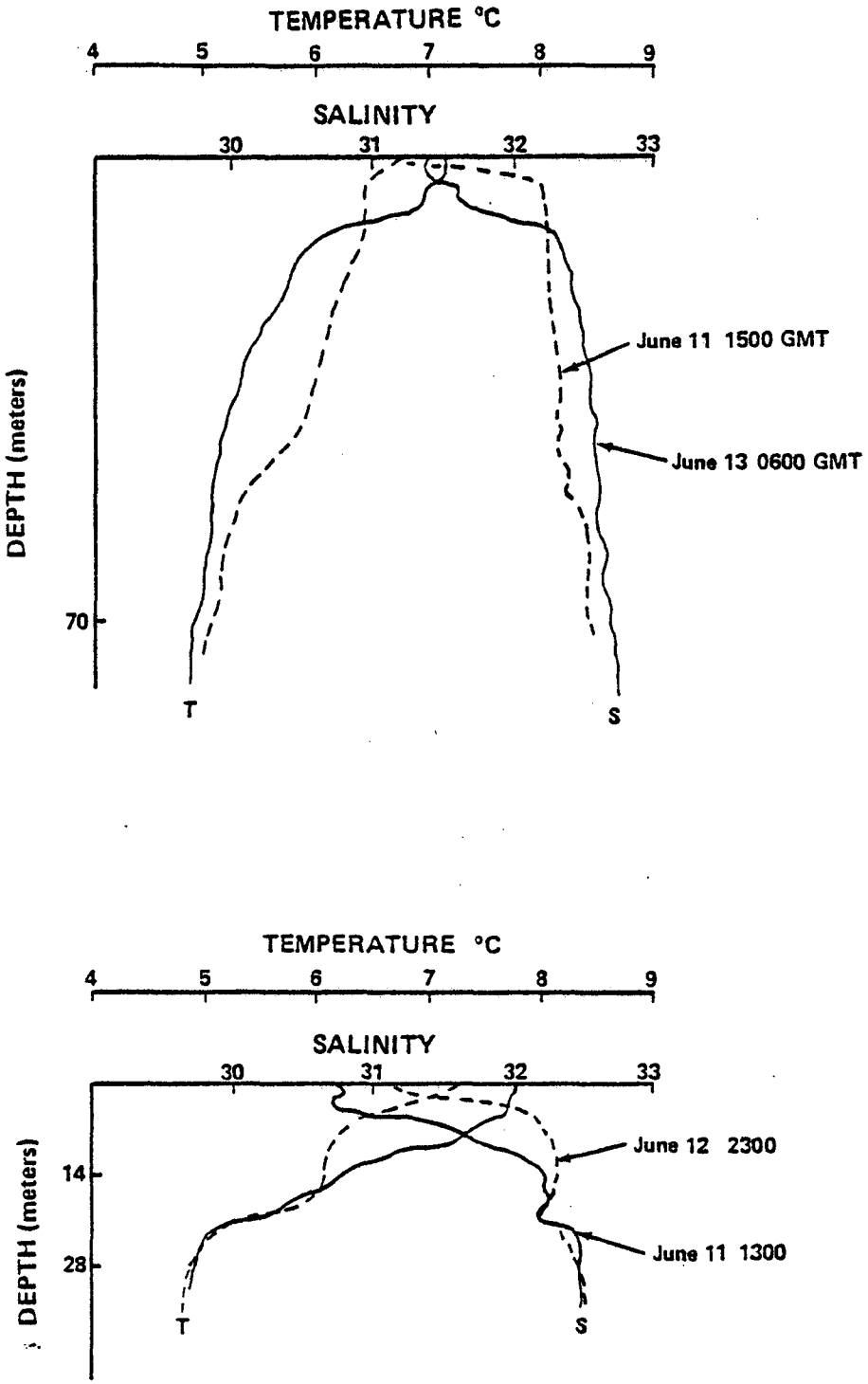


Figure 33. Short term temperature and salinity changes at Stations HEL-1 and DUT-00. T = temperature, S = salinity.

AC [illegible] CRUISE 261 CONSECUTIVE STATION NO. 55, DUT001 11/ 6/78
10.0 HOURS GMT

LATITUDE = 53 55.2N LONGITUDE = 166 21.2W SONIC DEPTH = 28 M

LIGHT (WATER) CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- ( ) ---NOT RECORDED

	DIRECTION	SPEED
WIND	190 - 190 DEGR	6 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES DRY = 10.0 DEGR C. BAROMETRIC PR. =1019.8MB
WET = DEGR C. TRANSPARENCY = M

OBSERVED

TIME	DEP	TEMP	SAL	SIG-T	OXY	PO4	NH3	NO2	NO3	NO	SIO3	PH	TALK
.0	0	7.370	30.321	23.67	9.12	0.37	01.1	0.26	00.0	814.2	7.	.	.
.0	5	7.025	31.515	24.59	9.24	0.31	01.1	0.24	00.5	829.4	7.	.	.
.0	15	6.448	32.329	25.43	8.67	1.37	03.3	0.35	00.0	774.1	16.	.	.
.0	18	5.60F	32.488	25.66	7.47	1.20	05.4	0.43	.		24.	.	.

STANDARD

DEP	TEMP	SAL	SIG-T	OXY	SP VOL	DEL D
0	7.37	30.321	23.67	9.12	424.06	.000
10	7.44	32.040	25.11	8.96	287.11	.036

Table 2. Dissolved oxygen and nutrient data: DUT-01A

AC CRUISE 361 CONSECUTIVE STATION NO. 56. DUT002 11/ 6/78
11.6 HOURS GMT

LATITUDE = 51 52.0N LONGITUDE = 166 31.2W SONIC DEPTH = 30 M

1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- ( ) ---NOT RECORDED

	DIRECTION	SPEED
WIND	135 - 144 DEGR	5 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -OXY =	9.4 DEGR C.	BAROMETRIC PR. =	1019.2MB
-WET =	DEGR C.	TRANSPARENCY =	M

OBSERVED

TIME	DEP	TEMP	SAL	SIG-T	OXY	PO4	NH3	NO2	NO3	nO	SIO3	PH	TALK
10.0	0	7.92A	.	.	9.16	4.97	04.7	0.39	.		22.	.	.
10.0	5	7.53A	.	.	9.44	0.39	01.1	0.27	00.0	844.6	6.	.	.
10.0	15	5.05A	.	.	8.56	1.04	05.4	0.42	00.6	769.6	17.	.	.
10.0	25	4.04A	.	.	4.65	3.43	24.6	0.58	1.6	430.4	64.	.	.

STANDARD

DEP	TEMP	SAL		SIG-T	OXY	SP VOL	DEL D
0	7.92	.	0	.	9.16	.	.
10	4.78	.	0	.	9.32	.	.
20	5.15	.	0	.	6.90	.	.

Table 3. Dissolved oxygen and nutrient data: DUT-02

AC CRUISE 261 CONSECUTIVE STATION NO. 57. OUT000 11/ 6/78
13.0 HOURS GMT

LATITUDE = 53 53.5N LONGITUDE = 166 30.8W SONIC DEPTH = 34 M

1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- ( ) ---NOT RECORDED

	DIRECTION	SPEED
WIND	115 - 124 DEGR	10 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	0.	SECS
SWELL	- DEGR	0.	SECS

TEMPERATURES -OXY =	7.2 DEGR C.	BAROMETRIC PR. =	1018.3MB
-WET =	DEGR C.	TRANSPARENCY =	M

OBSERVED

TIME	DEP	TEMP	SAL	SIG-T	OXY	PO4	NH3	NO2	NO3	NO	SIO3	PH	TALK
11.6	0	7.74A	34.537	26.99	9.10	0.31	01.5	0.25	00.0	812.4	6.	.	.
11.6	5	7.60A	31.596	24.70	9.71	0.24	00.4	0.26	00.2	868.7	18.	.	.
11.6	15	.	.	38.87	9.03	0.06	33.2	7.03	00.0	806.2	1.3	.	.
11.6	30	.	.	38.86	6.41	1.93	11.6	0.55	00.7	578.6	40.	.	.

STANDARD

DEP	TEMP	SAL	SIG-T	OXY	SP VOL	DEL D
0	7.74	34.537	26.99	9.10	.	.

Table 4. Dissolved oxygen and nutrient data: DUT-00

AC CRUISE 261 CONSECUTIVE STATION NO. 52. HEL001 11/ 6/78
15.0 HOURS GMT

LATITUDE = 53 56.0N LONGITUDE = 166 24.0W SONIC DEPTH = 80 M

1-DIGIT WEATHER CODE IS (X?) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (7) ---7/8
VISIBILITY --- (7) ---10-20 KM

	DIRECTION	SPEED
WIND	175 - 184 DEGR	10 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	175 - 184 DEGR	0.3 M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY =	7.6 DEGR C.	BAROMETRIC PR. =	1017.1MB
-WET =	DEGR C.	TRANSPARENCY =	M

OBSERVED

TIME	DEP	TEMP	SAL	SIG-T	OXY	PO4	NH3	NO2	NO3	SI	SIO3	PH	TALK
13.0	0	6.038	29.216	22.92	9.05	0.29	02.6	0.29	1.4	820.6	10.	.	.
13.0	5	6.41C	32.240	25.33	9.03	0.45	01.8	0.37	00.0	311.6	15.	.	.
13.0	15	6.31D	32.243	25.41	8.90	0.64	02.6	0.36	00.0	793.7	13.	.	.
13.0	30	6.022	32.263	25.45	8.33	0.81	03.6	0.39	6.5	907.6	23.	.	.
13.0	70	5.06A	32.599	25.81	7.46	1.10	06.2	0.42	13.2	786.6	38.	.	.

STANDARD

DEP	TEMP	SAL	SIG-T	OXY	SP VOL	DEL D
0	6.03	29.216	22.92	9.05	495.07	.000
10	6.36	32.242	25.37	9.02	261.63	.038
20	6.22	32.253	25.42	8.73	257.01	.044
30	6.02	32.263	25.45	8.32	254.71	.089
50	5.57	32.394	25.58	7.84	242.29	.139

Table 5. Dissolved oxygen and nutrient data: HEL-1

AC CRUISE 261 CONSECUTIVE STATION NO. 60, HEL002 11/ 6/78
17.7 HOURS GMT

LATITUDE = 51 54.6N LONGITUDE = 146 13.5W SONIC DEPTH = 14 M

1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- (4) ---STRATOCUMULUS
CLOUD AMOUNT --- (8) ---8/8 TOTAL
VISIBILITY --- (7) ---10-20 KM

	DIRECTION	SPEED
WIND	165 - 174 DEGR	15 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	165 - 174 DEGR	0.3 M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY =	7.8 DEGR C.	BAROMETRIC PR. =	1015.6MB
-WET =	DEGR C.	TRANSPARENCY =	M

OBSERVED

TIME	DEP	TEMP	SAL	SIG-T	OXY	PO4	NH3	NO2	NO3	HQ	SIO3	PH	TALK
15.9	0	7.40A	33.844	25.34	8.83	0.48	01.1	0.25	00.9	796.4	18.	.	.
15.9	5	6.79S	33.916	25.14	10.14	0.12	01.1	0.21	00.3	909.8	9.	.	.

STANDARD

DEP	TEMP	SAL	SIG-T	OXY	SP VOL	DEL D
0	7.40	33.844	25.34	8.83	.	.

Table 6. Dissolved oxygen and nutrient data: HEL-2

```
AC   CRUISE 261 CONSECUTIVE STATION NO.  61,      03E     11/ 6/78
                                                          19.3 HOURS GMT

  LATITUDE = 54  52.30   LONGITUDE = 166  33.49   SONIC DEPTH =   16 M

  1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
  CLOUD TYPE --- (6) ---STRATOCUMULUS
  CLOUD AMOUNT --- (8) ---8/8 TOTAL
  VISIBILITY --- (7) ---10-20 KM
-----------------------------------------------------------------
|          DIRECTION          SPEED                               |
| WIND     135 - 144 DEGR     20 KNOTS                            |
-----------------------------------------------------------------
|          DIRECTION          HEIGHT      PERIOD                  |
| SEA        0 -   0 DEGR        %.          SECS                 |
| SWELL      -     DEGR          %.          SECS                 |
-----------------------------------------------------------------
| TEMPERATURES -DRY =    5.3 DEGR C.   BAROMETRIC PR. =1014.9MB  |
|               -WET =        DEGR C.   TRANSPARENCY   =       M  |
-----------------------------------------------------------------
```

OBSERVED

TIME	DEP	TEMP	SAL	SIG-T	OXY	PO4	NH3	NO2	NO3	HO	SIO3	PH	TALK
:0	0	:	30.136	:	8.52	0.68	05.1	0.21	00.5	771.4	12.	:	:
:0	5	:	32.116	:	8.74	0.81	06.0	0.26	01.3	792.0	14.	:	:

STANDARD

DEP	TEMP	SAL	SIG-T	OXY	SP VOL	DEL D
0	. 3	01.360	.	8.59	.	.

Table 7. Dissolved oxygen and nutrient data: 3E

AC CRUISE 261 CONSECUTIVE STATION NO. 71, HEL03A 12/ 6/78
2.8 HOURS GMT

LATITUDE = 53 53.5N LONGITUDE = 166 33.2W SONIC DEPTH = 40 M

1-DIGIT WEATHER CODE IS (X6) AND INDICATES RAIN
CLOUD TYPE --- (7) ---STRATUS
CLOUD AMOUNT --- (1) ---1/8 TOTAL
VISIBILITY --- (7) ---10-20 KM

	DIRECTION	SPEED
WIND	145 - 174 DEGR	15 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	145 - 174 DEGR	6.2 M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY = 10.6 DEGR C. BAROMETRIC PR. =1009.9MB
-WET = DEGR C. TRANSPARENCY = M

OBSERVED

TIME	DEP	TEMP	SAL	SIG-T	OXY	PO4	NH3	NO2	NO3	SI	SIO3	PH	TALK
19.3	0	7.27A	30.502	23.69	9.47	0.25	01.8	0.23	00.4	849.1	13.	.	.
19.3	5	7.15A	30.740	24.11	9.62	0.35	00.7	0.23	00.4	773.2	13.	.	.
19.3	15	6.08A	32.291	25.46	8.61	1.50	05.4	0.31	03.5	600.2	19.	.	.
19.3	27	5.20A	32.481	25.68	7.25	1.02	08.0	0.43	10.8	744.5	32.	.	.

STANDARD

DEP	TEMP	SAL	SIG-T	OXY	SP VOL	DEL D
0	7.27	30.502	23.80	9.47	402.84	.000
10	6.67	31.520	24.77	8.63	312.28	.035
20	5.66	32.368	25.56	8.23	244.96	.064

Table 8. Dissolved oxygen and nutrient data: HEL-3A

AC CRUISE 261 CONSECUTIVE STATION NO. 74. HEL 03 12/ 6/78
8.0 HOURS GMT

LATITUDE = 59 53.2N LONGITUDE = 166 24.3W SONIC DEPTH = 49 M

4-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- ( ) ---NOT RECORDED

	DIRECTION	SPEED
WIND	135 - 180 DEGR	7 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY = 10.4 DEGR C. BAROMETRIC PR. =1008.0MB
-WET = DEGR C. TRANSPARENCY = M

OBSERVED

TIME	DEP	TEMP	SAL	SIG-T	OXY	PO4	NH3	NO2	NO3	HQ	SIO3	PH	TALK
2.6	0	7.149	30.540	24.21	9.42	0.24	02.2	0.24	00.6	946.4	12.	.	.
2.8	5	6.259	32.263	25.45	9.83	0.71	03.3	0.30	02.5	910.8	17.	.	.
2.3	15	5.513	32.354	25.58	7.77	1.10	06.5	0.39	07.9	764.8	25.	.	.
2.8	30	5.238	32.405	25.70	7.46	1.16	08.0	0.42	11.2	766.9	32.	.	.
2.8	40	5.06A	32.412	25.82	7.39	1.30	05.4	0.42	13.4	774.1	38.	.	.

STANDARD

DEP	TEMP	SAL	SIG-T	OXY	SP VOL	DEL D
0	7.14	30.960	24.27	9.42	366.95	.000
10	5.77	32.209	25.50	8.25	249.75	.031
20	5.36	32.364	25.61	7.57	238.94	.056
30	5.23	32.405	25.70	7.44	230.79	.079

Table 9. Dissolved oxygen and nutrient data: HEL-3

```
YC   CRUISE 761 CONSECUTIVE STATION NO.  78.   HEL 07     12/ 6/78
                                                          10.8 HOURS GMT

  LATITUDE = 53  53.6N   LONGITUDE = 166  35.8W   SONIC DEPTH =   98 M

  1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
  CLOUD TYPE --- ( ) ---NOT RECORDED
  CLOUD AMOUNT --- ( ) ---NOT RECORDED.
  VISIBILITY --- ( ) ---NOT RECORDED
```

	DIRECTION	SPEED
WIND	215 - 224 DEGR	15 KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	215 - 224 DEGR	2.3 M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES	DRY =	.0 DEGR C.	BAROMETRIC PR. =1009.6MB
	WET =	DEGR C.	TRANSPARENCY = M

OBSERVED

TIME	DEP	TEMP	SAL	SIG-T	OXY	PO4	NH3	NO2	NO3	NO	SIO3	PH	TALK
8.0	0	6.393	31.613	24.87	9.19	0.57	02.9	0.32	.		19.	.	.
8.0	5	6.363	31.628	25.18	9.09	0.58	02.6	0.34	01.7	826.0	17.	.	.
8.0	15	6.028	32.331	25.49	8.44	0.72	04.7	0.37	.		20.	.	.
8.0	30	5.338	32.431	25.64	7.58	1.10	08.0	0.32	.		16.	.	.
8.0	98	4.363	.	.	6.94	1.30	05.1	0.36	.		27.	.	.

STANDARD

DEP	TEMP	SAL	SIG-T	OXY	SP VOL	DEL D
0	6.39	31.613	24.87	9.19	308.98	.000
10	6.20	32.257	25.37	8.79	262.36	.029
20	5.81	32.420	25.56	8.13	241.95	.054
30	5.33	32.431	25.64	7.58	236.46	.078
50	5.20	. 0	.	7.36	.	.
75	4.98	. 0	.	7.06	.	.

Table 10. Dissolved oxygen and nutrient data: HEL-7

AC CRUISE 261 CONSECUTIVE STATION NO. 82, HEL 06 12/ 6/78
15.4 HOURS GMT

LATITUDE = 53 55.2N LONGITUDE = 166 35.9W SONIC DEPTH = 132 M

1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- (7) ---STRATUS
CLOUD AMOUNT --- (6) ---4/8
VISIBILITY --- (7) ---10-20 KM

	DIRECTION	SPEED
WIND	- DEGS	KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGS	M.	SECS
SWELL	- DEGS	M.	SECS

TEMPERATURES -DRY =	7.0 DEGS C.	BAROMETRIC PR. =	1009.0MB
-WET =	DEGS C.	TRANSPARENCY =	M

OBSERVED

TIME	DEP	TEMP	SAL	SIG-T	OXY	PO4	NH3	NO2	NO3	nO	SIO3	PH	TALK
15.8	0	6.86A	31.843	25.01	9.31	0.28	01.6	0.31	.		13.	.	.
10.8	5	6.46A	31.92C	25.04	9.15	0.29	02.6	0.32	.		14.	.	.
16.8	15	.	.	.	8.56	0.70	04.4	0.33	.		16.	.	.
13.8	30	.	32.469	.	7.74	0.80	.	0.30	.		12.	.	.
14.9	50	4.993	32.631	25.84	7.23	2.20	06.2	0.34	.		23.	.	.
10.6	75	4.46A	32.693	25.90	6.97	1.40	05.8	0.46	.		39.	.	.
15.9	125	4.71A	32.7a1	25.96	6.66	1.64	05.4	0.51	.		47.	.	.

STANDARD

DEP	TEMP	SAL	SIG-T	OXY	SP VOL	DEL D
0	6.56	31.843	25.03	9.31	293.77	.000
10	6.28	31.969	25.15	8.82	283.17	.029
20	5.94	32.101	25.34	8.25	261.31	.056
30	5.61	32.469	25.64	7.74	236.11	.091
50	4.99	32.631	25.84	7.23	217.42	.126
75	4.24	32.693	25.90	6.97	212.33	.180
100	4.77	32.733	25.95	6.79	207.78	.232

Table 11. Dissolved oxygen and nutrient data: HEL-6

AC CRUISE 261 CONSECUTIVE STATION NO. 93. HEL 04 13/ 6/78
4.7 HOURS GMT

LATITUDE = 51 52.2N LONGITUDE = 146 34.4W SONIC DEPTH = 95 M

1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (7) ---7/8
VISIBILITY --- (7) ---10-20 KM

	DIRECTION	SPEED
WIND	205 - 214 DEGR	KNOTS

	DIRECTION	HEIGHT	PERIOD
SEA	0 - 0 DEGR	M.	SECS
SWELL	- DEGR	M.	SECS

TEMPERATURES -DRY =	10.2 DEGR C.	BAROMETRIC PR. =	1008.1MB
-WET =	DEGR C.	TRANSPARENCY =	M

OBSERVED

TIME	DEP	TEMP	SAL	SIG-T	OXY	PO4	NH3	NO2	NO3	NO	SIO3	PH	TALK
15.4	0	6.349	31.855	25.01	9.49	1.13	02.2	0.35	.		18.	.	.
15.4	10	6.144	32.278	25.43	8.81	0.66	03.3	0.47	.		35.	.	.
15.4	30	4.710	32.422	25.71	6.62	2.00	06.2	0.43	14.8	724.2	35.	.	.
15.4	50	4.219	32.429	25.76	6.11	2.20	08.0	0.44	18.1	709.4	41.	.	.
15.4	90	4.330	32.495	25.79	6.03	2.60	09.4	0.47	19.0	714.7	45.	.	.

STANDARD

DEP	TEMP	SAL	SIG-T	OXY	SP VOL	DEL D
0	6.34	31.855	25.01	9.49	296.27	.000
10	6.14	32.278	25.43	8.81	256.31	.028
20	5.37	32.417	25.63	7.68	237.32	.052
30	4.71	32.422	25.70	6.62	230.14	.076
50	4.21	32.429	25.76	6.11	224.82	.121
75	4.28	32.463	25.77	6.10	223.82	.177

Table 12. Dissolved oxygen and nutrient data: HEL-4

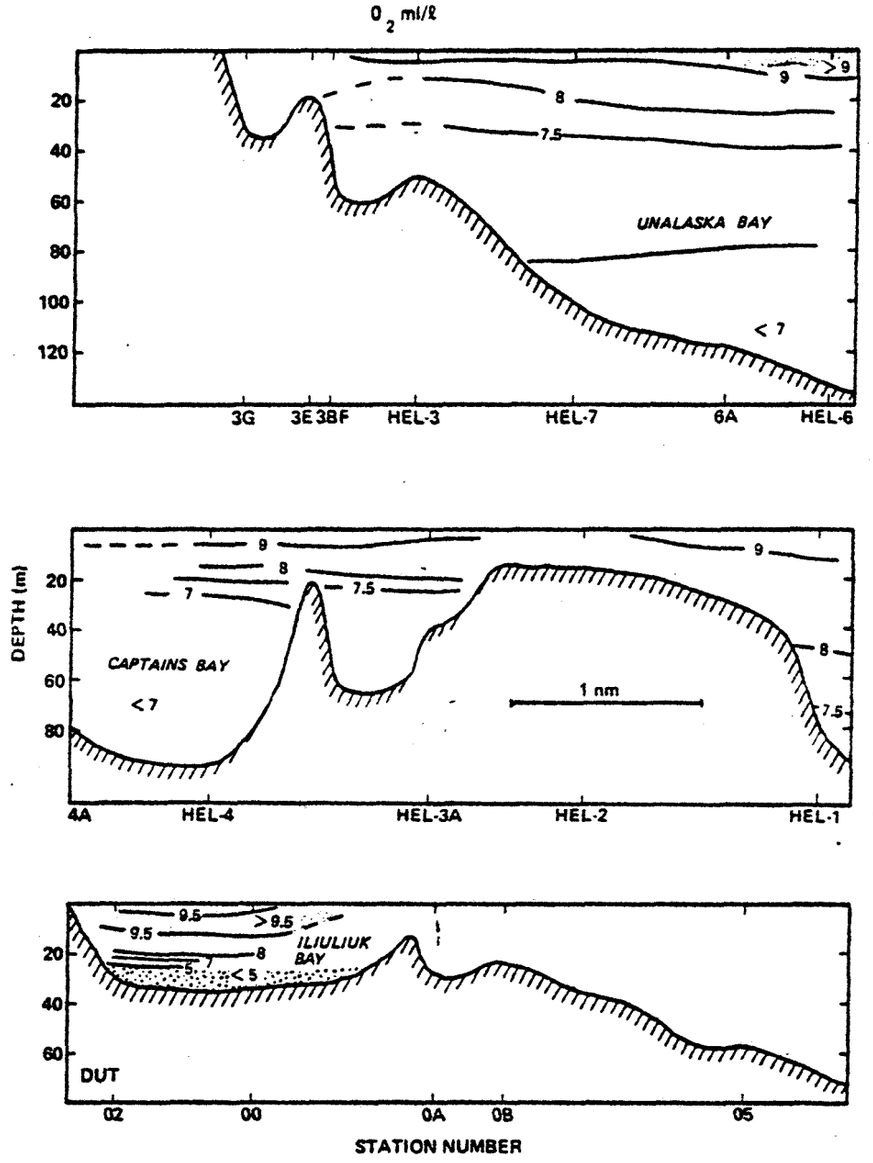


Figure 34. Longitudinal oxygen profiles.

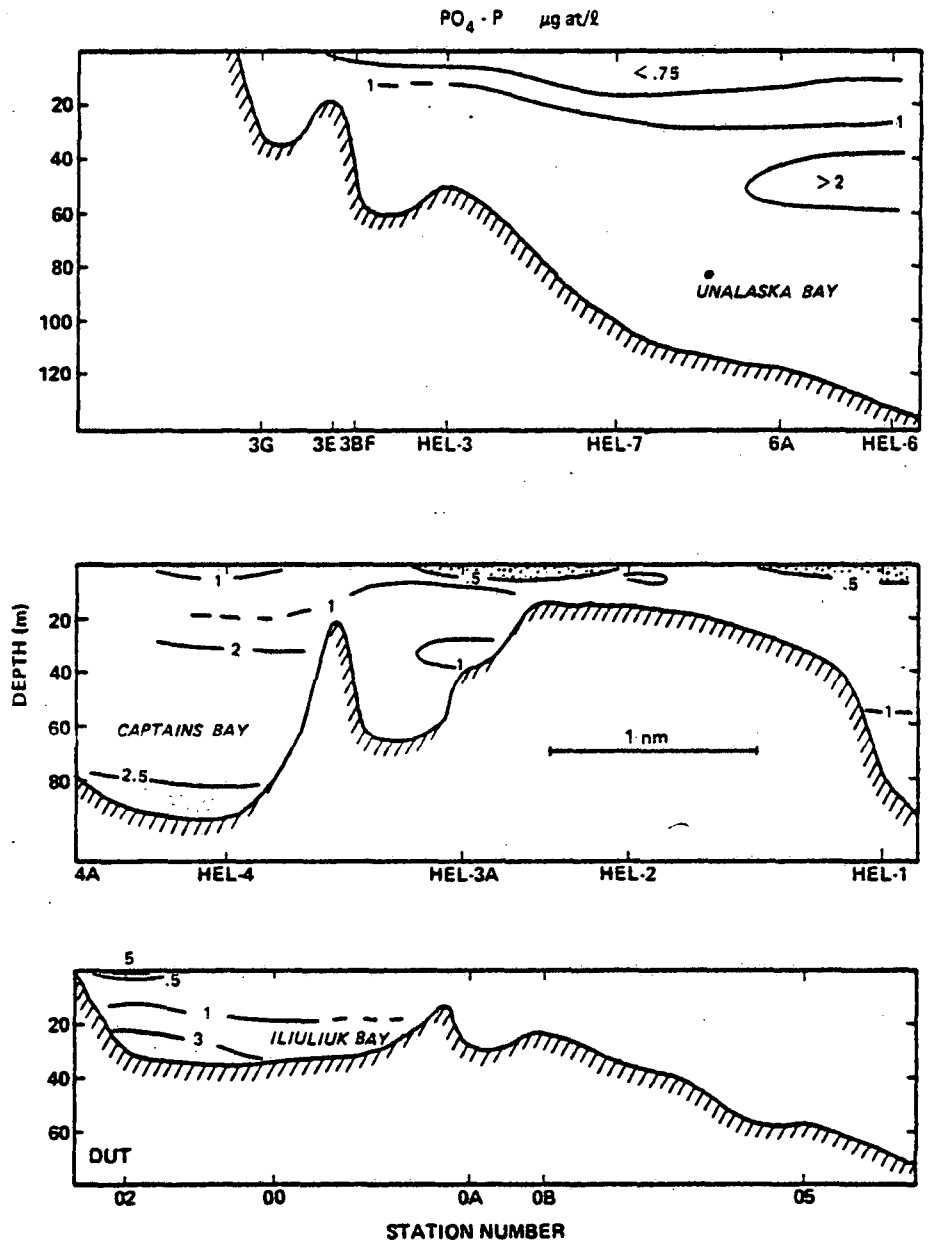


Figure 35. Longitudinal phosphate profiles.

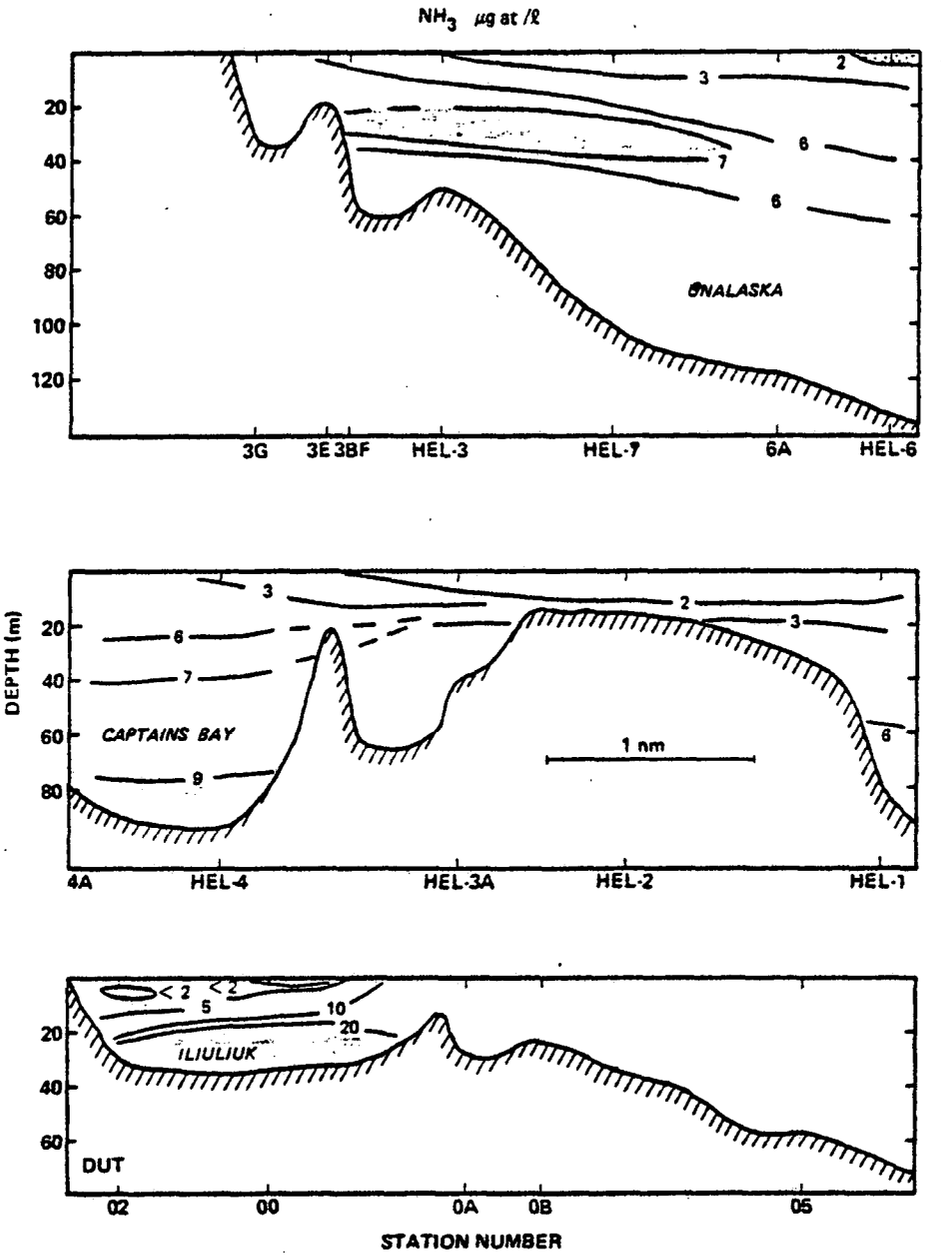


Figure 36. Longitudinal ammonia profiles.

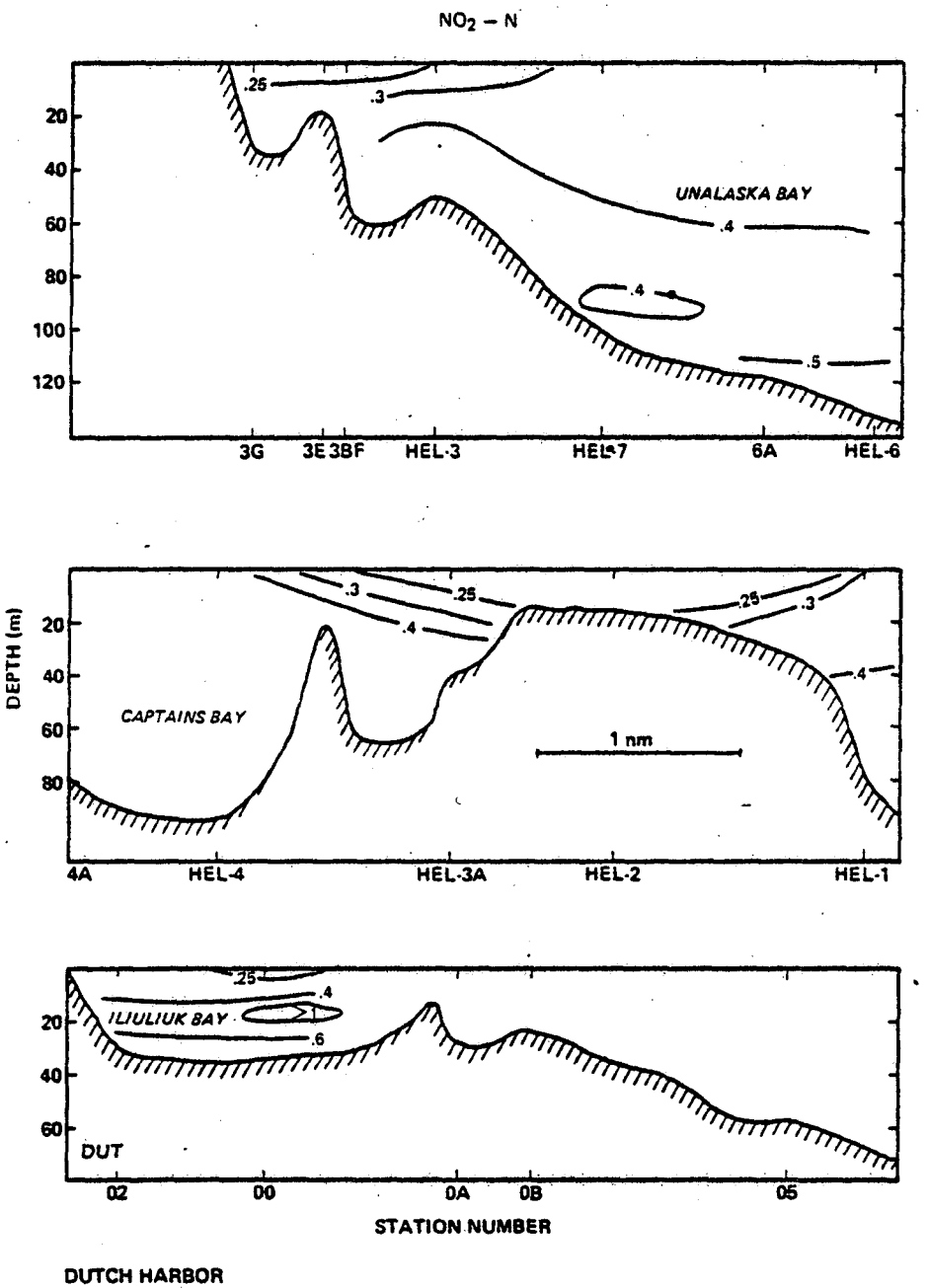


Figure 37. Longitudinal nitrite profiles.

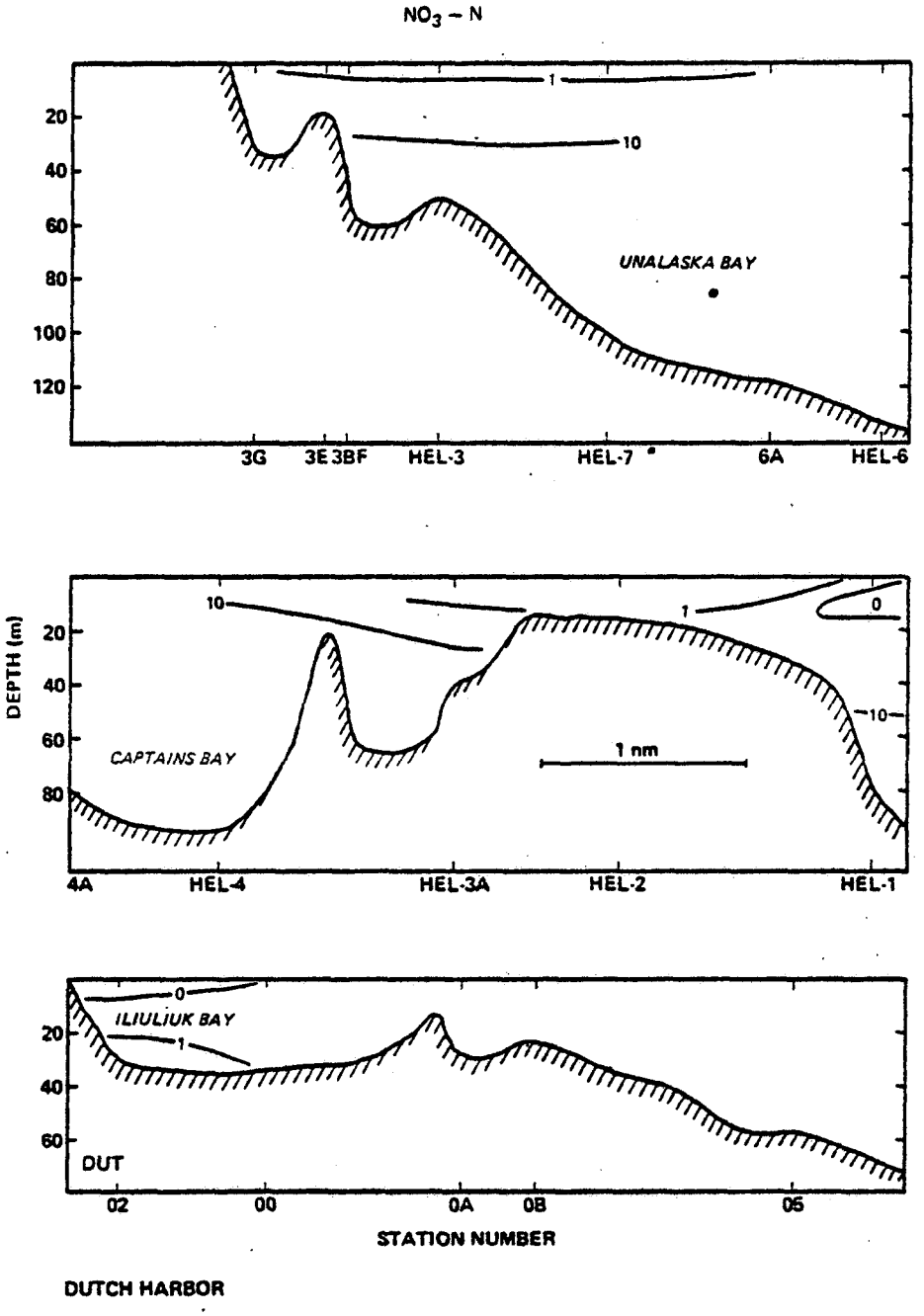


Figure 38. Longitudinal nitrate profiles.

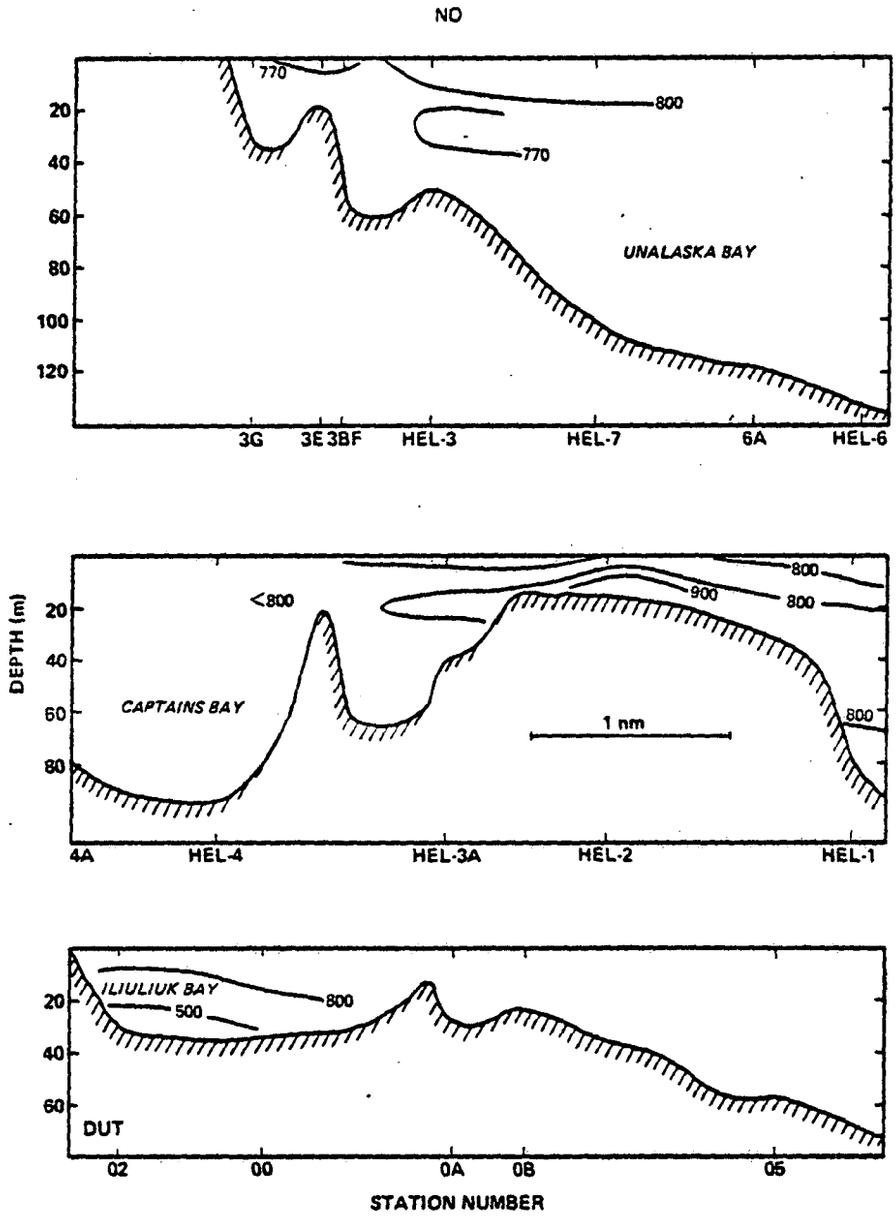


Figure 39. Longitudinal NO profiles.

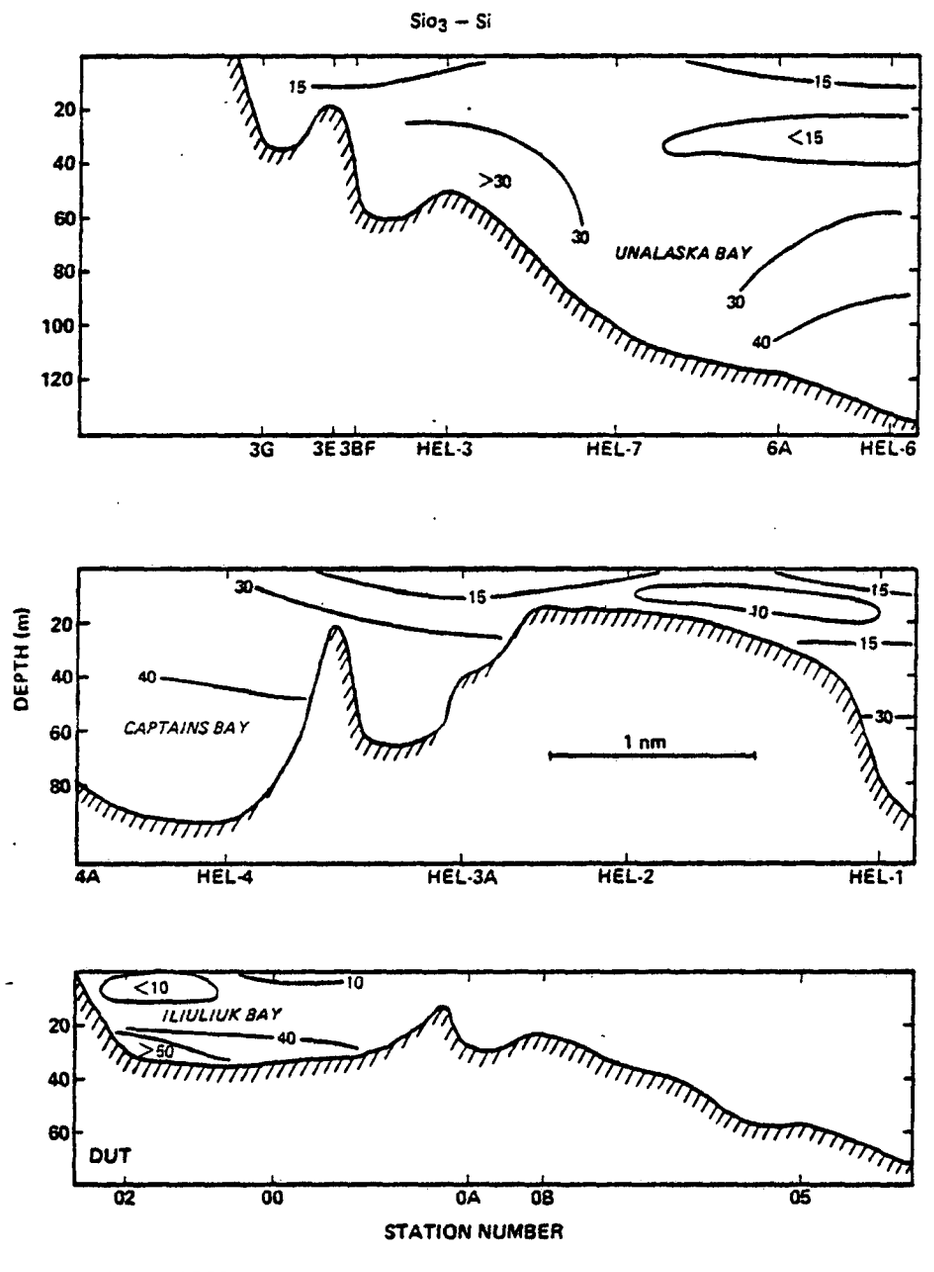


Figure 40. Longitudinal silicate profiles.

above) for dissolved oxygen, phosphate, the inorganic nitrogen species, computed NO and silicate respectively. Individual vertical station profiles are given as Figures 41-51. Sulfide analysis data are given as Table 13.

The principal sedimentological characteristics of the surficial sediments are listed in Tables 14 and 15. Figures 52 and 53 show the distributions of the (graphic) grain size means and the sorting indices (graphic standard deviations). Recent total organic carbon sediment contents are given in Figure 54.

DISCUSSION

Hydrography

In spite of the paucity of coverage certain hydrographic features are readily apparent. Figure 32 shows the water densities at this time of year to be well stratified: < 24 at the surface to > 26 at 120 m on the shelf, and lower surface densities, as would be expected, at the surface in the inlets. It is apparent also that the two restricted basins - Dutch Harbor and Captains Bay - are not in free exchange with adjacent shelf waters. Bottom waters within these basins are colder, and hence denser, than at corresponding shelf depths. Other factors being equal, it would be expected that summer surface stratification would maintain the apparent isolation of these basin waters, and this appears to be the case. In October 1977 - i.e. towards the end of the summer period - Colonell and Reeburgh (1978) have shown densities at 30 m at DUT-00 and HEL-1 to be 25.79 and 25.21 respectively; the corresponding June difference from the data presented here is 0.28. These values are cited here only as a rough guide since this is a dynamic nearshore environment and the profiles given have not been time averaged for tidal effects etc. Figure 33, for example, illustrates temperature and salinity profiles at two of these stations taken on different days and at different times and is illustrative of the sort of variation expected in the surface waters. Nevertheless from the little evidence presently available to us, it seems probable that the bottom waters of these basins are not advectively renewed through the summer. Colonell and Reeburgh (*op cit*) have noted that the prevailing summer winds here are northerly so that upwelling of denser water would not be expected at

*Note: Continuation of text on page 88

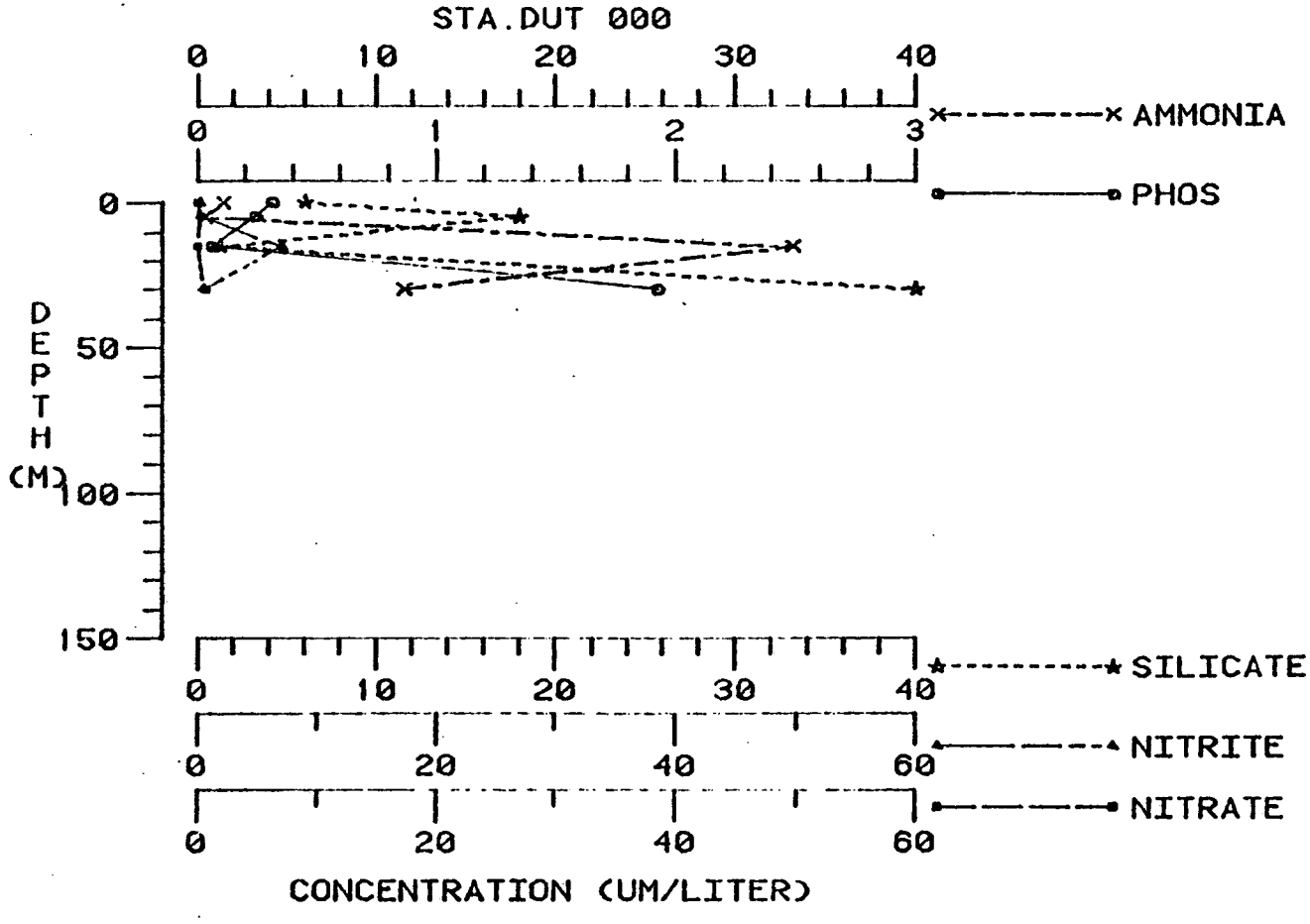


Figure 41. Vertical nutrient profiles: DUT-00.

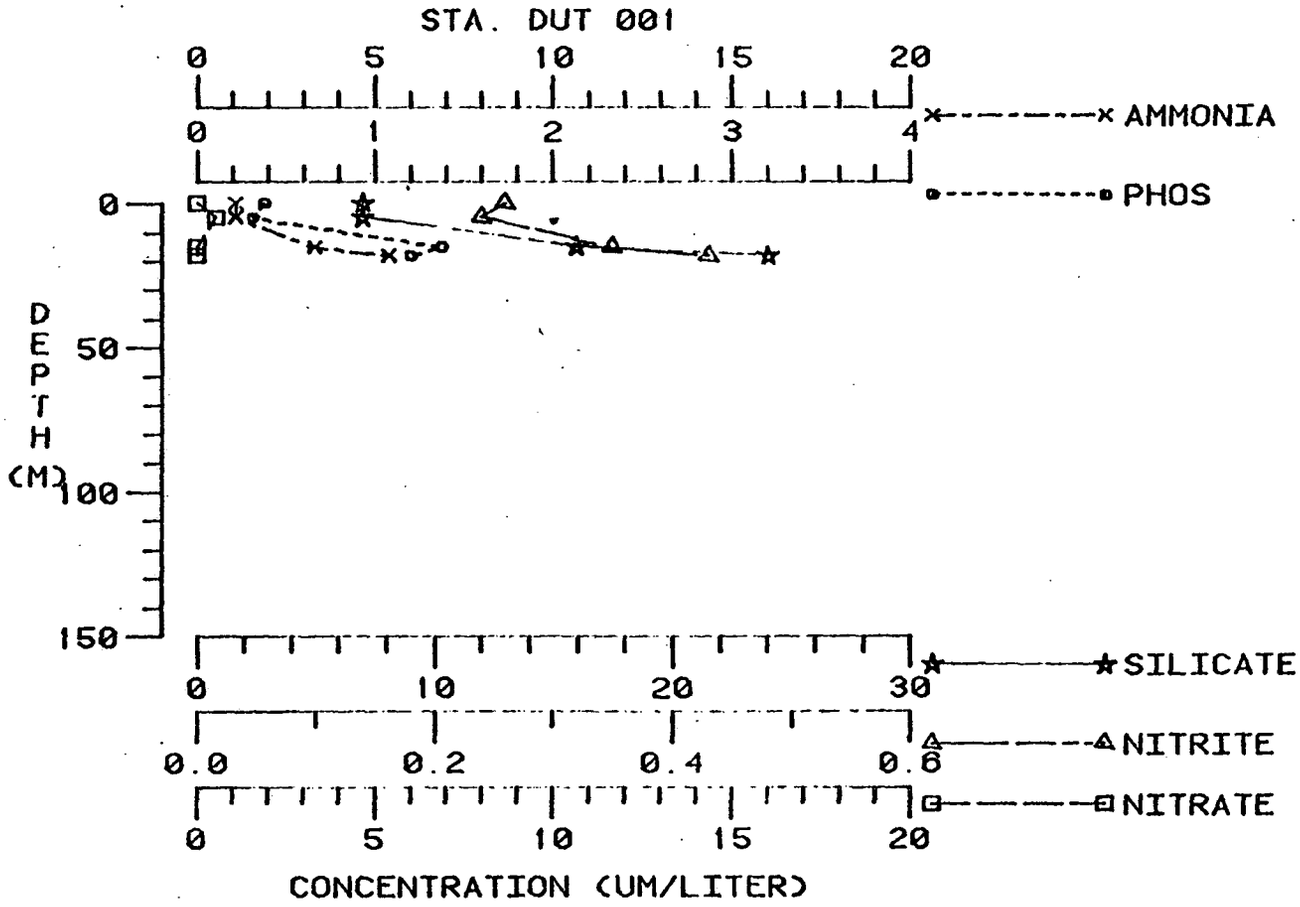


Figure 42. Vertical nutrient profiles: DUT-01A.

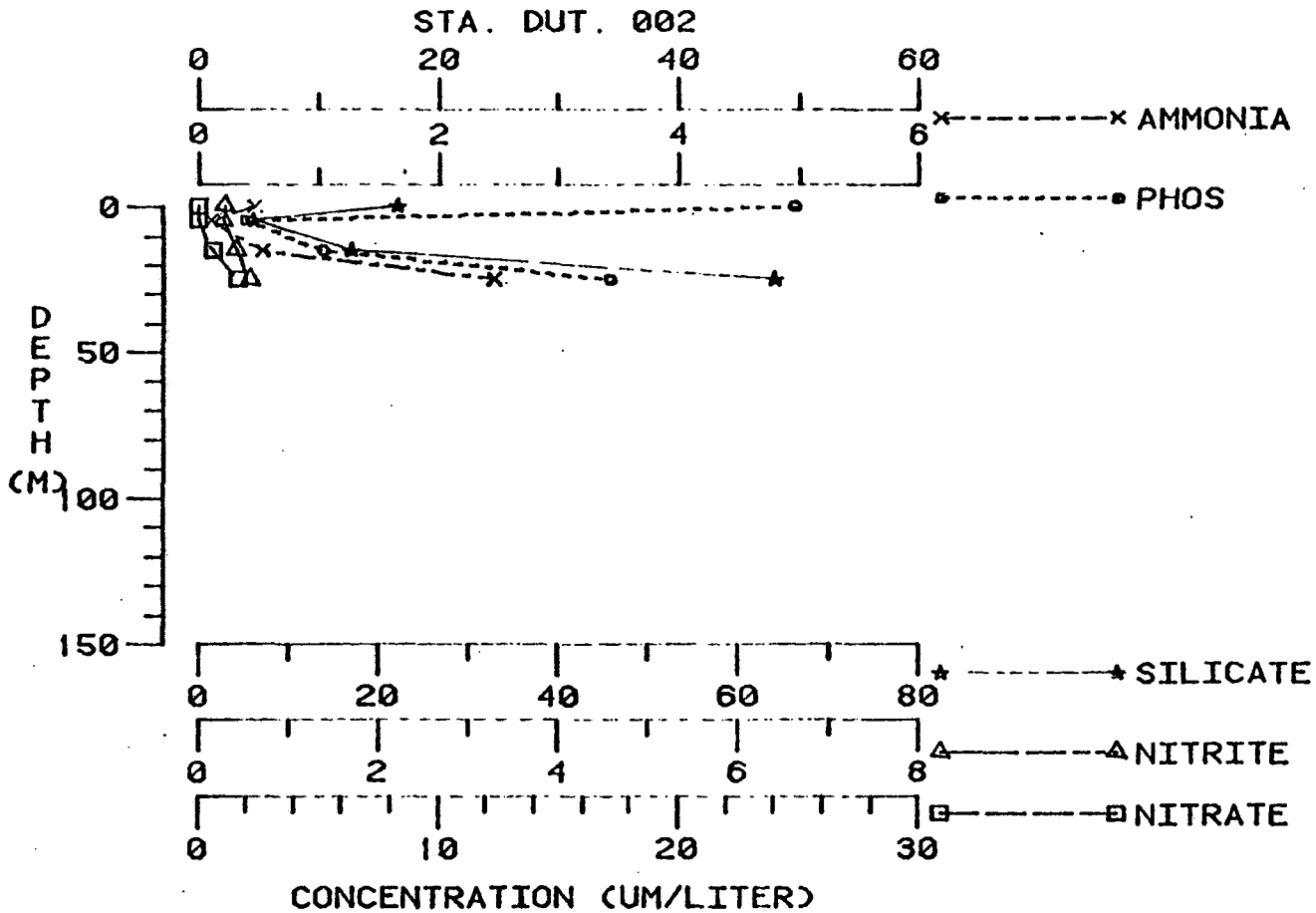


Figure 43. Vertical nutrient profiles: DUT-02.

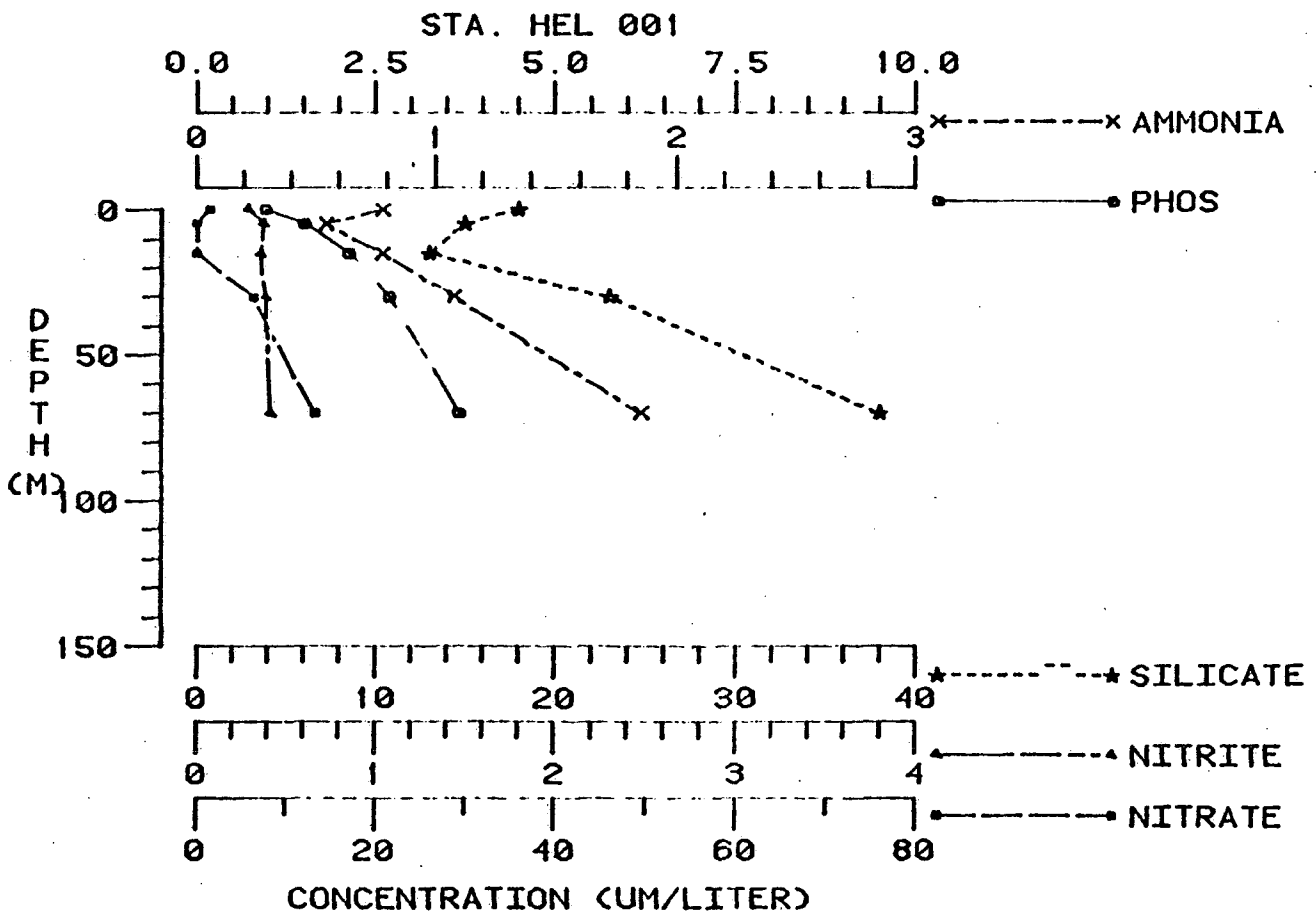


Figure 44. Vertical nutrient profiles: HEL-1.

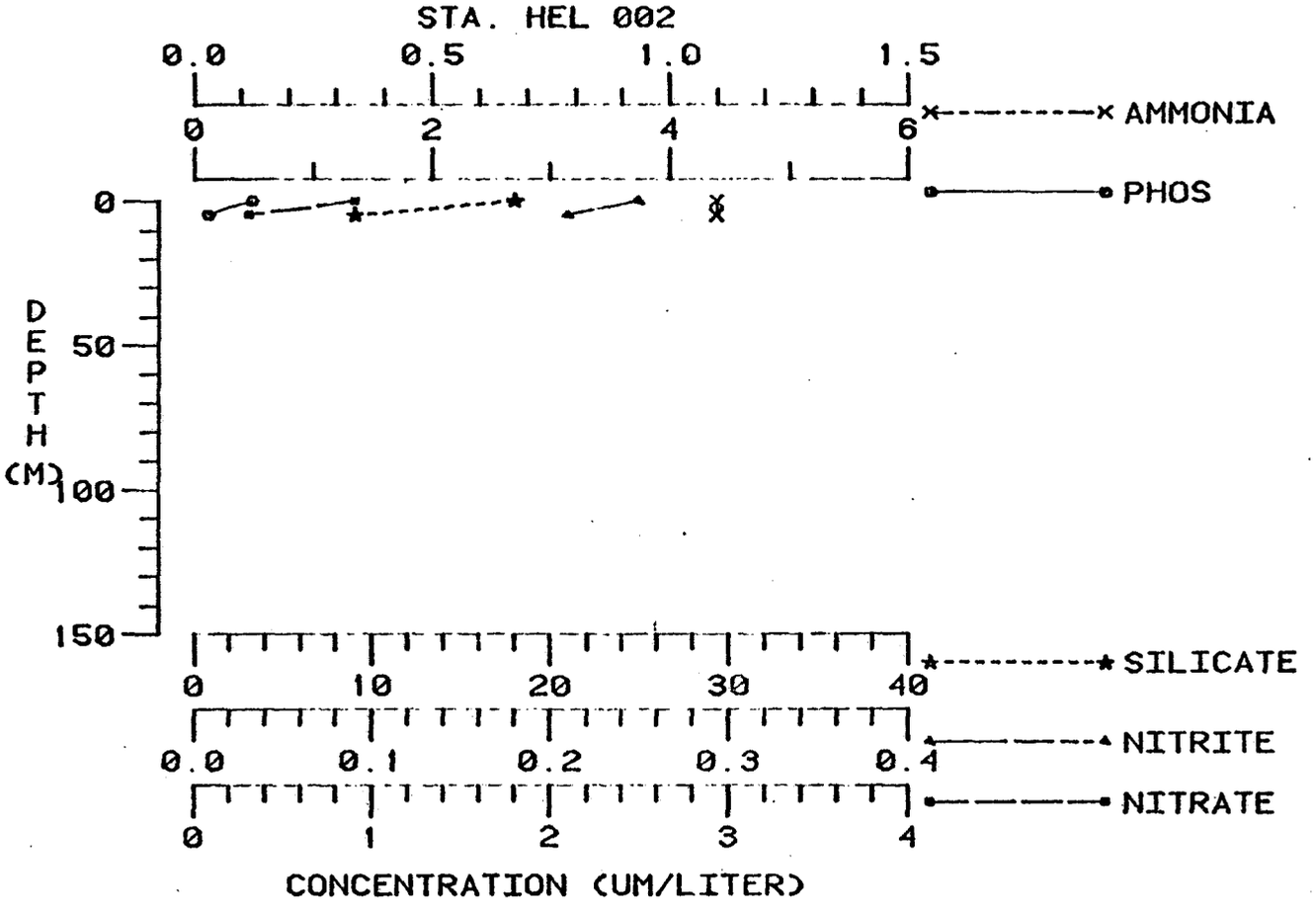


Figure 45. Vertical nutrient profiles: HEL-2.

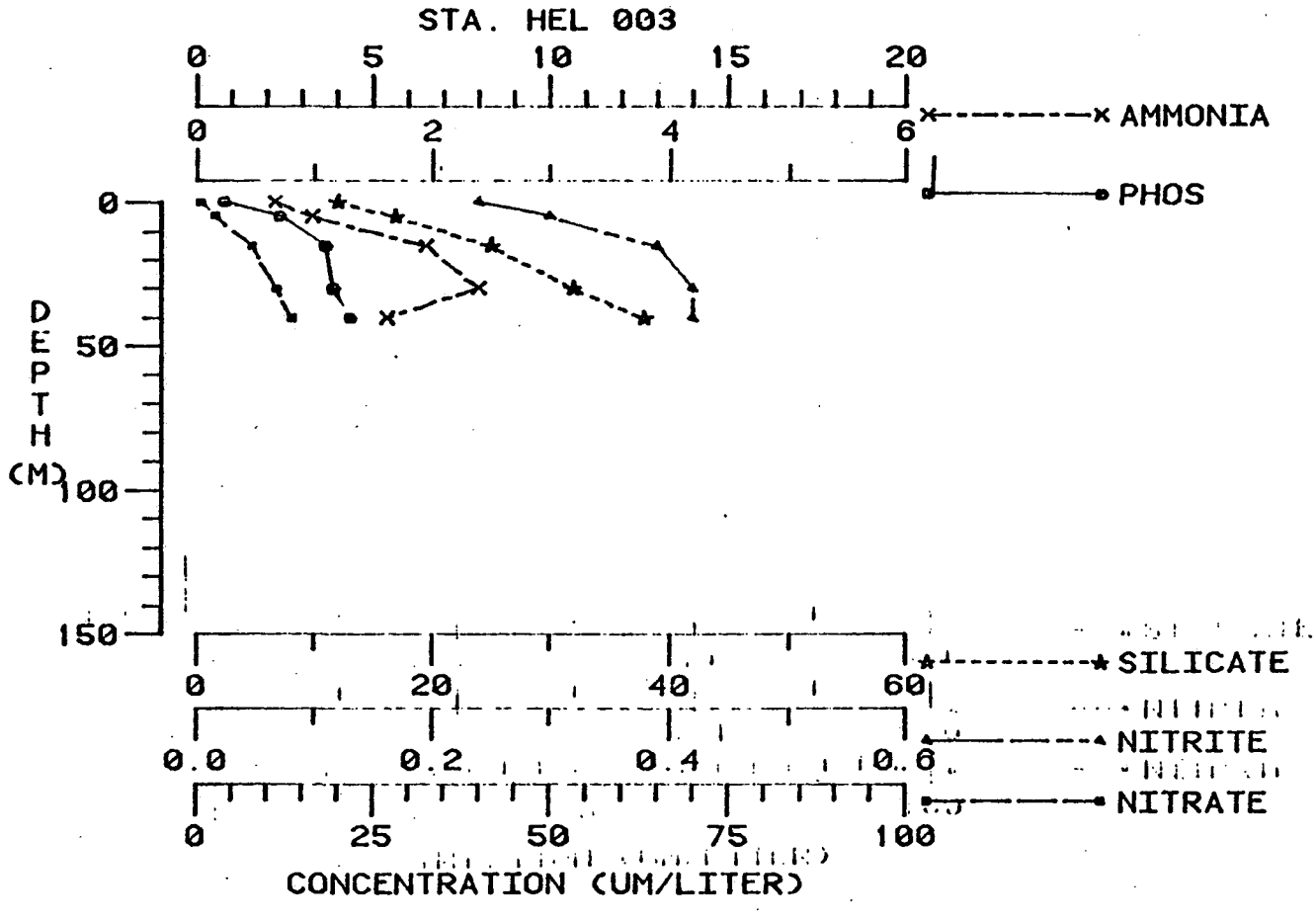


Figure 46. Vertical nutrient profiles: HEL-3.

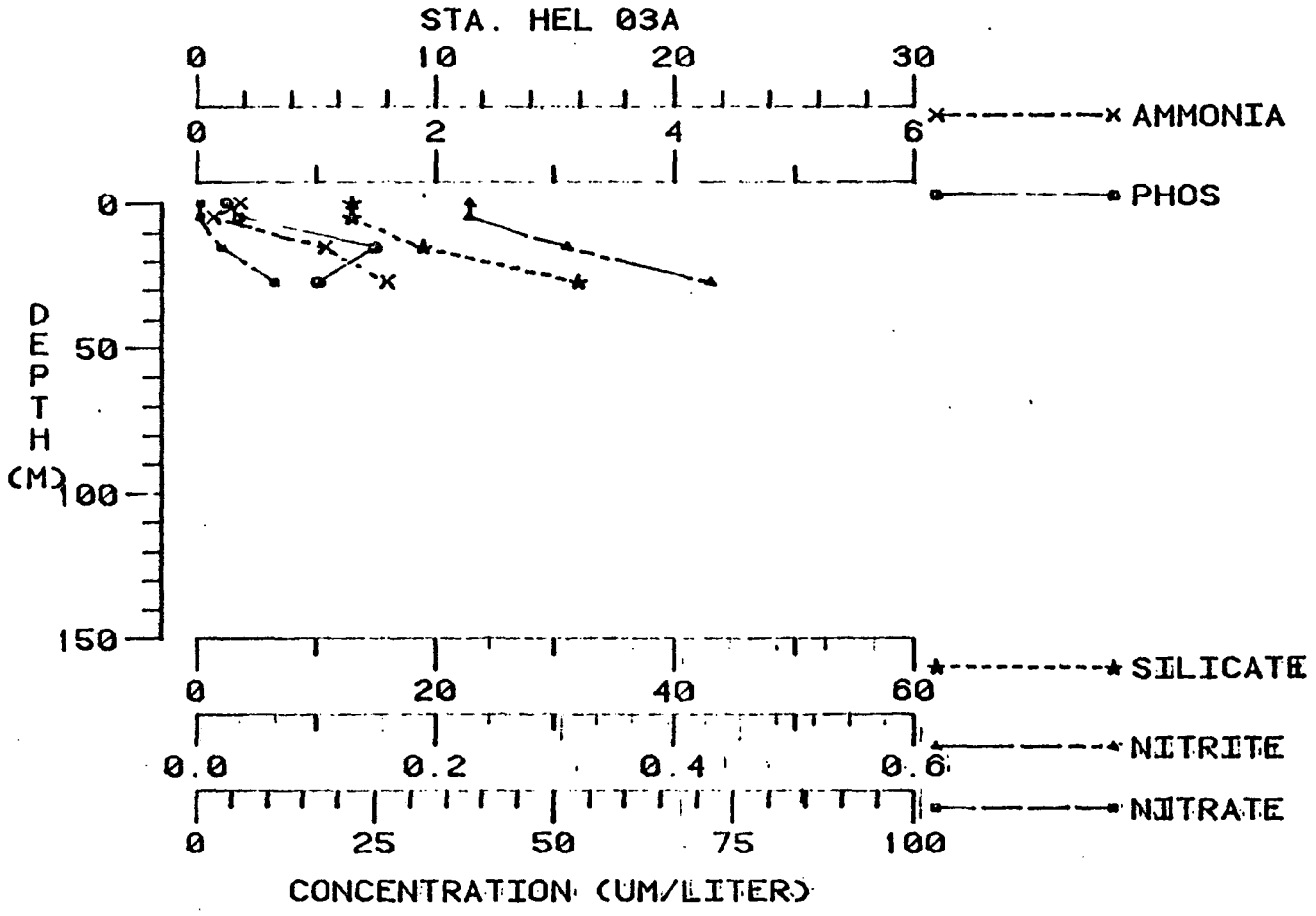


Figure 47. Vertical nutrient profiles: HEL-3A.

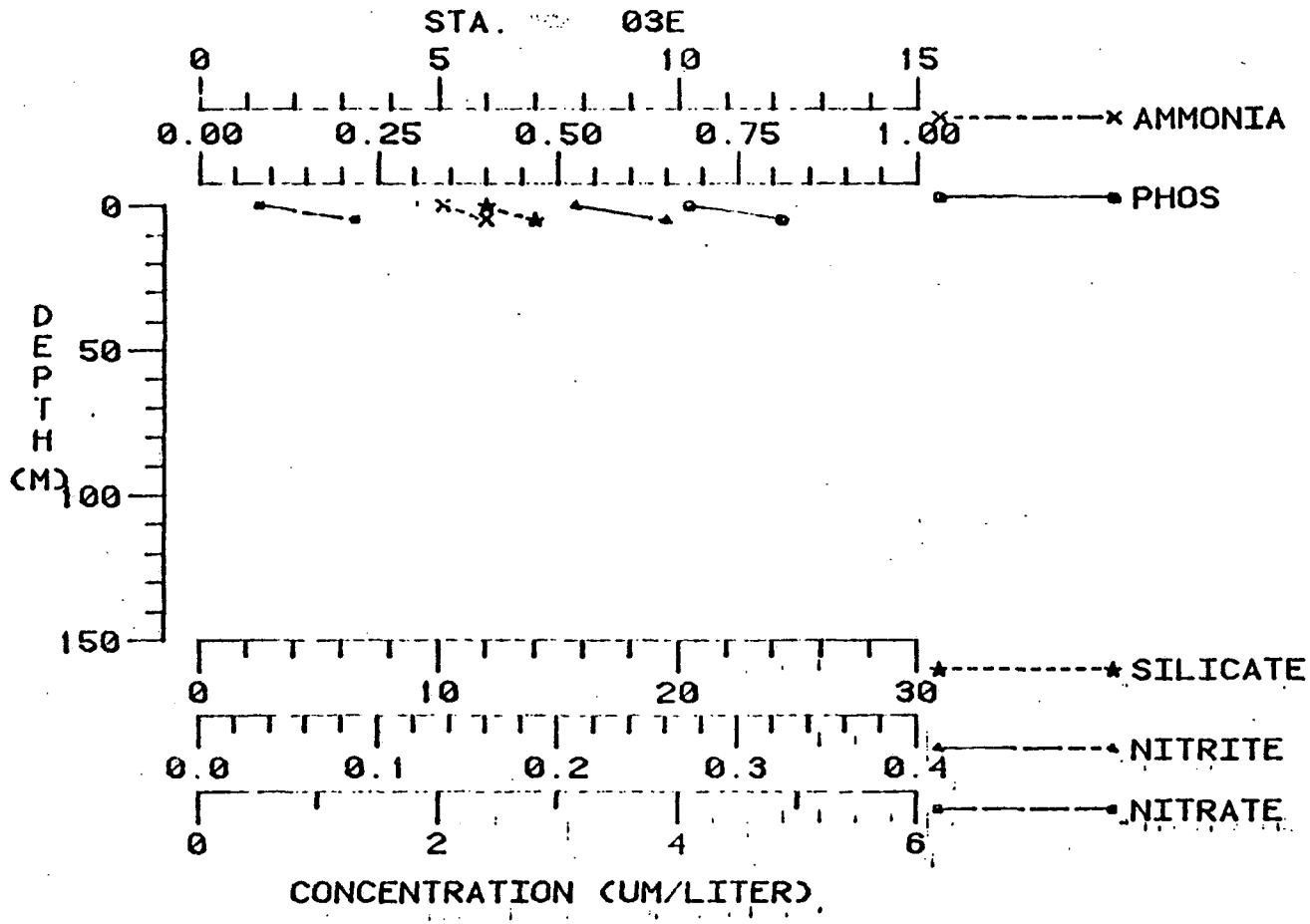


Figure 48. Vertical nutrient profiles: 3E.

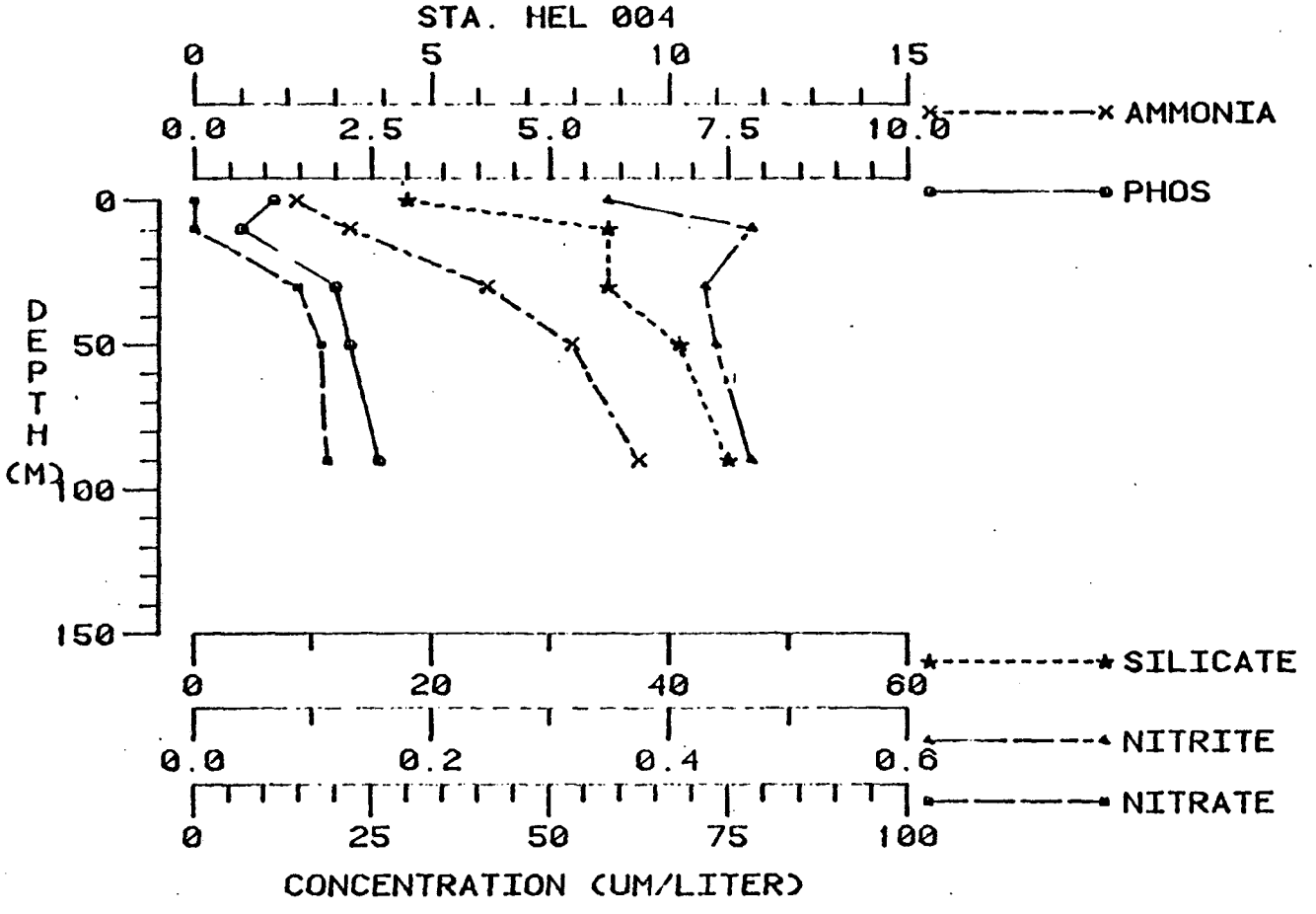


Figure 49. Vertical nutrient profiles: HEL-4.

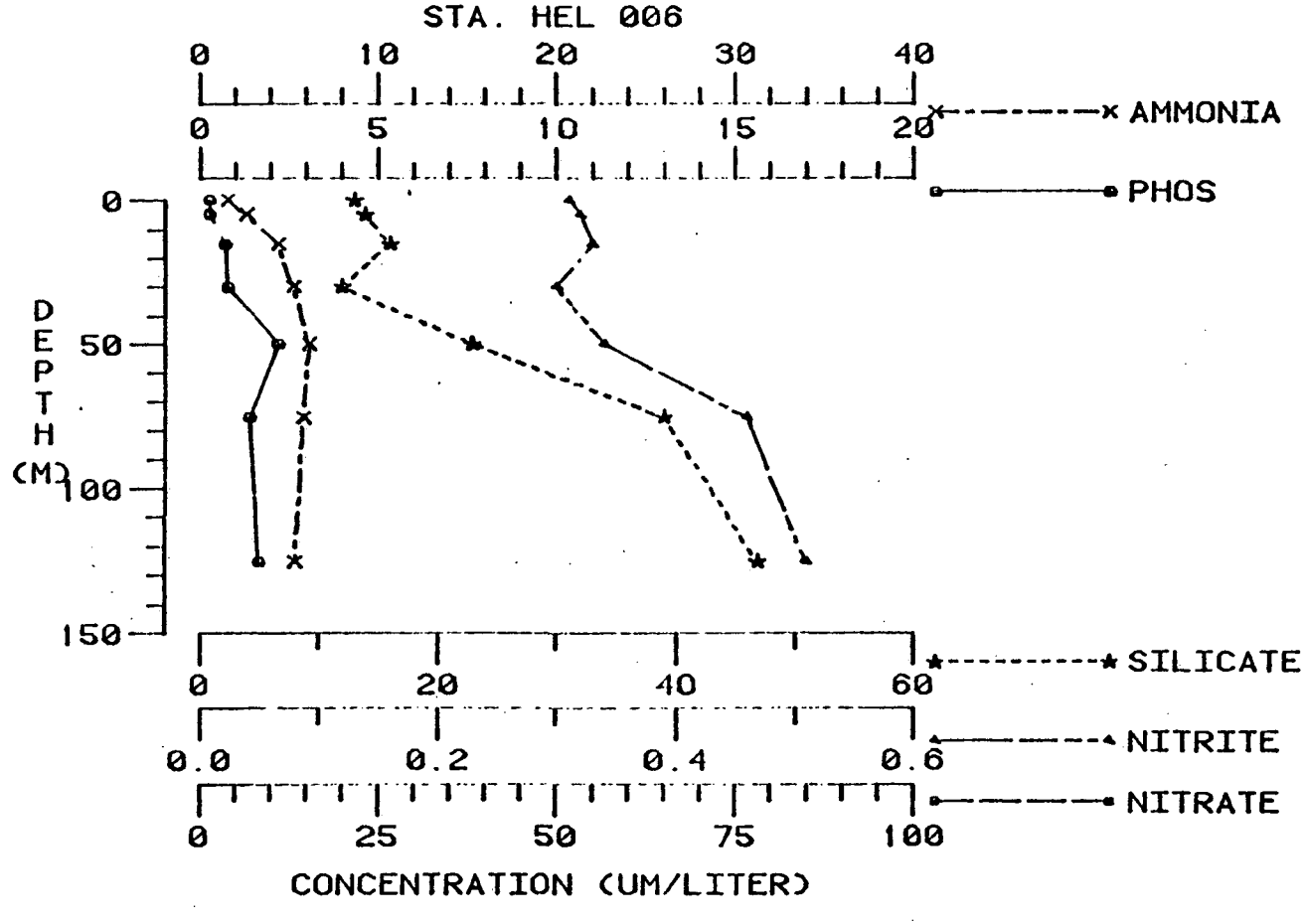


Figure 50. Vertical nutrient profiles: HEL-6.

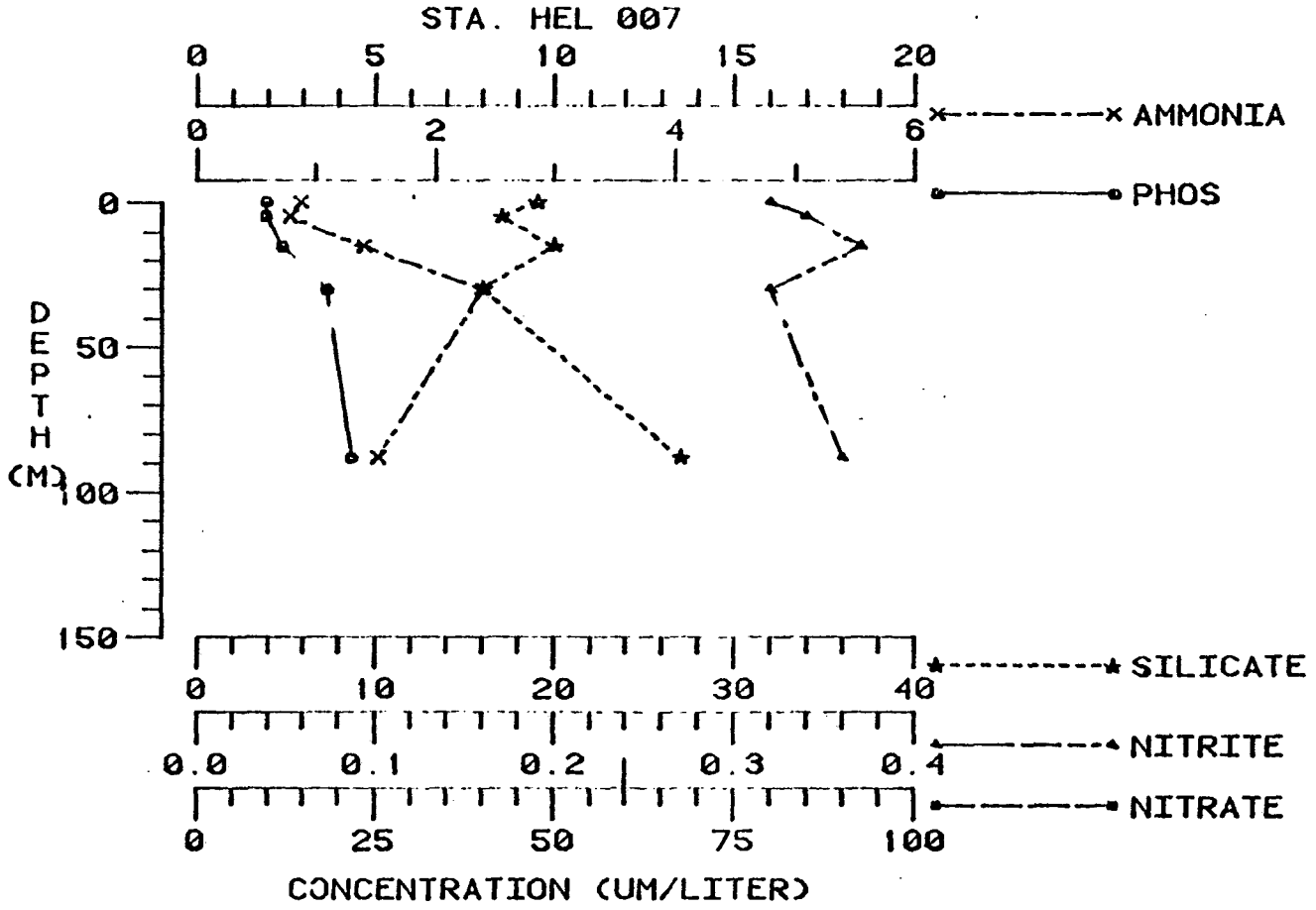


Figure 51. Vertical nutrient profiles: HEL-7.

TABLE 13. WATER COLUMN CHEMISTRY: TOTAL SOLUBLE SULFIDE CONCENTRATION (μg at/ℓ)

Station No.	Sample Depth (m)	Sulfide
DUT 00	27[1]	0.0
	34	0.0
HEL 1	67	0.0
	80	0.0
3H	29	0.0
	34	0.0
3AG	35	0.0
	38	0.0
3G	24	0.0
	31	0.0
3BF	51	0.0
	58	0.0
3DE	21	4.4
	26	12.4
HEL 4	95	0.0

[1]Two samples taken on station; ship not anchored at station.

TABLE 14. SEDIMENT GRAIN SIZE PARAMETERS

Station	Depth (m)	% Sand[a] (weight)	% Mud (weight)	Mean[b] (ϕ)	Standard Deviation[c] (ϕ)	Skewness[d]
DUT 0A	29	27.3	72.7	6.2	3.2	+0.58
DUT 0B	22	99.0	1.0	2.8	0.4	+0.06
DUT 02A	28	23.7	76.3	7.3	3.8	+0.12
1A	46	95.7	4.3	2.2	0.8	-0.07
HEL 3	49	70.4	29.6	3.5	2.4	+0.44
HEL 3A	40	88.8	11.2	2.9	1.7	+0.36
3B	51	70.3	29.7	4.0	2.5	+0.65
3AG	38	51.6	48.4	4.4	2.0	+0.67
3BF	58	36.2	63.8	6.0	3.2	+0.56
3C1	48	85.7	14.3	2.9	1.7	+0.29
3DE	26	80.2	19.8	3.1	2.2	+0.43
3E	16	72.3	27.7	3.7	2.6	+0.65
3G	31	52.8	47.2	5.0	2.9	+0.71
3H	34	17.1	82.9	6.6	3.2	+0.41
3I	32	89.5	10.5	2.9	0.9	+0.12
HEL 6	132	13.2	86.8	6.3	2.8	+0.60

a - sand < 1 mm; see text
b - graphic mean M_z
c - graphic standard deviation σ_I
d - inclusive graphic skewness Sk_I

TABLE 15. SEDIMENT TEXTURE

Station	Sorting	Skewness
DUT 0A	very poorly sorted	strongly fine skewed
DUT 0B	well sorted	near symmetrical
DUT 02A	very poorly sorted	fine skewed
1A	moderately sorted	near symmetrical
HEL 3	very poorly sorted	strongly fine skewed
HEL 3A	poorly sorted	strongly fine skewed
3B	very poorly sorted	strongly fine skewed
3AG	poorly sorted	strongly fine skewed
3BF	very poorly sorted	strongly fine skewed
3C1	poorly sorted	fine skewed
3DE	very poorly sorted	strongly fine skewed
3E	very poorly sorted	strongly fine skewed
3G	very poorly sorted	strongly fine skewed
3H	very poorly sorted	strongly fine skewed
3I	moderately sorted	fine skewed
HEL 6	very poorly sorted	strongly fine skewed

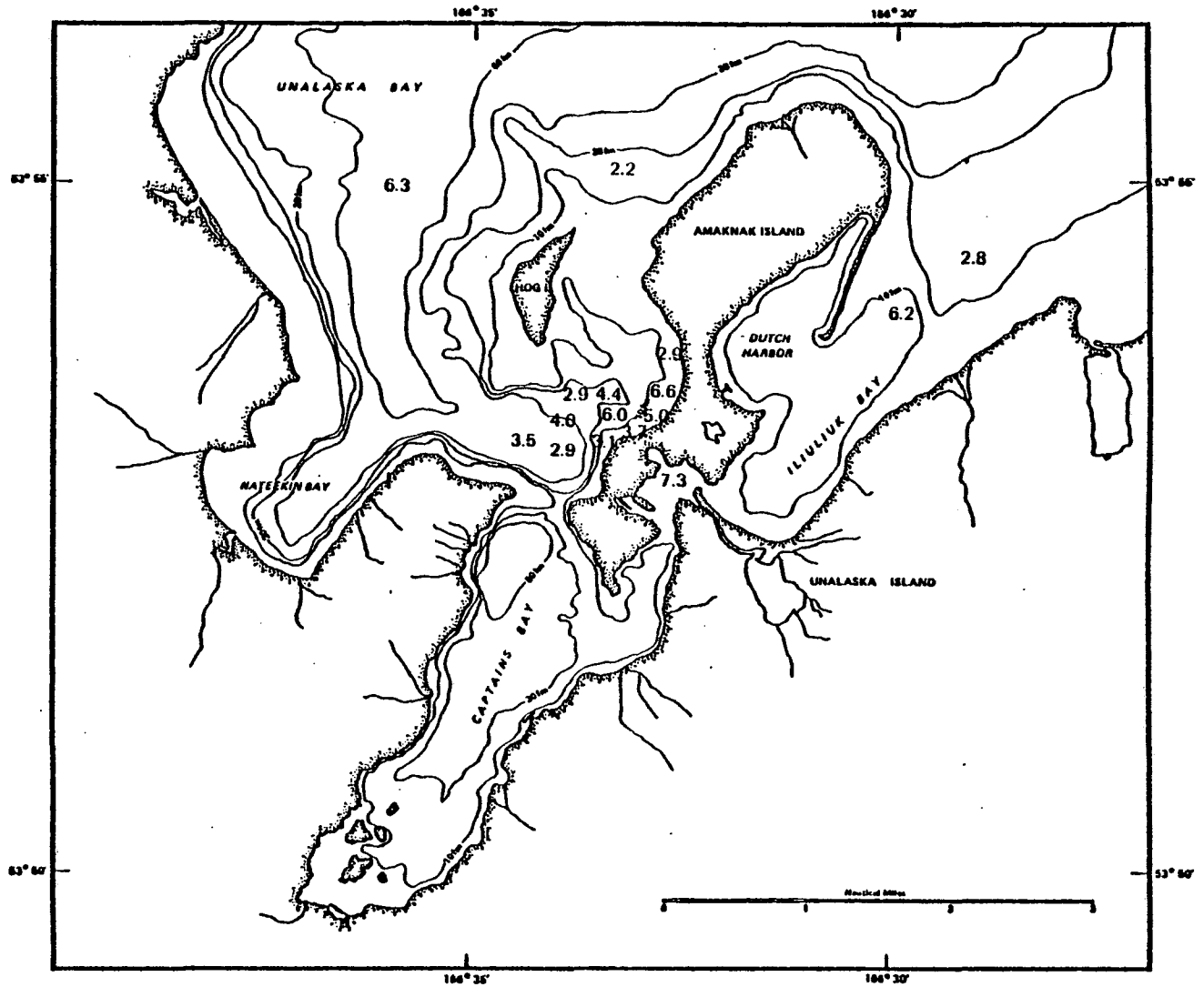


Figure 52. Grain size mean distributions of surficial sediments < 1mm (Ø).

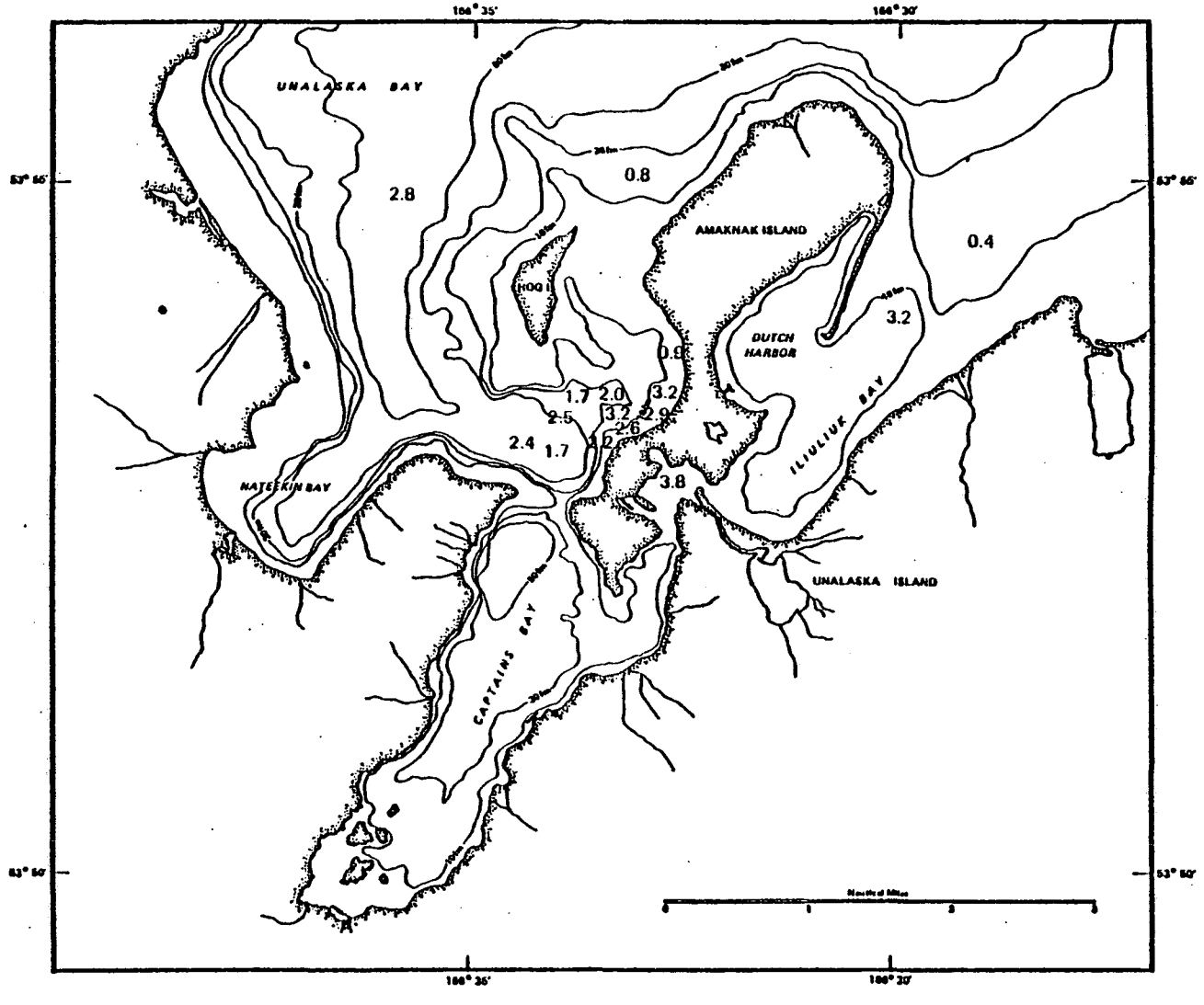


Figure 53. Grain size standard deviation (sorting) distributions of surficial sediments < 1mm (Ø).

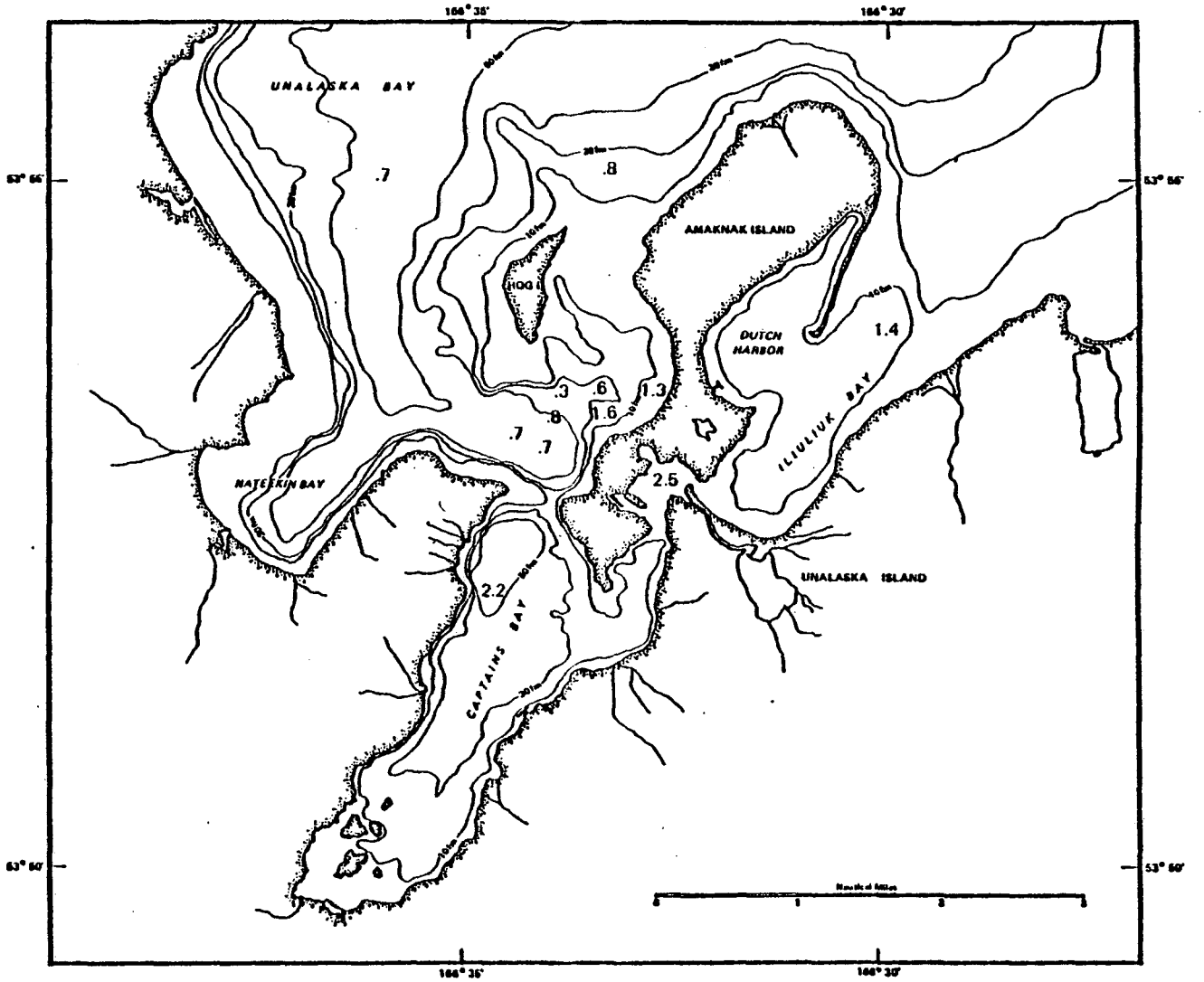


Figure 54. Organic carbon contents of surficial sediment (%).

this time. (The effects of tidal mixing are totally unknown.) No winter observations are presently available so the sequence of post-summer flushing events is not known.

Water Chemistry

At this time of year (June), oxygen values at the bottom of Captains Bay are somewhat lower than on the corresponding shelf, but not markedly so. Within Dutch Harbor proper, bottom oxygen is < 5 ml/ℓ. At this level benthic epifauna and pelagic organisms should not be adversely affected, neither should nitrate reduction occur in the column. However as oxygen consumption continues through the summer without basin water replenishment, near bottom anoxic conditions result: Colonell and Reeburgh (*op cit*) demonstrate this for the previous October. It should not be an impossible task to compute an order of magnitude carbon mass balance model, assuming stagnant conditions, to determine the relative importance of dumped carbon waste to natural run-off and column productivity in this scheme, but such data are not available to us at present.

Given the June oxygen distributions, there was no likelihood of other than a localized occurrence of water column sulfide, and such proved to be the case. The stations at which analyses for dissolved sulfide were made are shown in Table 13. Sulfide was present at one station only: 3DE showed 12.4 µg at/ℓ at 26 m and 4.4 µg at/ℓ five meters higher. (Fig. 55 is intended to show the approximate locations of this station in relation to the other parameters presented, but the represented bottom configuration is, as noted above, somewhat misleading here and the station is not quite on the profile line.) This locality is adjacent to a major processing waste outfall site (Universal Seafood Outfall). Although clearly an isolated phenomenon, such anoxia demonstrates that the carbon waste here is not rapidly dispersed and that mixing is slow in relation to the rate of production and release of sulfide at the sediment surface.

NO_3-N is depleted at the surface through this area and is, in fact, essentially absent at the surface of Dutch Harbor. At the time of year sampled (June) it may be assumed that the spring bloom has come and gone. Decomposition products are present at depth but the marked gradients in all the nitrogen species well demonstrate the stable stratification of the water. The

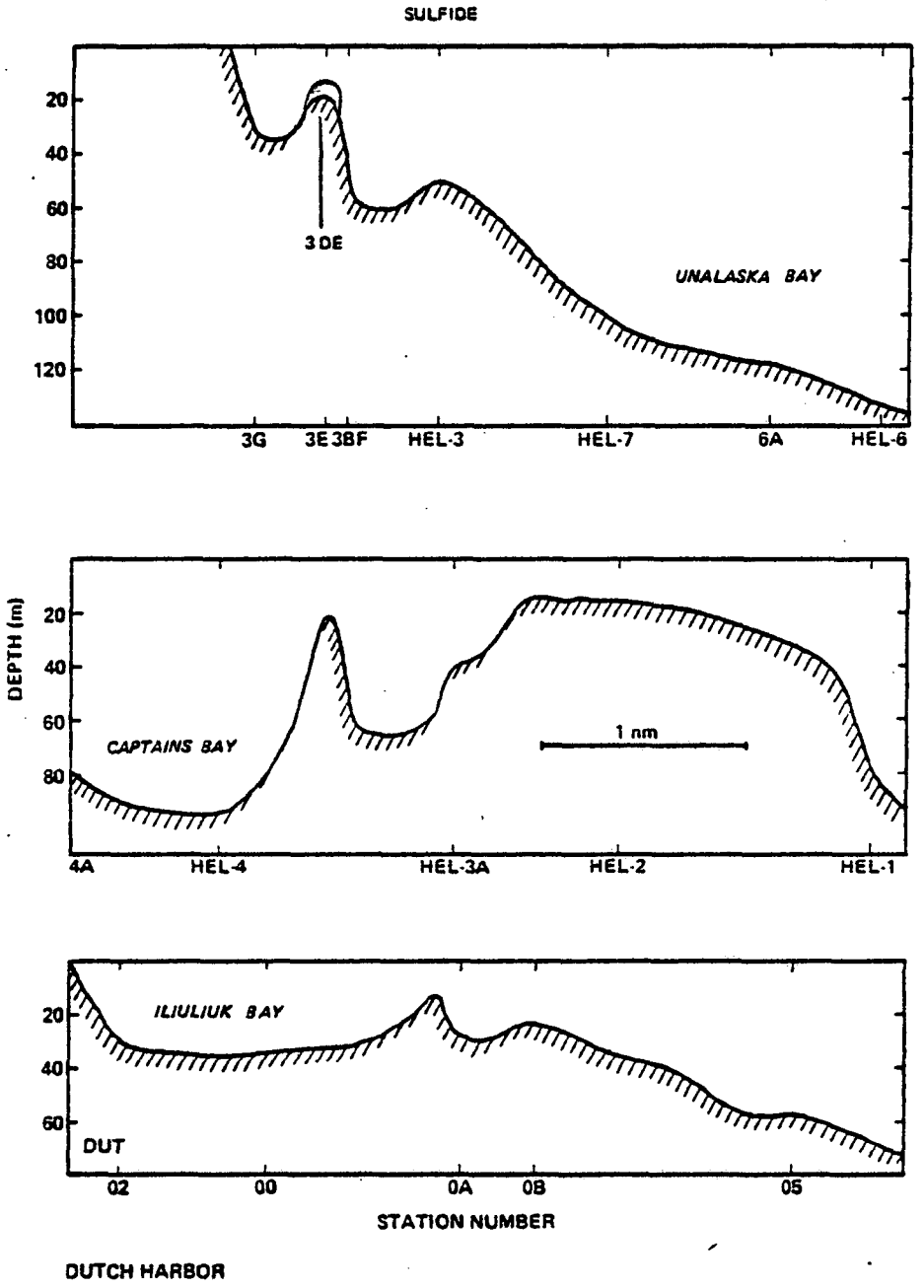


Figure 55. Longitudinal sulfide distribution.

phosphate and ammonia distributions shown in Figures 35 and 36 are of some interest. As in all shallow water, high organic lead regions, it may be presumed that major regeneration occurs at the sediment although, in general, the site of decomposition makes no difference to the mass balance. Table 16 attempts to compare the relative distribution of inorganic nitrogen and phosphate in the surface waters of "shelf stations" (HEL-1, -3, -6) and adjacent to the bottom within Captains Bay and Dutch Harbor (see Figs. 43 and 49). Data from June 1967 (Brickell and Goering, 1970), October 1977 (Colonell and Reeburgh, *op cit*) and from June 1978 (this study) are given. A N/P ratio of around 16 conforms with the classic Redfield expression. (We have combined ammonia, NO_3-N as being simple additive regeneration-nitrification products.) The low ratio values for the near bottom waters of Dutch Harbor may signify a better fit by an "anoxic model" having N/P closer to 8 as advocated by Suess (1976). However we favor enhanced bottom water concentrations of phosphate as signalling a significant flux from the sediments which are anoxic to very close to the benthic boundary. This phenomenon, basically related to the mobility of ferrous ions, has been discussed by many people (e.g. Taft and Taylor, 1976). Regardless of the nutrient sources these waters, once mixed back into the upper layers, must support considerable productivity. Given the overall dissolved oxygen concentrations at this time of year, the significant NO_2-N concentrations (Fig. 37) may be taken as an intermediary nitrification product rather than an indication of nitrate reduction in the column.

The June 1978 data for nutrients and oxygen are remarkably similar to values obtained for June ten years earlier by Brickell and Goering (1970). Changing seafood waste dispersal patterns over this decade are not known to us in detail, but it seems likely that, within Dutch Harbor proper, depletion of oxygen in the basin through the summer, leading to near-bottom fall anoxic conditions, is a natural annual phenomenon. Needless to say, any additional anthropogenic organic loading must increase the oxygen consumption rate and result in longer periods of anoxic water prior to the winter flushing.

TABLE 16. SUMMER DISTRIBUTION OF NUTRIENTS IN SURFACE SHELF WATERS (STATIONS HEL-1, -3, and -6) AND BOTTOM BASIN WATERS (STATIONS HEL-4 AND DUT-02)

µg at/ℓ; oxygen: ml/ℓ

A. June 1967 (Brickell and Goering, 1968)

Station	HEL-4	DUT-02
Depth	Bottom	Bottom
NH_3-N	1.6	23.8
NO_3-N	20.9	9.2
Total N	22.1	33.3
PO_4-P	2.5	5.0
N/P	9.0	7.8
Oxygen	5.6	4.3

B. October 1977 (Colonell and Reeburgh, 1978)

Station	HEL-1	HEL-6	HEL-4	DUT-02
Depth	Surface	Surface	Bottom	Bottom
NH_3-N	1.2	1.5	4.5	20.0
NO_3-N	12.5	13.0	35.8	1.0
Total N	14.1	14.9	40.6	21.1
PO_4-P	1.2	1.2	3.3	6.0
N/P	12.0	12.1	12.3	3.5
Oxygen	-	-	2.5	∿ 0

A. June 1978 (This study)

Station	HEL-1	HEL-3	HEL-4	DUT-02
Depth	Surface	Surface	Bottom	Bottom
NH_3-N	2.6	2.2	9.4	24.6
NO_3-N	1.4	0.6	19.0	1.6
Total	4.3	3.0	28.9	26.8
PO_4-P	0.3	0.2	2.6	3.4
N/P	14.4	12.9	11.1	7.8
Oxygen	-	-	6.1	4.7

Geology

Sediment from within the Dutch Harbor-Iliuliuk Bay basin and also from the floor of Unalaska Bay, is fine-grain (mean > 6 ϕ; Fig. 52) and poorly sorted (Fig. 53). Only small bottom currents would be expected at the benthic boundary within the confined basins and the sediment character is that of a "quiet" environment. We have insufficient information to consider the near-bottom conditons in Unalaska Bay. On the shelf seaward of Amaknak Island (Stations HEL-1 and DUT-OB), the sedimentology indicates an active, "dynamic" environment. Here the grain-size mean falls in the sand range (2.2-2.8 ϕ); winnowing of the finer grained material has resulted in a well-sorted and coarse grained sediment cover.

The sediment character within the Hog-Amaknak Island channel is more complex. The shallowest portion is apparently subject to considerable bottom current action and is sedimentologically akin to the northern (seaward) shelf region. Stations 2A, 2B and 3J had rocky substrates which could not be easily sampled using the van Veen grab. It was in this region - in the vicinity of Station HEL-2 - that Colonell and Reeburgh (1978) obtained direct, near-bottom current measurements over these periods in September-October of 1977. The mean N-S Vector component range was found to be -1.18 - 2.83 cm/sec at approximately 1.5 m above the channel floor. Here negative velocities indicate currents from the south. These authors have also shown that wind and current directions closely correlate - i.e. that these currents are wind-dominated - and that the prevailing winds are northerly. Station 3I - close to the shore of Amaknak Island - also shows similar evidence of a dynamic environment: some 90% well-sorted, sand-sized material.

The group of stations southward of this saddle between the two islands - i.e. physiographically at the head of the Unalaska Bay indentation - have a markedly different sediment character. Here finer grained, poorly sorted sediment predominates and the organic carbon content is generally higher. Processing waste is accumulating at the shore-side outfall sites and - as noted in Section 8 - macroalgal debris appears to be accumulating in the vicinity of Stations 3AG, 3H, 3BF and 3D.

SECTION 6
BENTHIC BIOLOGICAL STUDIES

INTRODUCTION

The activities connected with seafood processing present potential dangers to the marine environment (see Olson and Burgess, 1967, for general discussion of marine pollution problems). Adverse effects to an environment cannot be assessed, or even predicted, unless background data are recorded prior to and during industrial operations.

Insufficient long-term information about an environment, and the basic biology and recruitment of species in that environment, can lead to erroneous interpretations of changes in types and density of species that might occur if the area becomes altered (see Nelson-Smith, 1973; Pearson, 1971, 1972; Rosenberg 1973; Pearson and Rosenberg, 1976; Rhoads *et al.*, 1978 for general discussions on benthic biological investigations in disturbed marine areas, also see Sect. 1 of the present report for examples of useful environmental data). Populations of marine species fluctuate over a time span of a few to 30 years (Lewis, 1970). Such fluctuations are typically unexplainable because of the absence of long-term data on physical and chemical environmental parameters in association with biological information on the species involved (Lewis, 1970). Additionally, the presence or absence of benthic species can be, in part, determined by the nature of the substrate. Specifically, the close relationships of benthic faunal assemblages to particular sediment characteristics have been shown for some areas (Jones, 1950; Sanders, 1958). Furthermore, the ability of larval forms of benthic species to select or reject a substratum on the basis of its physical and chemical properties has been determined experimentally (Wilson, 1953). Thus, changes in the substrate character may be reflected by changes in resident fauna. However, such changes can only be properly interpreted if the biota and associated substrata are investigated over a reasonable time base prior to and after disturbance of the particular area (see Rosenberg, 1973 and Pearson, 1972, 1975, for examples of such an approach for monitoring areas affected by industrial activity).

Benthic organisms (primarily the infauna but also sessile and slow-moving epifauna) are particularly useful as indicator species for a disturbed area because they tend to remain in place, typically react to long-range environmental changes, and by their presence, generally reflect the nature of the substratum. Consequently, the organisms of the infaunal benthos have frequently been chosen to monitor long-term pollution effects, and are believed to reflect the biological health of a marine area (see Pearson, 1971, 1972, 1975; and Rosenberg, 1973 for discussion on long-term usage of benthic organisms for monitoring pollution).

Experience in marine benthic areas influenced by industrial activity in England (Smith, 1968), Scotland (Pearson, 1972, 1975), Sweden (Rosenberg, 1976), and California (Straughan, 1971) suggests that at the completion of an initial exploratory study, selected stations should be examined regularly on a long-term basis to determine any changes in species content, diversity, abundance and biomass. Such long-term data acquisition should make it possible to differentiate between normal ecosystem variation and pollutant-induced biological alteration.

The benthic macrofauna of the southeastern Bering Sea shelf is relatively well known taxonomically, and some data on distribution, abundance, and feeding mechanisms are available as well (Feder *et al.*, 1976; Feder and Mueller, in press). The relationship of specific infaunal feeding types to certain substrate conditions also has limited documentation (Feder, unpub. OCSEAP data). However, detailed information on the temporal and spatial variability of the benthic fauna is sparse. Most of the benthic species in the vicinity of Dutch Harbor are the same as those reported by Feder *et al.* (1976) for the inshore shelf areas of the southeastern Bering Sea; thus, some comparisons are possible. Some of these species may be affected by processing activities. Thus, a further understanding of these species and their interactions with each other and various aspects of the abiotic features of their environment is essential to the development of environmental predictive capabilities for the Dutch Harbor area. The benthic biological survey reported here emphasized a quantitative inventory of species as part of a preliminary examination of the biological components of the bottom likely to be impacted by processing operations.

The investigation described in this report was designed (1) to provide preliminary biological information for the nearshore invertebrate benthos in Dutch Harbor and vicinity in the summer, and in association with hydrographic, water chemistry, and sedimentological investigations, (2) to establish a base suitable for development of a monitoring program in the area. The study examined the distribution and relative density of both infaunal and slow-moving epifaunal species.

RESULTS

General

Thirty-two stations were occupied with a van Veen grab. The material was returned to the University of Alaska where seventeen of the stations were processed and used in the numerical analyses reported below. Qualitative data from all other stations were used for interpretation of conditions in the study area. Twenty of the stations were monitored with an underwater television camera. All data are compiled in Appendices A-D.

Analysis of Stations from Field and Television Observations (see Figs. 2, 4; Appendices A-D for detailed data)

1. Dutch Harbor-Iliuliuk Bay: Stations DUT-00, DUT-0A, DUT-02, DUT-01A.
   The sediment at these stations was fine, gray to black in color with a strong sulfide odor noted. Few species were present; the polychaete *Nephtys cornuta* was dominant at all stations. Station DUT-0A had four species, DUT-02 had two species, DUT-00 had two species (only one infaunal component), and DUT-01A had four species present. DUT-0A was close to a sill (see Fig. 2); the sediment was lighter in color and the sulfide odor was less noticeable than at the other three stations.

2. Iliuliuk Harbor: Station 02A
   The sediment was fine, light gray in color with a moderate sulfide odor. Three species of polychaetes were present in low numbers.

3. Outer Dutch Harbor: Station DUT-0B
   Located seaward of a sill. Sediment was clean sand; no organic

odor detectable. Apparent burrowing activity of infauna visible as mounds on bottom. Many species present including polychaetes, clams, snails, amphipods, and sea urchins.

4. Stations Adjacent to Processing Plant Outfalls: 3E, 3DE, 3F, 3G, 3H, 3D, 3BF, 3AG, HEL-3A

The sample taken at Station 3E (located directly over the Universal Seafood outfall) was composed exclusively of processing wastes (primarily crustacean carapace fragments) in various stages of decomposi- invertebrates were present. At Station 3DE, located near the Universal Seafood outfall, the bottom was also composed of decaying processing wastes; a strong sulfide odor was detectable. No living organisms were present. The surface of the grab material at both of these stations was covered with several centimeters of fresh processing wastes layered over the major mass of old, blackened shellfish processing wastes.

The sediment at Station 3F, off the Vita Outfall, was sandy and clean with an organic odor; no sulfide odor detected. Polychaetous annelids were common; a few protobranch clams were present. The effluent was apparently discharging onshore through a break in the pipe some 100-150 meters from the station.

Station 3G, off the Pan Alaska-Whitney Fidalgo outfall, was composed of sandy, black sediment with a relatively strong sulfide odor. Small polychaetes and a few species of clams were common. Shrimp, probably *Pandalus hypsinotus* (coonstripe) were observed in the water column.

Station 3H - the bottom was primarily a black, sandy silt with a strong sulfide odor. Decaying macroalgae were present in four of the grabs; the fifth grab was sandy with no sulfide odor detectable.

Station 3D, approximately 300 m from the Universal outfall the tan sediment had organic odor; no sulfide detectable in three of the replicates. Two additional grabs had a minor sulfide odor, but fauna present were similar to that found in the first three grabs. Blackened plant material in latter two grabs. A snow crab (*Chionoecetes* sp.) was collected in one of the grabs that had a sulfide

odor. All grabs were filled with worm tubes; polychaetes were common; also present were a few *Macoma* spp., several *Nuculana fossa* (a protobranch clam), and several small snails.

Stations 3AG, 3BF, HEL-3A - Located in the trough between Hog and Amaknak Islands approximately 250-350 m from the Universal Seafood outfall. Sediment oxic with mild to strong organic odor; no sulfide detectable. A variety of infaunal species present. Plant debris found at 3AG and 3BF. Large numbers of shrimp (probably *Pandalus hypsinotus*) present at 3AG.

5. Stations Adjacent to or on the Shallow Substrate Between Hog and Amaknak Island: 2A, 2B, HEL 2, 3I

The bottom consisted of pebbles, gravel, and rock with occasional presence of sand; epifaunal organisms were common on gravel and rocks. Pandalid shrimps, *Pandalus hypsinotus* were common at Station 3I. Greatly increased number of species, both infaunal and epifaunal, occurred at Station 3I.

6. North of Hog and Amaknak Islands: Station 1A, HEL 1, HEL 6

The sediment at all of the stations was clean, generally with a mild organic odor (no sulfide odor). A diverse and occasionally rich fauna was collected at the three stations, and consisted of polychaetes, clams, some snails, some brittle stars, and a few miscellaneous species. No processing wastes were present.

7. Transect Across Unalaska Bay Extending from Area South of Hog Island to Vicinity of Nateekin Bay: Stations 7A, HEL 7, 7B

The sediments were silty or sandy silt with variable amounts of organic material present; terrestrial plant debris was abundant at Station 7B. Polychaetes and clams were common at all stations on the transect.

8. Captains Bay: Stations HEL 4 and 4A

Silty sediment with mild organic odor (no sulfide). Polychaetes common; a few clams noted. This station group is separated by a sill from Iliuliuk Bay and Unalaska Bay. No processing wastes were present.

Numerical Analysis

A cluster analysis was run on data collected at the following stations (Figs. 2, 4; see Appendix Tables A-D for species composition of station groups):

DUT 00	DUT 01A	HEL 3
DUT 0A	DUT 02	HEL 3A
DUT 0B	3BF	HEL 7
3H	3B	3G
3C	3F	3I

Stations HEL 3E and HEL 3DE were not included in the analysis, because animals were not present at these stations. Station DUT 02A was also excluded because only one grab was collected (Appendix C), and the data could not be considered to be quantitative.

A normal cluster analysis using natural logarithm transformed data delineated seven (7) station groups at the 43% similarity level (Fig. 56; Table 17). Four of the "groups" formed, Station Groups 2, 5, 6, and 7, were composed of single stations. An inverse cluster analysis delineated 41 species groups at the 60% similarity level (Table 18). A two-way coincidence table (Table 19) comparing the station groups formed by the normal cluster analysis and species groups formed by an inverse cluster analysis was utilized to determine the species which characterized each of the station groups. Station Group 1 was composed of stations inside the sill in Dutch Harbor (Fig. 4). Stations in Station Group 1 were characterized by a polychaetous annelid of the family Nephtyidae, *Nephtys cornuta*; these stations had a very low species richness and diversity (Table 20). Station Group 2 was composed of Station 3H located in Unalaska Bay on the west shore of Amaknak Island. *Nephtys cornuta* was also the dominant organism in this station and *Tharyx* sp., *Prionospio malmgreni*, *Axinopsida serricata*, were also common at this station. The diversity and species richness in Station 3H was slightly higher than that of stations in Station Group 1. Station Group 3 was composed of 3 offshore stations (3BF, 3C and HEL 7). These stations were characterized by Species Groups 14 through 19, and *Nephtys cornuta* (Species Group 21). The diversity, species richness and abundance of the fauna of stations in this group (Group 3) was higher than that of Station Groups 1 and 2

*Note - text continued on page 108

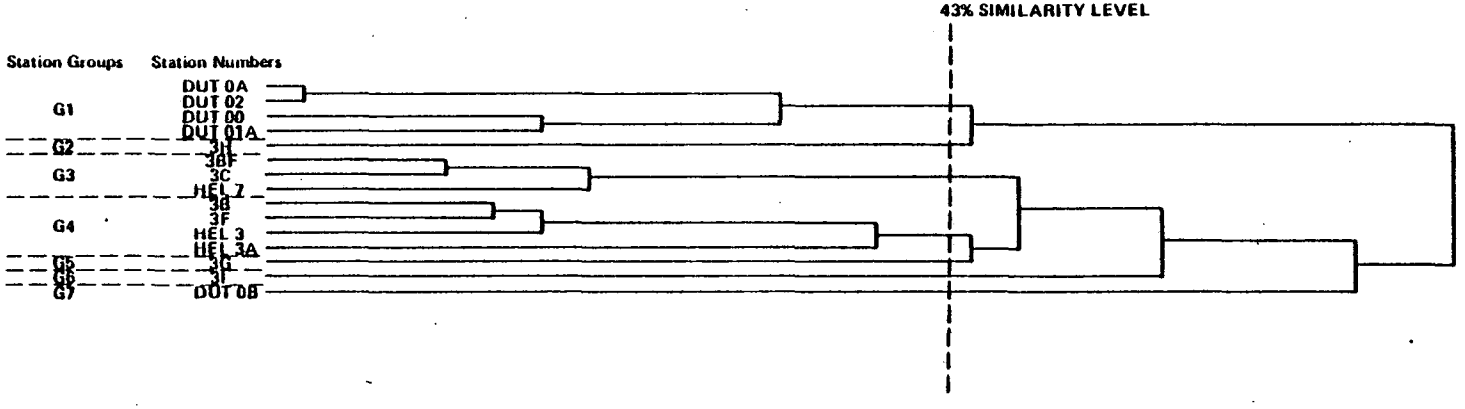


Figure 56. Dendrogram produced by cluster analysis using *ln* transformed numbers of individuals per m^2.

TABLE 17. STATION GROUPS FORMED BY CLUSTER ANALYSIS OF *ln* TRANSFORMED ABUNDANCE DATA

Station Group	Station Components	Notes
1	DUT 0A DUT 02 DUT 00 DUT 01A	Very low diversity and species richness. High dominance. Characterized by *Nephtys cornuta*
2	3H	Slight increase in diversity and species richness. Characterized by *Nephtys cornuta, Tharyx* sp., *Prionospio malmgreni* and *Axinopsida serricata.*
3	3BF 3C HEL 7	Increased diversity and species richness over the above Station Groups. Characterized by Species Groups[1] 14-19, 21.
4	3B 3F HEL 3 HEL 3A	Continued increase in diversity and species richness. Characterized by Species Groups 19-26.
5	3G	Reduced diversity and species richness. Characterized by Species Groups 19, 25, 26.
6	3I	Highest diversity and species richness. Characterized by Species Groups 15, 19-22, 28-34.
7	DUT 0B	Second highest diversity and species richness of all of the stations occupied. Characterized by Species Groups 1, 2, 3, 4, 5, 8, 9, 10, 19.

[1]Based on *ln* transformed data. See Table 19.

TABLE 18. SPECIES GROUPS FORMED BY AN INVERSE CLUSTER ANALYSIS OF *ln* TRANSFORMED ABUNDANCE DATA (#/m^2)

Species Group 1

Monoculodes sp.
Echinarachnius parma
Hesperonoe complanata
Thracia beringi
Retusa sp.
Sigalion sp.
Tellina lutea
Lyonsia sp.
Thracia sp.
Diplodonta aleutica

Species Group 2

Crenella dessicata
Allocentrotus fragilis
Psephidia lordi
Ampelisca macrocephala
Sthenelais sp.
Lumbrineris bicirrata
Mysella sp.
Macoma moesta moesta
Orchomene sp.
Oenopota sp.
Spisula polynyma
Hippomedon sp.
Paraphoxus sp.
Magelona longicornis
Cingula sp.
Eudorellopsis deformis

Species Group 3

Nephtys ferruginea
Spisula sp.

Species Group 4

Solariella obscura

Species Group 5

Spiophanes bombyx

Species Group 6

Spiophanes cirrata
Praxillella praetermissa

(continued)

TABLE 18 (continued)

Species Group 8

Tindaria sp.

Species Group 9

Harmothoe imbricata
Glycinde armigera
Solariella sp.

Species Group 10

Scoloplos fuliginosa
Prionospio sp.

Species Group 11

Golfingia margaritacea
Clinocardium ciliatum

Species Group 12

Brada inhabilis
Terebellides stroemii
Goniada maculata
Haploscoloplos sp.

Species Group 13

Onuphis iridescens
Melinna cristata

Species Group 14

Prionospio cirrifera
Chaetozone setosa
Eteone longa
Pholoe minuta

Species Group 15

Polynoe gracilis

Species Group 16

Aricidea jeffreysii

Species Group 17

Gyptis brevipalpa
Nephtys punctata

Species Group 18

Macoma brota

(continued)

TABLE 18 (continued)

Species Group 19

Scalibregma inflatum
Heteromastus filiformis
Lumbrineris luti
Prionospio malmgreni
Axinopsida serricata
Glycinde picta
Haploscoloplos elongatus

Species Group 20

Ammotrypane aulogaster

Species Group 21

Nephtys cornuta

Species Group 22

Glycera capitata
Lysippe labiata

Species Group 23

Spio filicornis
Ampharete arctica
Notomastus laeriatus
Capitella capitata
Nucula tenuis
Notomastus sp.
Axiothella catenata
Magelona pacifica
Chone cincta
Nuculana fossa
Macoma calcarea

Species Group 24

Spiophanes kroyeri

Species Group 25

Thyasira flexuosa

Species Group 26

Tharyx sp.

(continued)

TABLE 18 (continued)

Species Group 27

Acmaea sp.
Pinnixa sp.
Modiolus modiolus

Species Group 28

Pagurus sp.

Species Group 29

Paleanotus bellis
Exogone gemmifera
Oregonia gracilis
Phascolion strombi
Eunoe depressa
Trophonopsis sp.
Siphonaria sp.
*Collisella*sp.
Moelleria quadrai
Serpula sp.
Pododesmus macrochisma
Nereis sp.
Polydora ciliata
Pionosyllis gigantea
Exogone molesta
Harmothoe extenuata

Species Group 30

Idanthyrsus armatus
Balanus crenatus

Species Group 31

Anaitides sp.
Laonome kroyeri
Eunoe oerstedi
Eteone sp.
Polydora limicola
Owenia fusiformis
Ampharete sp.
Modiolus sp.
Chitinopoma groenlandica
Peisidice aspera
Pectinaria granulata
Hiatella sp.
Cryptobranchia concentrica
Spirorbis semidentatus

(continued)

TABLE 18 (continued)

Species Group 32

Mya sp.
Balanus sp.

Species Group 33

Myriochele heeri

Species Group 34

Clinocardium sp.

Species Group 35

Solariella sp.

Species Group 36

Heteromastus giganteus
Serripes groenlandicus
Syllis sp.
Spiophanes sp.

Species Group 37

Laonice sp.
Macoma carlottensis

Species Group 38

Cossura longocirrata
Yoldia thraciaeformis

Species Group 39

Antinoella sarsi

Species Group 40

Nuculana sp.
Yoldiella sp.

Species Group 41

Diplodonta sp.
Pandalus hypsinotus

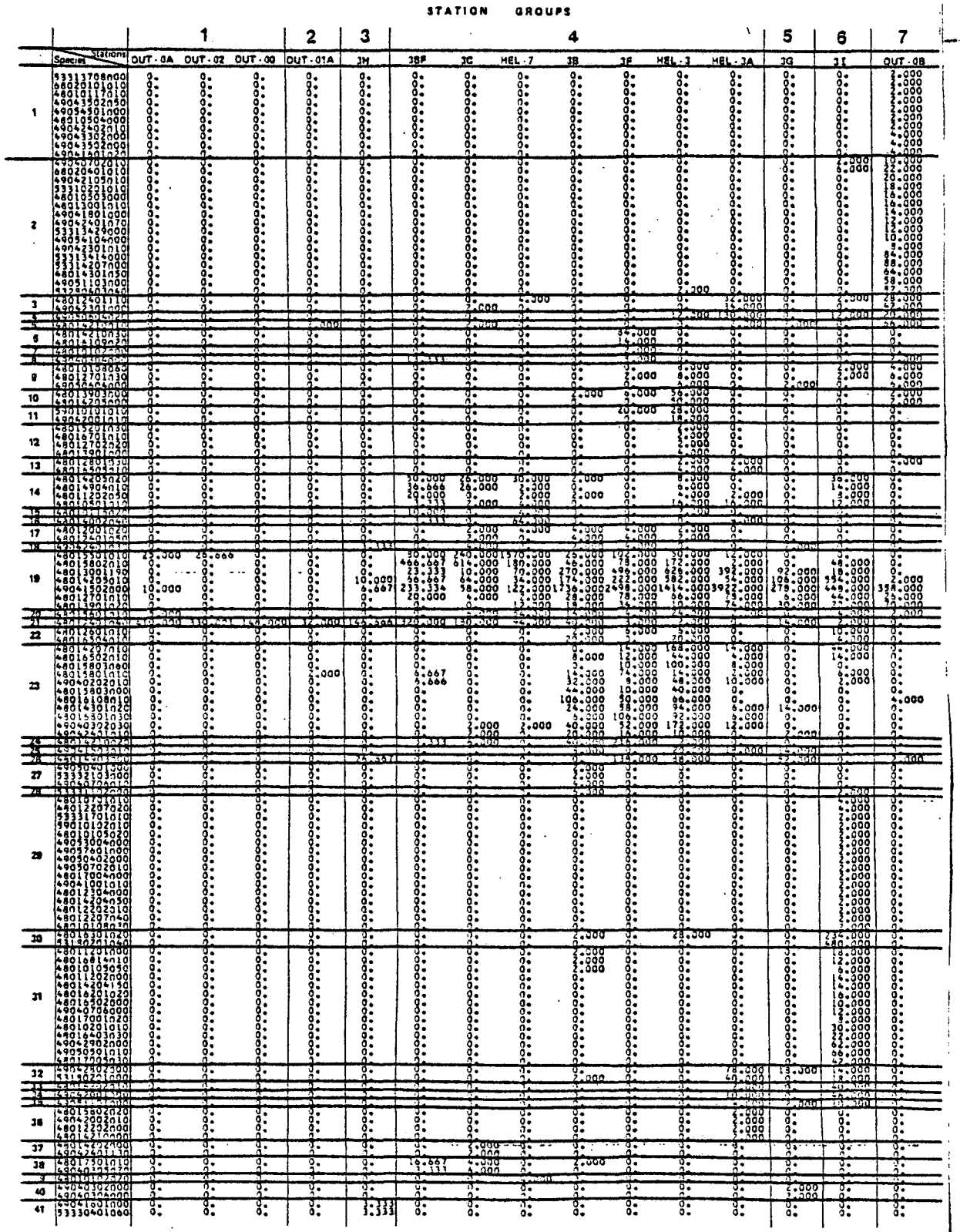


Table 19. Station group - Species group coincidence table formed by cluster analysis of transformed abundance data.

TABLE 20. DIVERSITY (SIMPSON, SHANNON, BRILLOUIN) AND SPECIES RICHNESS OF STATION GROUPS FORMED BY A CLUSTER ANALYSIS OF *ln* TRANSFORMED DATA

Station Group 1	No. Ind/m^2	No. Species	Simpson Diversity	Brillouin Diversity	Shannon Diversity	Brillouin Evenness	Species Richness
DUT 00	150	2	0.97	0.06	0.07	0.09	0.19
DUT 0A	450	4	0.83	0.39	0.41	0.25	0.65
DUT 01A	38	4	0.37	1.01	1.17	0.71	1.09
DUT 02	357	2	0.86	0.25	0.27	0.37	0.17
$\bar{x}$	249	4	0.76	0.43	0.48	0.36	0.53
Station Group 2							
3H	213	8	0.49	1.07	1.14	0.53	1.30
Station Group 3							
3BF	1630	26	0.16	2.14	2.18	0.67	3.38
3C	1616	38	0.19	2.17	2.21	0.60	5.00
HEL 7	2338	32	0.21	2.06	2.10	0.60	3.99
$\bar{x}$	1861	32	0.19	2.12	2.16	0.62	4.12
Station Group 4							
3B	2902	50	0.37	1.82	1.85	0.47	6.15
3F	4556	46	0.32	1.95	1.98	0.51	5.34
HEL 3	4582	69	0.13	2.75	2.78	0.65	8.06
HEL 3A	5242	50	0.57	1.24	1.26	0.31	5.72
$\bar{x}$	4321	54	0.35	1.94	1.97	0.49	6.32
Station Group 5							
3G	702	26	0.21	2.04	2.11	0.64	3.82
Station Group 6							
3I	2946	85	0.10	2.97	3.03	0.68	10.51
Station Group 7							
DUT 0B	2184	59	0.13	2.67	2.72	0.67	7.54

(Tables 17, 20), Station Group 4 was composed of 4 stations (3B, HEL 3A, HEL 3, 3C) south of Hog Island and Station 3F adjacent to Amaknak Island. These stations were characterized by Species Groups 17, 19, 20, 21, 22, 23, 24, 25 and 26 *Axinopsida serricata* was the dominant organism in these five stations, and it ranged in abundance from 1414 individuals/m^2 in Station HEL 3 to 3922 ind/m^2 in Station HEL 3A. The abundance and species richness of the fauna in the stations of Station Group 4 was higher than that in Station Groups 1-3. However, the diversity in some of the stations in Group 4 was lower than that of stations in Group 3 and 5, because the high abundance of *Axinopsida serricata* in several Group 4 stations reduced the evenness component of the diversity index, thus reducing the diversity.

Station Group 5 was composed of one station, 3G, close to Amaknak Island, and was composed of three species groups (19, 25, 26, 32). The dominant species at this station were the polychaetes *Lumbrineris luti, Prionospio malmgreni* and *Tharyx* sp., and the clam *Axinopsida serricata*. The abundance and species richness of Station 3G was lower than that of Station Groups 3 and 4 while the diversity, as noted above, was higher than that of Station Group 4; the abundance, diversity and species richness was higher than that of Station Groups 1 and 2.

Station Group 6 was composed of one station, 3I, close to Amaknak Island adjacent to a shallow sill. Station 3I was composed of Species Groups 15, 19, 20, 21, 22, 28, 29, 30, 31, 32, 33, 34. The most common organisms at this station were *Prionospio malmgreni, Spio filicornis*, Cirratulidae, *Heteromastus filiformis, Myriochele heeri, Idanthyrsus armatus, Spirorbis senidentatus, Axinopsida serricata, Macoma* sp., *Hiatella* sp., *Cryptobranchia concentrica, Balanus crenatus*, Amphipoda. The diversity and species richness was the highest of all station groups.

Station Group 7 was composed of one station, DUT 0B, located just outside of Iliuliuk Bay and separated from the Bay by a shallow sill. Station DUT 0B comprised Species Groups 1, 2, 3, 4, 5, 8, 9, 10, 19. The most common organisms were Foraminifera, *Haploscoloplos elongatus, Spiophanes bombyx, Magelona longicornis*, Cirratulidae, *Axinopsida serricata, Spisula* sp., *Cingula* sp., *Eudorellopsis deformis*, Amphipoda, Strongylocentrotidae. This station had the second highest diversity and species richness of all the stations occupied.

Station groups formed by a cluster analysis of untransformed abundance data are presented in Figure 57 and Table 21.

DISCUSSION

Sampling Efficiency of the van Veen Grab

The van Veen grab functioned effectively in the fine sediments covering most of the sampling area, and typically delivered 15-19 liters of sediment. Penetration was reduced in sites with considerable concentrations of sand or gravel. The surface of all samples, examined through the top door of the grab, was relatively undisturbed as evidenced by the smooth detrital cover (see Feder *et al.*, 1973, for further discussion).

Analysis Based on Field and Television Observation (see Appendices A-D; Table 22 for detailed data; Fig. 2)

The number of infaunal species present in the Dutch Harbor-Iliuliuk Bay basin is very much reduced with one polychaete worm, *Nephtys cornuta*, dominant at all of the stations (DUT 00, 0A, 02 01A, 02A). The paucity of the fauna at stations in this region appears to reflect the stressful aspects of the reducing conditions present throughout the basin. Sulfide concentrations, as determined qualitatively by sight and odor of sediment samples on shipboard, were greatest at Station DUT 01A, a site located within the old shellfish disposal area of several years ago. The few infaunal organisms present here were primarily deposit-feeding polychaetes. Sulfide deposition was also extensive at DUT 00 located in the approximate center of Iliuliuk Bay, and only one infaunal species, the deposit-feeding polychaete *N. cornuta*, was found here. Sulfide concentration was also high at DUT 02, inner Iliuliuk Bay, with concomitant reduced number of infaunal species present - two deposit-feeding polychaetes. DUT 02A, a station adjacent to most of the processing plants in Iliuliuk Harbor (Fig. 1), also contained a reduced number of species (three species) of polychaetes: two deposit feeders, one suspension feeder. Sulfide concentration appeared to be less here than that at DUT 01A and DUT 00. Station DUT 0A, located in outer Iliuliuk Bay, adjacent to a shallow sill separating the bay from the Bering Sea, is influenced by its proximity to

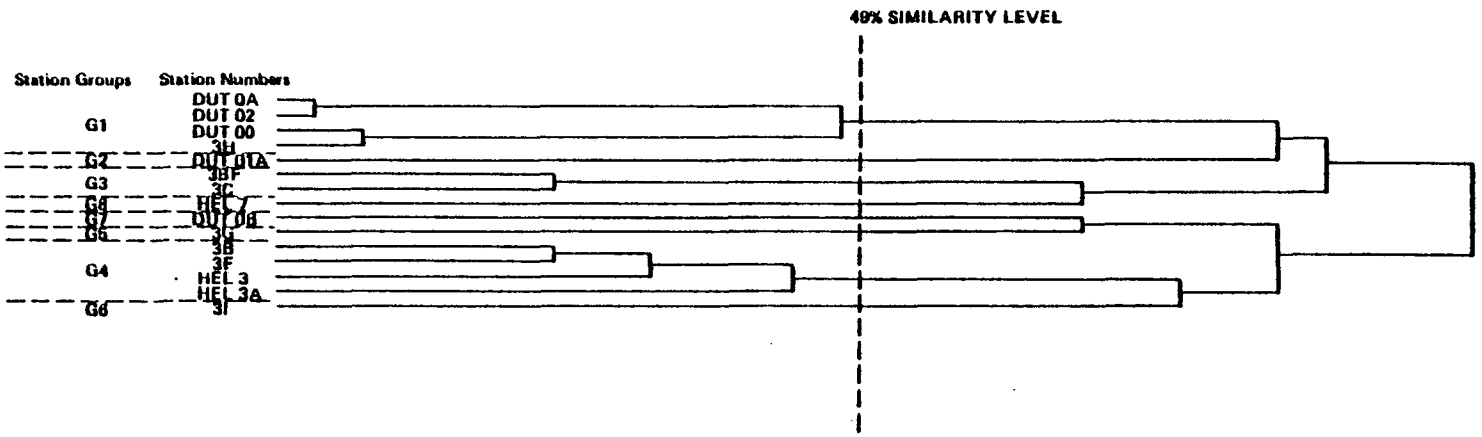


Figure 57. Dendrogram produced by cluster analysis using number of individuals per m^2.

TABLE 21. STATION GROUPS FORMED BY CLUSTER ANALYSIS OF *ln* TRANSFORMED AND UNTRANSFORMED ABUNDANCE DATA

	Transformed Data	Untransformed Data
Station Group 1	DUT 0A	DUT 0A
	DUT 02	DUT 02
	DUT 00	DUT 00
	DUT 01A	3H
Station Group 2	3H	DUT 01A
Station Group 3	3BF	3BF
	3C	3C
	HEL 7	———
Station Group 8	———	HEL 7
Station Group 4	3B	3B
	3F	3F
	HEL 3	HEL 3
	HEL 3A	HEL 3A
Station Group 5	3G	3G
Station Group 6	3I	3I
Station Group 7	DUT 0B	DUT 0B

TABLE 22. FEEDING[1] AND MOTILITY[2] CLASSES OF COMMON BENTHIC INVERTEBRATES FROM DUTCH HARBOR, ALASKA, BENTHIC SAMPLES OF JUNE 1978

Phylum	Identified Taxon	Family	Common Name	Feeding Class	Motility Class
Protozoa	Foraminifera	-	-	P	M
Cnidaria	Anthozoa	-	anemone	SF	S
Rhynchocoela	Rhynchocoela	-	ribbon worm	P	M
Annelida	Polynoidae	-	segmented worm	S	M
Annelida	*Harmothoe imbricata*	Polynoidae	segmented worm	S	M
Annelida	*Polynoe gracilis*	Polynoidae	segmented worm	S	M
Annelida	*Pholoe minuta*	Sigalionidae	segmented worm	S	M
Annelida	*Eteone longa*	Phyllodocidae	segmented worm	P	M
Annelida	*Gyptis brevipalpa*	Hesionidae	segmented worm	P	M
Annelida	*Nephtys cornuta*	Nephtyidae	segmented worm	DF/P	M
Annelida	*Nephtys punctata*	Nephtyidae	segmented worm	DF/P	M
Annelida	*Nephtys ferruginea*	Nephtyidae	segmented worm	DF/P	M
Annelida	*Glycera capitata*	Gylceridae	segmented worm	DF/P	M
Annelida	*Glycinde picta*	Goniadidae	segmented worm	DF/P	M
Annelida	*Glycinde armigera*	Goniadidae	segmented worm	DF/P	M
Annelida	*Onuphis iridescens*	Onuphidae	segmented worm	DF	S/DM
Annelida	*Lumbrineris luti*	Lumbrineridae	segmented worm	DF/P	M
Annelida	*Haploscoloplos elongatus*	Orbiniidae	segmented worm	DF/	M
Annelida	*Scoloplos fuliginosa*	Orbiniidae	segmented worm	DF	M
Annelida	*Aricidea jeffreysii*	Paraonidae	segmented worm	DF	M
Annelida	*Polydora* sp.	Spionidae	segmented worm	DF	DM
Annelida	*Prionospio malmgreni*	Spionidae	segmented worm	DF	DM
Annelida	*Prionospio cirrifera*	Spionidae	segmented worm	DF	DM
Annelida	*Spio filicornis*	Spionidae	segmented worm	DF	DM
Annelida	*Spiophanes bombyx*	Spionidae	segmented worm	DF	DM
Annelida	*Spiophanes kroyeri*	Spionidae	segmented worm	DF	DM
Annelida	*Magelona pacifica*	Magelonidae	segmented worm	DF	DM
Annelida	Cirritulidae	Cirratulidae	segmented worm	DF	S/DM
Annelida	*Tharyx* sp.	Cirratulidae	segmented worm	DF	S/DM
Annelida	*Chaetozone setosa*	Cirratulidae	segmented worm	DF	DM
Annelida	*Scalibregma inflatum*	Scalibregmidae	segmented worm	DF	DM
Annelida	*Ammotrypane aulogaster*	Opheliidae	segmented worm	DF	DM
Annelida	Capitellidae	Capitellidae	segmented worm	DF	M
Annelida	*Capitella capitata*	Capitellidae	segmented worm	DF	M
Annelida	*Heteromastus filiformis*	Capitellidae	segmented worm	DF	M
Annelida	*Notomastus* sp.	Capitellidae	segmented worm	DF	M
Annelida	*Notomastus laeriatus*	Capitellidae	segmented worm	DF	M
Annelida	Maldanidae	Maldanidae	segmented worm	DF	S
Annelida	*Axiothella catenata*	Maldanidae	segmented worm	DF	S
Annelida	*Myriochele heeri*	Owenidae	segmented worm	SF/DF	S
Annelida	*Idanthyrsus armatus*	Sabellariidae	segmented worm	SF	S
Annelida	Ampharetidae	Ampharetidae	segmented worm	DF	S
Annelida	*Ampharete arctica*	Ampharetidae	segmented worm	DF	S

TABLE 22 (continued)

Phylum	Identified Taxon	Family	Common Name	Feeding Class	Motility Class
Annelida	*Lysippe labiata*	Ampharetidae	segmented worm	DF	S
Annelida	*Chone cincta*	Sabellidae	segmented worm	SF	S
Annelida	*Spirorbis semidentatus*	Serpulidae	segmented worm	SF	S
Annelida	*Cossura longocirrata*	Cossuridae	segmented worm	DF	M
Mollusca	*Nucula tenuis*	Nuculidae	clam	DF	M
Mollusca	Nuculanidae	Nuculanidae	clam	DF	M
Mollusca	*Nuculana fossa*	Nuculanidae	clam	DF	M
Mollusca	*Tindaria* sp.	Nuculanidae	clam	DF	M
Mollusca	*Yoldia* sp.	Nuculanidae	clam	DF	M
Mollusca	*Yoldia thraciaeformis*	Nuculanidae	clam	DF	M
Mollusca	*Axinopsida serricata*	Thyasiridae	clam	SF/DF	S
Mollusca	*Thyasira flexousa*	Thyasiridae	clam	SF/DF	S
Mollusca	*Clinocardium ciliatum*	Cardiidae	cockle	SF	M
Mollusca	*Spisula polynyma*	Mactridae	clam	SF	M
Mollusca	*Macoma* sp.	Tellinidae	clam	DF	S
Mollusca	*Macoma calcarea*	Tellinidae	clam	DF	S
Mollusca	*Macoma brota*	Tellinidae	clam	DF	S
Mollusca	*Hiatella arctica*	Hiatellidae	clam	SF	S
Mollusca	*Mya* sp.	Myidae	clam	SF	S
Mollusca	*Cryptobranchia concentrica*	Lepetidae	limpet		
Mollusca	*Solariella* sp.	Trochidae	snail	S/P	M
Mollusca	*Solariella obscura*	Trochidae	snail	S/P	M
Mollusca	*Alvinia* sp.	Rissoidae	snail	S/P	M
Arthropoda	*Balanus* sp.	Balanidae	barnacle	SF	S
Arthropoda	*Balanus crenatus*	Balanidae	barnacle	SF	S
Arthropoda	Cumacea	-	-	DF	M
Arthropoda	Amphipoda	-	sand flea	DF/S	M
Arthropoda	*Pandalus hypsinotus*	Pandalidae	shrimp	S/P	M
Echinodermata	Ophiuridae	-	brittle star	DF	M
Chordata	Pholididae	-	fish-gunnel	DF	M

[1] P = predator; SF = suspension feeder; DF = deposit feeder; S = scavenger

[2] M = motile; DM = discretely motile; S = sessile

a region of extensive mixing. Only a moderate sulfide odor was detectable in sediments here. However, only four infaunal species were present. The number of individuals of each infaunal species at DUT 0A was high in comparison to densities at DUT 01A and 02A. In general, conditions in Iliuliuk Bay are not presently conducive to the establishment of the diverse assemblages of species found at DUT 0B, just outside of Iliuliuk Bay (see Discussion below).

Station DUT 0B is located approximately 2000 m from DUT 0A, and is separated from the latter station by a shallow sill (Fig. 2). The overlying waters in the vicinity of DUT 0B are well mixed. The sediment was clean sand, and no organic odor was detectable. The bottom, as viewed by television, reflected the activities of infaunal species, as opposed to the uniform sediment surface visible at stations in Iliuliuk Bay and Iliuliuk Harbor. A dramatic increase of species occurred at DUT 0B: 59 species here, in contrast to a mean of 4 species at stations in Iliuliuk Bay.

The bottom on and adjacent to the Universal Seafood outfall (Stations 3E and 3DE) was covered by blackened processing wastes. The very extensive amount of wastes present and the marked reducing conditions associated with them strongly suggests that these wastes are accumulating, and are not being removed to any extent by water movement. No infaunal organisms were able to tolerate the toxic conditions associated with the decaying processing wastes. Similar observations were reported for this region in 1976 and 1977 (Karna, 1978).

The bottom approximately 100 m north of the Vita Food Products outfall (Station 3F) was free of processing wastes, and sulfide was not detectable in the grab samples. A large number of species were present (46) with polychaetes and clams dominant. Effluent was apparently discharging through a break in the pipe onshore some 100-150 m from Station 3F. The relative health of the infauna of the area and lack of processing wastes in the grab samples indicate that little or no material is moving from the disposal sites described in Karna (1978) to adjacent areas.

The sediment, as observed in the grab samples, at Station 3G near the Pan Alaska-Whitney Fidalgo outfalls was black with a strong sulfide odor. Although processing wastes were not detectable (i.e., crustaceans' skeletal parts), the marked reducing conditions present here suggest that dissolved or particulate organic material is carried into the area. The reduced number of infaunal species (26) here reflects the presence of sulfide in the sediment. Again, the lack of skeletal fragments from the nearby outfall indicates little movement of the larger fractions of processing material from the waste piles (see Karna, 1978 for photographs and diagrams) to adjacent areas. The fully oxygenated conditions of the overlying waters was emphasized by the presence of healthy shrimp and fish over the bottom at Station 3G (Appendix C).

The bottom at Station 3H, north of 3G, varied from a light-colored oxic to a black anaerobic sediment. No processing wastes were detectable, and the reducing conditions present here were presumably a response of the system to the accumulation of macrophytes (algae) in the area. The toxic conditions at this station are demonstrated by the presence of only eight infaunal species.

The polychaete *N. cornuta* was dominant here as it was at Stations DUT 00, 0A, 02, 01A, 02A in Iliuliuk Bay where sediment sulfide concentrations were also high. The accumulation of plant material on the bottom at this station once again suggests that water movement is sufficient for removal and transport of dense materials, such as processing wastes, from the shallow shelf of Amaknak Island.

The well-mixed shallow area at Station HEL-2, as well as adjacent nearshore stations (3I, 3J, 2A and 2B), showed increased numbers of species (e.g. 3I has 85 species). No processing wastes were evident at these stations.

The bottom between Hog and Amaknak Islands was enriched with organic material (Stations 3BF, 3AG), although no sulfide odor was detectable. No processing wastes were present, but terrestrial plant debris had accumulated at Stations 3AG and 3BF, indicating little water movement here. Twenty-six infaunal species were present at Station 3BF.

The bottom at Station HEL-3A, close to 3BF and 3AG, did not have accumulations of plant debris present, and no processing wastes were present. An organic odor was noticeable, but a sulfide odor was not detectable in the sediment. Fifty species were present at HEL 3A. Accumulation of plant and processing wastes might be expected at HEL-3A if the accumulated wastes in shallow water were dispersed by water movement (e.g. longshore currents, tidal action, wave activity). The relatively clean bottom at this station (as well as lack of processing wastes at 3BF and 3AG) indicates that wastes are not being moved to or deposited in the channel located less than one mile from the processing plant outfalls.

An examination of a transect extending from the Universal Seafood outfall site (Station 3E where no infaunal organisms were found) through a series of stations extending to the far side of Unalaska Bay demonstrates changes on the bottom at varying distances from a point source of pollution. Some of the stations on this transect were also sampled for hydrographic data (see Fig. 3; Sect. 5). A summarization of some data at the appropriate stations is tabulated below (see Table 20; Appendix C):

Station	No. species present	Brillouin diversity	Species richness	Approx. dist. from 3E (outfall) (m)	Comments
3E	0	-	-	0	At discharge point. H_2S present
3DE	0	-	-	100	Processing wastes. H_2S present
3BF	26	2.14	3.38	250-300	Large amount terrestrial plant debris. No H_2S. Strong organic odor.
3C	38	2.17	5.00	750-800	No debris. Clean. Mild organic odor.
3B	50	1.82	6.15	750-800	No debris. Clean. Mild organic odor.
HEL-3	69	2.75	8.06	1200-1400	No debris. Clean. Mild organic odor.
HEL-7	32	2.06	3.99	2500-2700	No debris. Clean. No odor.

The summary above and the previous discussion for all stations indicate that the negative effects of processing wastes do not extend far from the point source of discharge. On the other hand, dissolved and small particulate wastes dispersing from the point source may enrich the bottom and serve as an additional food source for infaunal deposit feeders in adjacent areas. No benthic infauna can be expected under and directly next to accumulations of processing wastes.

Numerical Analysis: General

Numerical analysis makes the evaluation of large data sets feasible, and its use has greatly reduced the subjective element in the analysis of benthic faunal distributions. However, numerical techniques have not completely eliminated subjectivity. Among the subjective decisions required during the development of the numerical analysis protocols used in this study were the selection of (1) a method of data standardization of transformation (if any were desired); (2) a similarity coefficient; and (3) a clustering strategy or method of ordination. A subjective judgement delimiting the groups formed by the analysis must also be made, either by examining a dendrogram (classification) or loadings of points on coordinate or component axes (ordination). The effectiveness of the analysis chosen for this study (classification) was evaluated by using two-way coincidence tables and examining the extent to which the groupings formed by cluster analysis reflected environmental (physical, chemical, biological) conditions.

Some form of data transformation or standardization has often been utilized in the analysis of benthic communities (Field and MacFarlane, 1968; Field and Robb, 1970; Ebeling *et al.*, 1970; Day *et al.*, 1971; Thorrington-Smith, 1971; Stephenson and Williams, 1971; Stephenson *et al.*, 1972; Raphael and Stephenson, 1972; Williams and Stephenson, 1973; Levings, 1975; Maurer *et al.*, 1978). Boesch (1973) used a double standardization to eliminate the effects of differences in abundance between individuals. He argued that two species which might have "similar habitat requirements, yet one is always much more abundant than the other", would be segregated by the analysis unless abundances are standardized. Some form of standardization or transformation should be

utilized; however, differences in abundance may also imply that differences in the suitability of the habitat for the species in question may, in fact, exist. In the absence of a thorough knowledge of the habitat requirements of the species utilized for the analysis we feel that both unaltered and transformed or standardized data should be examined.

The Czekanowski coefficient was used in the present study to calculate similarity matrices for cluster analysis because it tends to emphasize the effect of dominant species on the classification. Raphael and Stephenson (1972) found that the Czekanowski coefficient, with its emphasis on dominant species, produced station groups that were more closely correlated with abiotic attributes.

A hierarchical agglomerative clustering strategy was used to create dendrograms from similarity matrices. We have found that the group average sorting strategy gives useful results, and we have used it almost exclusively here. Boesch (1973) and Stephenson *et al.* (1972) used both group average and "flexible" sorting strategies (Lance and Williams, 1966). Boesch (1973) found the flexible strategy yielded "the more instructive classification" while Stephenson *et al.* (1972), using a variety of criteria, found both strategies to have merit. We experimented with the use of the flexible sorting strategy with $\alpha = 0.85$ using data collected in the northeastern Gulf of Alaska (Feder and Matheke, in press), and found that the results were not appreciably different from those obtained using the group average strategy.

Numerical Analysis: Data From Grab Samples

The station groups formed by a cluster analysis of untransformed abundance data (Fig. 57) were similar to those formed by cluster analysis of natural logarithm transformed data (Fig. 56). The only differences between the results of these two analyses were (Table 21):

1. Station 3H switched from Group 2 (ln transformed data) to Group 1 when untransformed data were used.
2. Station DUT 01A switched from Group 1 (ln transformed data) to Group 2 when untransformed data were used.
3. Station HEL 7 was split from Group 3 (ln transformed data) to form a new "single station" group, Group 8 untransformed data.

When untransformed data are used, the effect that dominant species have on the analysis is emphasized (see Appendices A-D for data). Thus, when untransformed data was used, Station DUT 01A was excluded from Group 1 because of differences in the abundance of the dominant species, *Nephtys cornuta* in both Group 1 and Group 2 stations. The abundance of *Nephtys cornuta* was lower in Station DUT 01A than in the other stations in Group 1. Similarly Station 3H was included in Group 1 when untransformed data was used because the abundance of *Nephtys cornuta* in the station was similar to that of Stations DUT 0A, 02, 00, even though Station HEL 3H was less similar to Stations DUT 0A, 02, 00, in terms of its total species composition. Station HEL 7 differed from the other stations in Station Group 3 in the abundance of the polychaetous annelid *Scalibregma inflatum*. This polychaete was much more abundant in Station HEL 7 (1570 ind/m^2) than in Stations 3BF and 3C ($\bar{x}$ = 160.0 ind/m^2) and as a result Station HEL 7 was not included in Station Group 3 when untransformed data was used.

Stations 3DE and 3E were not included in the analysis because no fauna was collected in these stations. According to the coefficient, the Czekanowski coefficient, used for calculating similarities they would have no similarities with any station group. In reality these stations are more similar to Stations DUT 0A, 02, 00, 01A, and HEL 3H, all of which have a very low species richness (number of species) and low densities of individuals, than they are to other stations with a greater number of species.

Combined Analysis Based on Field and Television Observations and Numerical Analysis

A qualitative assessment of the conditions within the study area in conjunction with numerical analysis of grab data have clarified the relationship of benthic infauna to seafood processing waste discharge in the Dutch Harbor area. The numerical analysis delineated seven station groups, and 41 species groups associated with the station groups. An assessment of the relationships of station and species groups as delineated by numerical analysis strengthens the qualitative assessment of each station made by underwater television and direct observation of grab material on shipboard.

All analyses indicate that the Dutch Harbor-Iliuliuk Bay basin (Station Group 1 as formed by cluster analysis; Table 17; Appendix C) is a stressed area with few infaunal individuals and species present. The anoxic conditions that may normally occur within this basin in the fall would result in a reduced infauna there. Additional stresses to the system by way of increased organic loading (e.g. processing wastes) and oxygen demand would further reduce the number of infaunal species that could survive in the area.

The sea bottom at the point of discharge of processing wastes and areas immediately adjacent to that point are always anaerobic and reducing environments. No infaunal or epifaunal organisms can be expected to survive such conditions, and none were observed in this study. However, as indicated in the previous discussion, the effects of shellfish wastes were dissipated over a relatively short distance. The stations on the west side of Amaknak Island near the waste outfalls are considered in the Results and previous Discussion sections of this report (also see Appendix C). Variable conditions exist at these stations depending on their distance from outfalls, the presence or absence of plant material, their location in the channel between Hog and Amaknak Islands where water movement is reduced, and their proximity to the shallow sill between Hog and Amaknak Islands where well-mixed water is found. The interpretation of the effects of processing wastes are complicated by the presence of algal accumulations at Stations 3D, 3H, 3AG, 3BF, 7B on the far side of Unalaska Bay. Stress on the benthic system in the Dutch Harbor basins must be a common occurrence whenever plant (marine and terrestrial) material accumulates on the bottom. The additional input of processing wastes to such a stressed system in conjunction with reduced water movement (e.g. inside a sill) can be expected to alter the benthic infauna. Ultimately, pelagic organisms (e.g. shrimps) would be affected if hydrogen sulfide diffuses into overlying waters in the stressed areas, as noted at Station DE in the present study (see Sect. 5).

An examination of all station groups formed by cluster analysis and the qualitative assessment of species in these groups and at stations not processed, suggest that a reasonable data base now exists to monitor the

Dutch Harbor area. The infaunal species are now well known, and the use of numerical analysis will make it possible to assess change in bottom fauna as industrial activity progresses.

Underwater television used in conjunction with bottom sampling is also a good tool to examine the shallow bottom regions on a continuing basis. The TV monitor can identify stressed areas by identifying relative amounts of suspended processing wastes, accumulations of processing wastes on the bottom, and the color of the bottom - a black bottom indicating extreme reducing conditions.

SECTION 7
GENERAL DISCUSSION

A variety of coastal environments are present in the vicinity of Dutch Harbor. North (NE & NW) of Amaknak Island is a dynamic region facing the Bering Sea and blanketed with coarse grained, well-sorted sediment. The head of Unalaska Bay (which itself appears to be relatively quiet at depth) lies immediately south of a shallow sill structure between Hog and Amaknak Islands separating it from the active region northwards. Net water movement (at least in the summer) appears to be southwards through the channel and south of this sill the relatively carbon-rich surficial sediment is finer grained and poorly sorted. A number of stations in this latter region show accumulations of algal debris and it is here that the bulk of the shellfish processing waste is currently being dumped. Because of the apparently restricted bottom circulation here, this waste material is not well dispersed and a very localized patch of anoxic water was observed.

Processing waste was formerly discharged directly into Dutch Harbor proper which, with Iliuliuk Bay, comprises one of the two physically restricted coastal basins. The other - much deeper - basin is the adjacent Captains Bay. At the time of year sampled (June) the spring phytoplankton bloom was apparently complete in this region and the water within the basins was well stratified and isolated from the adjacent shelf waters. Nitrate was depleted at the surface and there were strong positive gradients for, in particular, ammonia, phosphate and silica to the bottom, due to regeneration at depth and in the surface sediments. Because of this active consumption and lack of advective influx of new water, dissolved oxygen concentrations at the base of the water column in Dutch Harbor were less than 5 ml/ℓ. However, this consumption rate (assuming isolation of the basin water at approximately the same time of year) is not conspicuously different from that observed a decade previously, at which time the additional organic loading due to processing waste was much higher. From data obtained the previous September (1977) it appears that oxygen depletion continues through the summer and that anoxic conditions occur in late summer-fall at depth, persisting until new shelf water flushes

to be annual and is apparently a natural consequence of local productivity and terrestrial carbon input; ie., while anthropogenic carbon dumping must exacerbate the situation, it is unlikely to be, *per se*, the cause of summer basin anoxia. Chemical trends in Captains Bay proceed along similar paths but the greater volume of water there, and possibly unknown differences in natural carbon input, do not allow complete removal of oxygen within the water column. The sediments in both these basins are anoxic almost to the surface and, particularly in Dutch Harbor, there is a substantial additional flux of phosphate into the water.

The infaunal composition within the Dutch Harbor-Iliuliuk Bay basin reflects a biologically stressed system. The anoxic conditions that normally occur seasonally within this basin at depth contribute to the depauperate conditions present there. However, additional stresses to this system by way of plant debris and/or processing wastes would be expected to increase the oxygen demand by the benthos and result in a further reduction of infaunal species present. It is obvious that the future deposition of processing wastes in this basin would be ecologically unsound.

Processing wastes accumulating on the shallow shelf on the west side of Amaknak Island are responsible for severe anoxic and reducing conditions on the bottom at the site of and immediately adjacent to effluent piles. No benthic infaunal organisms are surviving under or close to the waste accumulations. However, the negative effects of these wastes dissipate over relatively short distances from the accumulated deposits, and healthy infaunal populations occur within a few hundred meters of these deposits.

It is apparent that processing wastes are accumulating adjacent to outfalls off Amaknak Island and that the existing water currents do not provide sufficient energy for adequate dispersal of the wastes (also see report of Stewart and Tangerone, 1977). Thus, although processing wastes are not presently impacting broad areas near outfalls, it is probable that accumulated wastes adjacent to Amaknak Island will eventually cover much of the nearshore bottom with potentially serious ecological and sanitary problems to be expected.

The television camera, used in conjunction with the grab, is a useful tool to delineate the extent of bottom areas contaminated by processing wastes. Stations, with a black bottom, indicating the presence of sulfide, was detectable by the camera and was verified by the van Veen Grab.

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APPENDIX A

SUMMARY OF ALL SPECIES DATA FOR STATIONS ANALYZED IN THE LABORATORY

STATION-SAMPLE LISTING

		TOT CNT	TOT WWGT	CNT/SQM	WWGT/SQM	GRABS				
CRUISE 261	STATION 0A	91.	0.557	455.	2.785	1	2			
CRUISE 261	STATION 0B	1100.	98.540	2200.	197.080	1	2	5	4	3
CRUISE 261	STATION 0C	75.	0.286	150.	0.572	5	4	3	2	1
CRUISE 261	STATION 01A	19.	0.668	38.	1.336	2	5	4	3	1
CRUISE 261	STATION 02	108.	1.085	360.	3.617	5	4	3		
CRUISE 261	STATION 02A	7.	0.024	70.	0.240	1				
CRUISE 261	STATION 3	2307.	67.145	4614.	134.290	4	5	3	2	1
CRUISE 261	STATION 3A	2630.	64.877	5260.	129.754	2	1	3	4	5
CRUISE 261	STATION 3B	1459.	103.614	2918.	207.228	1	5	4	3	2
CRUISE 261	STATION 3BF	494.	19.886	1647.	66.293	3	2	1		
CRUISE 261	STATION 3C	820.	349.339	1640.	698.678	5	4	3	1	2
CRUISE 261	STATION 3E	0.	0.	0.	0.	1				
CRUISE 261	STATION 3F	2289.	99.041	4578.	198.082	2	5	1	4	3
CRUISE 261	STATION 3G	356.	40.599	712.	81.198	3	4	5	1	2
CRUISE 261	STATION 3H	66.	26.920	220.	89.733	5	2	1		
CRUISE 261	STATION 3I	1480.	2773.256	2960.	5546.512	3	1	4	2	5
CRUISE 261	STATION 7	1176.	167.697	2352.	335.394	2	5	3	4	1

TOTAL NUMBER OF STATIONS = 17.

LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION
CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
310431000000	FORAMINIFERA		X		X		2
330100000000	HYDROZOA						1
330300000000	ANTHOZOA			X		X	1
330300000F0	ANTHOZOA FRAGS						1
340000000000	CTENOPHORA						1
400000000000	RHYNCHOCOELA						6
400000000F0	RHYNCHOCOELA FRAGS.			X		X	6
440000000000	NEMATODA						1
480000000F0	ANNELIDA FRAGS						4
480100000000	POLYCHAETA						2
480100000F0	POLYCHAETA FRAG.	X					12
480101000000	POLYNOIDAE						8
480101020000	NEMIDIA SP.						1
480101020200	ANTINOELLA SARSI						1
480101050200	EUNOE DEPRESSA						1
480101050500	EUNOE OERSTEDI						2
480101080300	HARMOTHOE EXTENUATA						1
480101080600	HARMOTHOE IMBRICATA						3
480101150200	POLYNOE GRACILIS						3
480101170100	HESPERONE COMPLANATA						1
480102010100	PEISIDICE ASPERA						1
490105000000	SIGALIONIDAE						2
480105010100	PHLOE MINUTA		X				7
480105030000	STHENELAIS SP.						1
480105040000	SIGALION SP.						1
490107010100	PALEANOTUS BELLIS						1
480112010000	ANAITIDES SP.						2
490112020000	ETEONE SP.						1
480112020500	ETEONE LONGA						6
480112020500	ETEONE LONGA FRAGS						1
480120010200	GYPTIS BREVIPALPA						5
480122020000	SYLLIS SP.						1
490122020100	PIONOSYLLIS GIGANTEA						1
480122070200	EXOGONE GEMMIFERA						1
480122070400	EXOGONE MOLESTA						1
480123000000	NEREIDAE						1
490123040000	NEREIS SP.						1
490124010000	NEPHTYS SP.						2
490124010000	NEPHTYS SP. FRAGS						1
480124010400	NEPHTYS CORNUTA	X	X	X	X	X	14
480124010500	NEPHTYS PUNCTATA						4
480124011100	NEPHTYS FERRUGINEA						4
480126000000	GLYCERIDAE						2
490126010100	GLYCERA CAPITATA						4
480127010100	GLYCINDE PICTA	X					10
490127010300	GLYCINDE ARMIGERA						4
480127020200	GONIADA MACULATA						1
490128010300	ONUPHIS IRIDESCENS						3

LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION
CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
480130000F0	LUMBRINERIDAE FRAGS						1
480130010F0	LUMBRINERIS SP. FRAGS.						2
480130010100	LUMBRINERIS BICIRRATA						1
480130011900	LUMBRINERIS LUTI	X	X		X		9
480139000F0	OPHELIIDAE FRAGS						1
480139010000	HAPLOSCOLOPLOS SP.						1
480139010200	HAPLOSCOLOPLOS ELONGATUS						8
480139030000	SCOLOPLOS FULIGINOSA						4
480140000000	PARAONIDAE						1
480140020400	ARICIDEA JEFFREYSII						3
480142000000	SPIONIDAE						2
480142000F0	SPIONIDAE FRAGS						3
480142020000	LAONICE SP.						1
480142040000	POLYDORA SP.						5
480142040500	POLYDORA CILIATA						1
480142041500	POLYDORA LIMICOLA						1
480142050000	PRIONOSPIO SP.						2
480142050100	PRIONOSPIO MALMGRENI	X	X		X		11
480142050200	PRIONOSPIO CIRRIFERA						6
480142070100	SPIO FILICORNIS						4
480142100000	SPIOPHANES SP.						1
480142100100	SPIOPHANES BOMBYX						5
480142100200	SPIOPHANES KROYERI						5
480142100300	SPIOPHANES CIRRATA						1
480143010200	MAGELONA PACIFICA						5
480143010500	MAGELONA LONGICORNIS						1
480149000000	CIRRATULIDAE	X	X		X		9
480149030000	THARYX SP.		X				5
480149040F0	CHAETOZONE SP. FRAGS						1
480149040100	CHAETOZONE SETOSA						5
480152010300	BRADA INHABILIS						1
480155010100	SCALIBREGMA INFLATUM	X	X	X	X	X	10
480156010100	AMMOTRYPANE AULOGASTER	X					9
480158000000	CAPITELLIDAE						4
480158000F0	CAPITELLIDAE FRAGS						3
480158010100	CAPITELLA CAPITATA			X			7
480158020000	HETEROMASTUS SP. FRAGS						4
480158020100	HETEROMASTUS FILIFORMIS		X	X	X	X	8
480158020200	HETEROMASTUS GIGANTEUS						1
480158030000	NOTOMASTUS SP.						3
480158030600	NOTOMASTUS LAERIATUS						3
480161000000	MALDANIDAE			X		X	3
480161000F0	MALDANIDAE FRAGS.						1
480161080100	AXIOTHELLA CATENATA						4
480161090200	PRAXILLELLA PRAETERMISSA						1
480161100200	RHODINE GRACILIOR						1
480162010200	OWENIA FUSIFORMIS						1
480162020100	MYRIOCHELE HEERI						2

LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION
CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
4901630102OO	IDANTHYRSUS ARMATUS						3
4901840303OO	PECTINARIA GRANULATA						1
4901650000OO	AMPHARETIDAE						3
4901650200OO	AMPHARETE SP.						1
4901650201OO	AMPHARETE ARCTICA						5
4901650401OO	LYSIPPE LABIATA						3
4901650501OO	MELINNA CRISTATA						2
4901670101OO	TEREBELLIDES STROEMII						1
4901680000OO	SABELLIDAE						1
4901680000FO	SABELLIDAE FRAGS.						1
4901680103OO	CHONE CINCTA						4
4901681401OO	LAONOME KROYERI						2
4901700000OO	SERPULIDAE						1
4901700102OO	CHITINOPOMA GROENLANDICA						1
4901700400OO	SERPULA SP.						1
4901700503OO	SPIRORBIS SEMIDENTATUS						1
4901750101OO	COSSURA LONGOCIRRATA						3
4902000000OO	OLIGOCHAETA						1
4903000000OO	POLYPLACOPHORA						2
4904000000OO	PELECYPODA						2
4904000000FO	PELECYPODA FRAGS.						4
4904020201OO	NUCULA TENUIS						6
4904030000OO	NUCULANIDAE						3
4904030200OO	NUCULANA SP.						1
4904030203OO	NUCULANA FOSSA			X		X	6
4904030400OO	TINDARIA SP.						3
4904030500OO	YOLDIA SP.						3
4904030507OO	YOLDIA THRACIAEFORMIS			X			2
4904030600OO	YOLDIELLA SP.						1
4904070201OO	CREMELLA DESSICATA						2
4904070600OO	MODIOLUS SP.						1
4904070601OO	MODIOLUS MODIOLUS						1
4904100101OO	PODODESMUS MACROCHISMA						1
4904140000OO	LUCINIDAE						1
4904150200OO	AXINOPSIDA SP.	X	X	X	X		12
4904150301OO	THYASIRA FLEXUOSA						4
4904160100OO	DIPLODONTA SP.						1
4904160102OO	DIPLODONTA ALEUTICA						1
4904170000OO	KELLIDAE						1
4904180100OO	MYSELLA SP.						1
4904200100OO	CLINOCARDIUM SP.						2
4904200101OO	CLINOCARDIUM CILIATUM			X		X	1
4904200201OO	SERRIPES GROENLANDICUS						1
4904210501OO	PSEPHIDIA LORDI						1
4904230100OO	SPISULA SP.			X		X	3
4904230101OO	SPISULA POLYNYMA						1
4904240100OO	MACOMA SP.			X		X	5
4904240101OO	MACOMA CALCAREA			X		X	5

LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
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CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
490424010300	MACOMA BROTA			X		X	5
490424010700	MACOMA MOESTA MOESTA						1
490424011300	MACOMA CARLOTTENSIS						1
490424020100	TELLINA LUTEA						1
490428000000	MYIDAE						2
490428020000	MYA SP.						3
490429020000	HIATELLA SP.						1
490433020000	LYONSIA SP.						1
490435020000	THRACIA SP.						1
490435020500	THRACIA BERINGI						1
490500000000	GASTROPODA						4
490500000F0	GASTROPODA FRAGS						1
490504010000	ACMAEA SP.						1
490504020000	COLISELLA SP.						1
490505010100	CRYPTOBRANCHIA CONCENTRICA						1
490506040000	SOLARIELLA SP.						3
490506040200	SOLARIELLA OBSCURA						4
490507020100	MOELLERIA QUADRAT						1
490511010000	SOLARIELLA SP.						3
490511030000	CINGULA SP.						1
490530040000	TROPHONOPSIS SP.						1
490541040000	OENOPOTA SP.						1
490545010000	RETUSA SP.						1
490576010000	SIPHONARIA SP.						1
530000000000	CRUSTACEA			X			3
530200000000	ANOSTRACA						1
531200000000	CYCLOPOIDA						1
531802010000	BALANUS SP.			X		X	3
531802010400	BALANUS CRENATUS		X	X	X	X	5
532800000000	CUMACEA						2
532804030400	EUDORELLOPSIS DEFORMIS						2
533100000000	AMPHIPODA						8
533102010100	AMPELISCA MACROCEPHALA						1
533134140000	HIPPOMEDON						1
533134210000	LEPIDEPECREUM SP.			•			0 •
533134290000	ORCHOMENE SP.						1
533137080000	MONOCULODES SP.						1
533142070000	PARAPHOXUS SP.					•	1
533300000000	DECAPODA						4
533304010600	PANDALUS HYPSINOTUS						1
533311000000	PAGURIDAE						1
533311020000	PAGURUS SP.						2
533317010100	OREGONIA GRACILIS						1
533321030000	PINNIXA SP.						1
590101010100	GOLFINGIA MARGARITACEA						2
590101020100	PHASCOLION STROMBI						1
680201010100	DENDRASTER EXCENTRICUS						1
680204000000	STRONGYLOCENTROTIDAE				X		1

LIST OF ALL TAXONOMIC GROUPS FOUND

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CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
6802040101OO	ALLOCENTROTUS FRAGILIS						2
6803090000OO	OPHIURIDAE						4
6803090000F0	OPHIURIDAE FRAGS						3
7916130000OO	PHOLIDIDAE			X		X	2
9999000000OO	NO FAUNA COLLECTED IN THIS GRAB		X	X	X	X	3
9999999999OO	UNIDENTIFIED						1
9999999999F0	UNIDENTIFIED FRAGS.						2

TOTAL NUMBER OF TAXONS = 198

CRUISE 761 STATION 0A

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480100000FO	POLYCHAETA FRAG.	06/12/78	1	1	1.10	0.001	0.18	5	0.005	X
480124010400	NEPHTYS CORNUTA	06/12/78	2	32	35.16	0.178	31.96	160	0.890	X X X X X
480124010400	NEPHTYS CORNUTA	06/12/78	1	50	54.95	0.227	40.75	250	1.135	X X X X X
		SUBTOTAL		82	90.11	0.405	72.71	410	2.025	
480155010100	SCALIBREGMA INFLATUM	06/12/78	1	4	4.40	0.109	19.57	20	0.545	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/12/78	2	1	1.10	0.023	4.13	5	0.115	X X X X X
		SUBTOTAL		5	5.49	0.132	23.70	25	0.660	
480156010100	AMMOTRYPANE AULOGASTER	06/12/78	1	1	1.10	0.017	3.05	5	0.085	X
490415020000	AXINOPSIDA SP.	06/12/78	1	1	1.10	0.001	0.18	5	0.005	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	2	1	1.10	0.001	0.18	5	0.005	X X X X
		SUBTOTAL		2	2.20	0.002	0.36	10	0.010	
STATION TOTAL				91		0.557		455	2.785	

SIMPSON INDEX 0.813675 SHANNON DIVERSITY INDEX 0.436305

CRUISE 261 STATION 08

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
310431000000	FORAMINIFERA	06/12/78	1	116	10.55	0.335	0.34	232	0.670	X X
310431000000	FORAMINIFERA	06/12/78	2	113	10.27	0.289	0.29	226	0.578	X X
310431000000	FORAMINIFERA	06/12/78	5	96	8.73	0.224	0.23	192	0.448	X X
		SUBTOTAL		325	29.55	0.848	0.86	650	1.696	
400000000000	RHYNCHOCOELA	06/12/78	5	1	0.09	0.004	0.00	2	0.008	
480100000FO	POLYCHAETA FRAG.	06/12/78	4	1	0.09	0.040	0.04	2	0.080	X
480100000FO	POLYCHAETA FRAG.	06/12/78	2	1	0.09	0.077	0.08	2	0.154	X
480100000FO	POLYCHAETA FRAG.	06/12/78	3	1	0.09	0.045	0.05	2	0.090	X
		SUBTOTAL		3	0.27	0.162	0.16	6	0.324	
480101000000	POLYNOIDAE	06/12/78	2	2	0.18	0.011	0.01	4	0.022	
480101080600	HARMOTHOE IMBRICATA	06/12/78	3	1	0.09	0.072	0.07	2	0.144	
480101080600	HARMOTHOE IMBRICATA	06/12/78	4	1	0.09	0.032	0.03	2	0.064	
		SUBTOTAL		2	0.18	0.104	0.11	4	0.208	
480101170100	HESPERONE COMPLANATA	06/12/78	1	1	0.09	0.015	0.02	2	0.030	
480105030000	STHENELAIS SP.	06/12/78	1	3	0.27	1.181	1.20	6	2.362	
480105030000	STHENELAIS SP.	06/12/78	3	2	0.18	0.393	0.40	4	0.786	
480105030000	STHENELAIS SP.	06/12/78	2	1	0.09	0.009	0.01	2	0.018	
480105030000	STHENELAIS SP.	06/12/78	4	1	0.09	0.230	0.23	2	0.460	
480105030000	STHENELAIS SP.	06/12/78	5	1	0.09	0.210	0.21	2	0.420	
		SUBTOTAL		8	0.73	2.023	2.05	16	4.046	
480105040000	SIGALION SP.	06/12/78	4	1	0.09	0.001	0.00	2	0.002	
480124010000	NEPHTYS SP.	06/12/78	4	1	0.09	0.046	0.05	2	0.092	
480124011100	NEPHTYS FERRUGINEA	06/12/78	4	5	0.45	0.081	0.08	10	0.162	
480124011100	NEPHTYS FERRUGINEA	06/12/78	5	2	0.18	0.106	0.11	4	0.212	
480124011100	NEPHTYS FERRUGINEA	06/12/78	2	2	0.18	0.060	0.06	4	0.120	
480124011100	NEPHTYS FERRUGINEA	06/12/78	3	3	0.27	0.094	0.10	6	0.188	
480124011100	NEPHTYS FERRUGINEA	06/12/78	1	2	0.18	0.101	0.10	4	0.202	
		SUBTOTAL		14	1.27	0.442	0.45	28	0.884	
480127010100	GLYCINDE PICTA	06/12/78	1	2	0.18	0.020	0.02	4	0.040	X
480127010100	GLYCINDE PICTA	06/12/78	3	2	0.18	0.014	0.01	4	0.028	X
480127010100	GLYCINDE PICTA	06/12/78	2	2	0.18	0.009	0.01	4	0.018	X
480127010100	GLYCINDE PICTA	06/12/78	5	7	0.64	0.133	0.13	14	0.266	X
		SUBTOTAL		13	1.18	0.176	0.18	26	0.352	
480127010300	GLYCINDE ARMIGERA	06/12/78	2	1	0.09	0.051	0.05	2	0.102	
480127010300	GLYCINDE ARMIGERA	06/12/78	1	2	0.18	0.083	0.08	4	0.166	
		SUBTOTAL		3	0.27	0.134	0.14	6	0.268	
480128010300	ONUPHIS IRIDESCENS	06/12/78	2	1	0.09	0.260	0.26	2	0.520	
480128010300	ONUPHIS IRIDESCENS	06/12/78	4	1	0.09	0.274	0.28	2	0.548	
		SUBTOTAL		2	0.18	0.534	0.54	4	1.068	

CRUISE 261 STATION 08

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
490130000OF0	LUMBRINERIDAE FRAGS	06/12/78	2	1	0.09	0.031	0.03	2	0.062	
480130010100	LUMBRINERIS BICIRRATA	06/12/78	3	2	0.18	0.445	0.45	4	0.890	
480130010100	LUMBRINERIS BICIRRATA	06/12/78	1	1	0.09	0.363	0.37	2	0.726	
480130010100	LUMBRINERIS BICIRRATA	06/12/78	4	2	0.18	1.224	1.24	4	2.448	
480130010100	LUMBRINERIS BICIRRATA	06/12/78	5	3	0.27	1.655	1.68	6	3.310	
		SUBTOTAL		8	0.73	3.687	3.74	16	7.374	
480139000OF0	ORBINIDAE FRAGS	06/12/78	5	1	0.09	0.027	0.03	2	0.054	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/12/78	5	11	1.00	0.201	0.20	22	0.402	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/12/78	4	3	0.27	0.014	0.01	6	0.028	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/12/78	1	8	0.73	0.262	0.27	16	0.524	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/12/78	3	4	0.36	0.050	0.05	8	0.100	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/12/78	2	9	0.82	0.051	0.05	18	0.102	
		SUBTOTAL		35	3.18	0.578	0.59	70	1.156	
480139030000	SCOLOPLOS FULIGINOSA	06/12/78	5	1	0.09	0.001	0.00	2	0.002	
480142000OF0	SPIONIDAE FRAGS	06/12/78	5	1	0.09	0.005	0.01	2	0.010	
480142000OF0	SPIONIDAE FRAGS	06/12/78	2	1	0.09	0.027	0.03	2	0.054	
		SUBTOTAL		2	0.18	0.032	0.03	4	0.064	
480142040000	POLYDORA SP.	06/12/78	5	1	0.09	0.001	0.00	2	0.002	
480142050000	PRIONOSPIO SP.	06/12/78	2	1	0.09	0.001	0.00	2	0.002	
480142050100	PRIONOSPIO MALMGRENI	06/12/78	1	1	0.09	0.001	0.00	2	0.002	X X X
480142100100	SPIOPHANES BOMBYX	06/12/78	1	5	0.45	0.046	0.05	10	0.092	
480142100100	SPIOPHANES BOMBYX	06/12/78	2	5	0.45	0.026	0.03	10	0.052	
480142100100	SPIOPHANES BOMBYX	06/12/78	3	10	0.91	0.101	0.18	20	0.362	
480142100100	SPIOPHANES BOMBYX	06/12/78	5	11	1.00	0.272	0.28	22	0.544	
490142100100	SPIOPHANES BOMBYX	06/12/78	4	2	0.18	0.005	0.01	4	0.010	
		SUBTOTAL		33	3.00	0.530	0.54	66	1.060	
480143010500	MAGELONA LONGICORNIS	06/12/78	4	6	0.55	0.047	0.05	12	0.094	
480143010500	MAGELONA LONGICORNIS	06/12/78	5	8	0.73	0.044	0.04	16	0.088	
480143010500	MAGELONA LONGICORNIS	06/12/78	3	4	0.36	0.022	0.02	8	0.044	
490143010500	MAGELONA LONGICORNIS	06/12/78	2	9	0.82	0.044	0.04	18	0.088	
480143010500	MAGELONA LONGICORNIS	06/12/78	1	5	0.45	0.040	0.04	10	0.080	
		SUBTOTAL		32	2.91	0.197	0.20	64	0.394	
480149000000	CIRRATULIDAE	06/12/78	1	7	0.64	0.046	0.05	14	0.092	X X X
480149000000	CIRRATULIDAE	06/12/78	2	16	1.45	0.078	0.08	32	0.156	X X X
480149000000	CIRRATULIDAE	06/12/78	3	19	1.73	0.095	0.10	38	0.190	X X X
480149000000	CIRRATULIDAE	06/12/78	5	20	1.82	0.138	0.14	40	0.276	X X X
480149000000	CIRRATULIDAE	06/12/78	4	7	0.64	0.050	0.05	14	0.100	X X X
		SUBTOTAL		69	6.27	0.407	0.41	138	0.814	

CRUISE 261 STATION 08

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480149030000	THARYX SP.	06/12/78	1	1	0.09	0.005	0.01	2	0.010	X
480156010100	AMMOTRYPANE AULOGASTER	06/12/78	1	1	0.09	0.001	0.00	2	0.002	X
480161000000	MALDANIDAE	06/12/78	3	4	0.36	0.702	0.71	8	1.404	X X
480161000000	MALDANIDAE	06/12/78	4	1	0.09	0.104	0.11	2	0.208	X X
		SUBTOTAL		5	0.45	0.806	0.82	10	1.612	
480161080100	AXIOTHELLA CATENATA	06/12/78	2	1	0.09	0.240	0.24	2	0.480	
480161080100	AXIOTHELLA CATENATA	06/12/78	1	1	0.09	0.103	0.10	2	0.206	
		SUBTOTAL		2	0.18	0.343	0.35	4	0.686	
480165000000	AMPHARETIDAE	06/12/78	5	1	0.09	0.002	0.00	2	0.004	
490403040000	TINDARIA SP.	06/12/78	1	1	0.09	0.001	0.00	2	0.002	
490407020100	CRENELLA DESSUCATA	06/12/78	3	3	0.27	0.035	0.04	6	0.070	
490407020100	CRENELLA DESSUCATA	06/12/78	5	1	0.09	0.004	0.00	2	0.008	
490407020100	CRENELLA DESSUCATA	06/12/78	4	1	0.09	0.005	0.01	2	0.010	
		SUBTOTAL		5	0.45	0.044	0.04	10	0.088	
490415020000	AXINOPSIDA SP.	06/12/78	4	24	2.18	0.441	0.45	48	0.882	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	5	42	3.82	0.418	0.42	84	0.836	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	3	45	4.09	0.350	0.36	90	0.700	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	2	39	3.55	0.392	0.40	78	0.784	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	1	29	2.64	0.384	0.39	58	0.768	X X X X
		SUBTOTAL		179	16.27	1.985	2.01	358	3.970	
490416010200	DIPLODONTA ALEUTICA	06/12/78	1	1	0.09	0.271	0.28	2	0.542	
490416010200	DIPLODONTA ALEUTICA	06/12/78	4	1	0.09	0.001	0.00	2	0.002	
		SUBTOTAL		2	0.18	0.272	0.28	4	0.544	
490418010000	MYSELLA SP.	06/12/78	4	1	0.09	0.002	0.00	2	0.004	
490418010000	MYSELLA SP.	06/12/78	1	3	0.27	0.004	0.00	6	0.008	
490418010000	MYSELLA SP.	06/12/78	2	3	0.27	0.004	0.00	6	0.008	
		SUBTOTAL		7	0.64	0.010	0.01	14	0.020	
490421050100	PSEPHIDIA LORDI	06/12/78	3	3	0.27	0.006	0.01	6	0.012	
490421050100	PSEPHIDIA LORDI	06/12/78	1	3	0.27	0.036	0.04	6	0.072	
490421050100	PSEPHIDIA LORDI	06/12/78	4	2	0.18	0.003	0.00	4	0.006	
490421050100	PSEPHIDIA LORDI	06/12/78	5	2	0.18	0.035	0.04	4	0.070	
		SUBTOTAL		10	0.91	0.080	0.08	20	0.160	
490423010000	SPISULA SP.	06/12/78	5	7	0.64	0.027	0.03	14	0.054	X X
490423010000	SPISULA SP.	06/12/78	4	7	0.64	0.043	0.04	14	0.086	X X
490423010000	SPISULA SP.	06/12/78	3	4	0.36	77.422	78.57	8	154.844	X X
490423010000	SPISULA SP.	06/12/78	2	3	0.27	0.011	0.01	6	0.022	X X
		SUBTOTAL		21	1.91	77.503	78.65	42	155.006	

CRUISE 261 STATION 0B

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
490423010100	SPISULA POLYNYMA	06/12/78	1	4	0.36	0.012	0.01	8	0.024	
490424010700	MACOMA MOESTA MOESTA	06/12/78	1	1	0.09	0.420	0.43	2	0.840	
490424010700	MACOMA MOESTA MOESTA	06/12/78	2	5	0.45	1.546	1.57	10	3.092	
		SUBTOTAL		6	0.55	1.966	2.00	12	3.932	
490424020100	TELLINA LUTEA	06/12/78	5	1	0.09	3.083	3.13	2	6.166	
490433020000	LYONSIA SP.	06/12/78	4	1	0.09	0.002	0.00	2	0.004	
490433020000	LYONSIA SP.	06/12/78	3	1	0.09	0.005	0.01	2	0.010	
		SUBTOTAL		2	0.18	0.007	0.01	4	0.014	
490435020000	THRACIA SP.	06/12/78	2	1	0.09	0.177	0.18	2	0.354	
490435020000	THRACIA SP.	06/12/78	5	1	0.09	0.052	0.05	2	0.104	
		SUBTOTAL		2	0.18	0.229	0.23	4	0.458	
490435020500	THRACIA BERINGI	06/12/78	1	1	0.09	0.099	0.10	2	0.198	
490500000000	GASTROPODA	06/12/78	5	2	0.18	0.015	0.02	4	0.030	
490506040000	SOLARIELLA SP.	06/12/78	1	3	0.27	0.013	0.01	6	0.026	
490506040200	SOLARIELLA OBSCURA	06/12/78	2	3	0.27	0.083	0.08	6	0.166	
490506040200	SOLARIELLA OBSCURA	06/12/78	3	2	0.18	0.060	0.06	4	0.120	
490506040200	SOLARIELLA OBSCURA	06/12/78	5	5	0.45	0.073	0.07	10	0.146	
		SUBTOTAL		10	0.91	0.216	0.22	20	0.432	
490511030000	CINGULA SP.	06/12/78	5	2	0.18	0.002	0.00	4	0.004	
490511030000	CINGULA SP.	06/12/78	4	5	0.45	0.004	0.00	10	0.008	
490511030000	CINGULA SP.	06/12/78	3	1	0.09	0.002	0.00	2	0.004	
490511030000	CINGULA SP.	06/12/78	2	18	1.64	0.016	0.02	36	0.032	
490511030000	CINGULA SP.	06/12/78	1	3	0.27	0.002	0.00	6	0.004	
		SUBTOTAL		29	2.64	0.026	0.03	58	0.052	
490541040000	OENOPOTA SP.	06/12/78	2	1	0.09	0.013	0.01	2	0.026	
490541040000	OENOPOTA SP.	06/12/78	1	1	0.09	0.096	0.10	2	0.192	
490541040000	OENOPOTA SP.	06/12/78	3	1	0.09	0.160	0.16	2	0.320	
490541040000	OENOPOTA SP.	06/12/78	5	2	0.18	0.092	0.09	4	0.184	
		SUBTOTAL		5	0.45	0.361	0.37	10	0.722	
490545010000	RETUSA SP.	06/12/78	5	1	0.09	0.005	0.01	2	0.010	
532804030400	EUDORELLOPSIS DEFORMIS	06/12/78	5	9	0.82	0.009	0.01	18	0.018	
532804030400	EUDORELLOPSIS DEFORMIS	06/12/78	4	8	0.73	0.009	0.01	16	0.018	
532804030400	EUDORELLOPSIS DEFORMIS	06/12/78	3	3	0.27	0.003	0.00	6	0.006	
532804030400	EUDORELLOPSIS DEFORMIS	06/12/78	1	11	1.00	0.009	0.01	22	0.018	
532804030400	EUDORELLOPSIS DEFORMIS	06/12/78	2	10	0.91	0.006	0.01	20	0.012	
		SUBTOTAL		41	3.73	0.036	0.04	82	0.072	

CRUISE 261 STATION 08

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
533100000000	AMPHIPODA	06/12/78	4	1	0.09	0.003	0.00	2	0.006	
533102010100	AMPELISCA MACROCEPHALA	06/12/78	4	2	0.18	0.004	0.00	4	0.008	
533102010100	AMPELISCA MACROCEPHALA	06/12/78	5	3	0.27	0.053	0.05	6	0.106	
533102010100	AMPELISCA MACROCEPHALA	06/12/78	1	1	0.09	0.036	0.04	2	0.072	
533102010100	AMPELISCA MACROCEPHALA	06/12/78	3	2	0.18	0.049	0.05	4	0.098	
533102010100	AMPELISCA MACROCEPHALA	06/12/78	2	1	0.09	0.002	0.00	2	0.004	
		SUBTOTAL		9	0.82	0.144	0.15	18	0.288	
533134140000	HIPPOMEDON	06/12/78	2	10	0.91	0.077	0.08	20	0.154	
533134140000	HIPPOMEDON	06/12/78	3	8	0.73	0.060	0.06	16	0.120	
533134140000	HIPPOMEDON	06/12/78	1	2	0.18	0.015	0.02	4	0.030	
533134140000	HIPPOMEDON	06/12/78	5	17	1.55	0.151	0.15	34	0.302	
533134140000	HIPPOMEDON	06/12/78	4	5	0.45	0.060	0.06	10	0.120	
		SUBTOTAL		42	3.82	0.363	0.37	84	0.726	
533134290000	ORCHOMENE SP.	06/12/78	5	2	0.18	0.004	0.00	4	0.008	
533134290000	ORCHOMENE SP.	06/12/78	1	1	0.09	0.003	0.00	2	0.006	
533134290000	ORCHOMENE SP.	06/12/78	2	3	0.27	0.033	0.03	6	0.066	
		SUBTOTAL		6	0.55	0.040	0.04	12	0.080	
533137080000	MONOCULODES SP.	06/12/78	5	1	0.09	0.002	0.00	2	0.004	
533142070000	PARAPHOXUS SP.	06/12/78	5	15	1.36	0.046	0.05	30	0.092	
533142070000	PARAPHOXUS SP.	06/12/78	4	10	0.91	0.027	0.03	20	0.054	
533142070000	PARAPHOXUS SP.	06/12/78	2	8	0.73	0.024	0.02	16	0.048	
533142070000	PARAPHOXUS SP.	06/12/78	3	7	0.64	0.023	0.02	14	0.046	
533142070000	PARAPHOXUS SP.	06/12/78	1	4	0.36	0.014	0.01	8	0.028	
		SUBTOTAL		44	4.00	0.134	0.14	88	0.268	
533300000000	DECAPODA	06/12/78	2	1	0.09	0.005	0.01	2	0.010	
680201010100	DENDRASTER EXCENTRICUS	06/12/78	2	1	0.09	0.205	0.21	2	0.410	
680204000000	STRONGYLOCENTROTIDAE	06/12/78	2	19	1.73	0.032	0.03	38	0.064	X
680204000000	STRONGYLOCENTROTIDAE	06/12/78	3	12	1.09	0.016	0.02	24	0.032	X
680204000000	STRONGYLOCENTROTIDAE	06/12/78	4	21	1.91	0.026	0.03	42	0.052	X
680204000000	STRONGYLOCENTROTIDAE	06/12/78	5	28	2.55	0.037	0.04	56	0.074	X
		SUBTOTAL		80	7.27	0.111	0.11	160	0.222	
680204010100	ALLOCENTROTUS FRAGILIS	06/12/78	1	11	1.00	0.014	0.01	22	0.028	
6803090000F0	OPHIURIDAE FRAGS	06/12/78	2	1	0.09	0.406	0.41	2	0.812	
		STATION TOTAL		1100		98.540		2200	197.080	

SIMPSON INDEX 0.131458 SHANNON DIVERSITY INDEX 2.710343

CRUISE 261 STATION 00

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480124010400	NEPHTYS CORNUTA	05/11/78	5	14	18.67	0.084	29.37	28	0.168	X X X X X
480124010400	NEPHTYS CORNUTA	05/11/78	4	23	30.67	0.076	26.57	46	0.152	X X X X X
480124010400	NEPHTYS CORNUTA	05/11/78	3	14	18.67	0.067	23.43	28	0.134	X X X X X
480124010400	NEPHTYS CORNUTA	05/11/78	2	12	16.00	0.052	18.18	24	0.104	X X X X X
480124010400	NEPHTYS CORNUTA	05/11/78	1	11	14.67	0.006	2.10	22	0.012	X X X X X
		SUBTOTAL		74	98.67	0.285	99.65	148	0.570	
533300000000	DECAPODA	05/11/78	3	1	1.33	0.001	0.35	2	0.002	
		STATION TOTAL		75		0.286		150	0.572	

SIMPSON INDEX 0.973333 SHANNON DIVERSITY INDEX 0.070811

CRUISE 761 STATION 01A

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480124010400	NEPHTYS CORNUTA	05/11/78	2	6	31.58	0.038	5.69	12	0.076	X X X X X
480124010400	NEPHTYS CORNUTA	05/11/78	5	2	10.53	0.040	5.99	4	0.080	X X X X X
480124010400	NEPHTYS CORNUTA	05/11/78	4	3	15.79	0.046	6.89	6	0.092	X X X X X
480124010400	NEPHTYS CORNUTA	05/11/78	3	5	26.32	0.046	6.89	10	0.092	X X X X X
		SUBTOTAL		16	84.21	0.170	25.45	32	0.340	
480142100100	SPIOPHANES BOMBYX	05/11/78	2	1	5.26	0.004	0.60	2	0.008	
480158010100	CAPITELLA CAPITATA	05/11/78	3	1	5.26	0.167	25.00	2	0.334	X
791613000000	PHOLOIDIDAE	05/11/78	2	1	5.26	0.327	48.95	2	0.654	X X
999900000000	NO FAUNA COLLECTED IN THIS GRAB	05/11/78	1	0	0.	0.	0.	0	0.	X X X X
		STATION TOTAL		19		0.668		38	1.336	

SIMPSON INDEX 0.701754 SHANNON DIVERSITY INDEX 0.609627

CRUISE 261 STATION 02

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
4801000000FO	POLYCHAETA FRAG.	06/12/78	5	1	0.93	0.005	0.46	3	0.017	X
4801240104OO	NEPHTYS CORNUTA	06/12/78	5	35	32.41	0.151	13.92	117	0.503	X X X X X
4801240104OO	NEPHTYS CORNUTA	06/12/78	4	44	40.74	0.280	25.81	147	0.933	X X X X X
4801240104OO	NEPHTYS CORNUTA	06/12/78	3	20	18.52	0.153	14.10	67	0.510	X X X X X
		SUBTOTAL		99	91.67	0.584	53.82	330	1.947	
4801550101OO	SCALIBREGMA INFLATUM	06/12/78	3	1	0.93	0.074	6.82	3	0.247	X X X X X
4801550101OO	SCALIBREGMA INFLATUM	06/12/78	4	7	6.48	0.422	38.89	23	1.407	X X X X X
		SUBTOTAL		8	7.41	0.496	45.71	27	1.653	
		STATION TOTAL		108		1.085		360	3.617	

SIMPSON INDEX 0.844410 SHANNON DIVERSITY INDEX 0.315905

CRUISE 261 STATION 02A

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480105010100	PHLOE MINUTA	06/12/78	1	1	14.29	0.001	4.17	10	0.010	X
480124010400	NEPHTYS CORNUTA	06/12/78	1	5	71.43	0.018	75.00	50	0.180	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/12/78	1	1	14.29	0.005	20.83	10	0.050	X X X X X
STATION TOTAL				7		0.024		70	0.240	

SIMPSON INDEX 0.476190 SHANNON DIVERSITY INDEX 0.796312

CRUISE 261 STATION 3

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
4000000000F0	RHYNCHOCOELA FRAGS.	06/11/78	4	1	0.04	8.570	12.76	2	17.140	X X
4000000000000	RHYNCHOCOELA	06/11/78	5	3	0.13	0.078	0.12	6	0.156	
4000000000000	RHYNCHOCOELA	06/11/78	3	1	0.04	0.009	0.01	2	0.018	
		SUBTOTAL		4	0.17	0.087	0.13	8	0.174	
4800000000F0	ANNELIDA FRAGS	06/11/78	2	1	0.04	0.065	0.10	2	0.130	
4800000000F0	ANNELIDA FRAGS	06/11/78	1	1	0.04	0.092	0.14	2	0.184	
4800000000F0	ANNELIDA FRAGS	06/11/78	4	1	0.04	0.078	0.12	2	0.156	
4800000000F0	ANNELIDA FRAGS	06/11/78	3	1	0.04	0.066	0.10	2	0.132	
		SUBTOTAL		4	0.17	0.301	0.45	8	0.602	
4801000000F0	POLYCHAETA FRAG.	06/11/78	3	1	0.04	0.337	0.50	2	0.674	X
4801000000F0	POLYCHAETA FRAG.	06/11/78	5	1	0.04	0.538	0.80	2	1.076	X
4801000000F0	POLYCHAETA FRAG.	06/11/78	2	1	0.04	0.506	0.75	2	1.012	X
		SUBTOTAL		3	0.13	1.381	2.06	6	2.762	
480101000000	POLYNOIDAE	06/11/78	1	2	0.09	0.006	0.01	4	0.012	
480101000000	POLYNOIDAE	06/11/78	5	1	0.04	0.001	0.00	2	0.002	
		SUBTOTAL		3	0.13	0.007	0.01	6	0.014	
480101080600	HARMOTHOE IMBRICATA	06/11/78	5	2	0.09	0.041	0.06	4	0.082	
480101080600	HARMOTHOE IMBRICATA	06/11/78	2	2	0.09	0.055	0.08	4	0.110	
		SUBTOTAL		4	0.17	0.096	0.14	8	0.192	
480101150200	POLYNOE GRACILIS	06/11/78	5	1	0.04	0.057	0.08	2	0.114	
480105000000	SIGALIONIDAE	06/11/78	5	1	0.04	0.001	0.00	2	0.002	
480105010100	PHLOE MINUTA	06/11/78	5	3	0.13	0.005	0.01	6	0.010	X
480105010100	PHLOE MINUTA	06/11/78	3	1	0.04	0.002	0.00	2	0.004	X
480105010100	PHLOE MINUTA	06/11/78	2	4	0.17	0.007	0.01	8	0.014	X
		SUBTOTAL		8	0.35	0.014	0.02	16	0.028	
480112020500	ETEONE LONGA	06/11/78	5	2	0.09	0.014	0.02	4	0.028	
480120010200	GYPTIS BREVIPALPA	06/11/78	1	1	0.04	0.001	0.00	2	0.002	
480124010OF0	NEPHTYS SP. FRAGS	06/11/78	2	1	0.04	1.131	1.68	2	2.262	
480124010400	NEPHTYS CORNUTA	06/11/78	2	1	0.04	0.005	0.01	2	0.010	X X X X X
480124010500	NEPHTYS PUNCTATA	06/11/78	4	1	0.04	1.409	2.10	2	2.818	
480126010100	GLYCERA CAPITATA	06/11/78	3	2	0.09	0.116	0.17	4	0.232	
480126010100	GLYCERA CAPITATA	06/11/78	2	1	0.04	0.006	0.01	2	0.012	
		SUBTOTAL		3	0.13	0.122	0.18	6	0.244	
480127010100	GLYCINDE PICTA	06/11/78	2	9	0.39	0.050	0.07	18	0.100	X
480127010100	GLYCINDE PICTA	06/11/78	1	3	0.13	0.034	0.05	6	0.068	X
480127010100	GLYCINDE PICTA	06/11/78	3	6	0.26	0.052	0.08	12	0.104	X
480127010100	GLYCINDE PICTA	06/11/78	4	4	0.17	0.083	0.12	8	0.166	X
480127010100	GLYCINDE PICTA	06/11/78	5	11	0.48	0.090	0.13	22	0.180	X
		SUBTOTAL		33	1.43	0.309	0.46	66	0.618	

CRUISE 261 STATION 3

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480127010300	GLYCINDE ARMIGERA	06/11/78	3	3	0.13	0.044	0.07	6	0.088	
480127010300	GLYCINDE ARMIGERA	06/11/78	1	1	0.04	0.004	0.01	2	0.008	
		SUBTOTAL		4	0.17	0.048	0.07	8	0.096	
480127020200	GONIADA MACULATA	06/11/78	5	1	0.04	0.029	0.04	2	0.058	
480128010300	ONUPHIS IRIDESCENS	06/11/78	5	1	0.04	0.008	0.01	2	0.016	
480130010FO	LUMBRINERIS SP. FRAGS.	06/11/78	2	1	0.04	0.175	0.26	2	0.350	
480130011900	LUMBRINERIS LUTI	06/11/78	2	54	2.34	0.241	0.36	108	0.482	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	1	51	2.21	0.376	0.56	102	0.752	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	5	84	3.64	0.751	1.12	168	1.502	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	3	71	3.08	0.860	1.28	142	1.720	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	4	53	2.30	0.450	0.67	106	0.900	X X X
		SUBTOTAL		313	13.57	2.678	3.99	626	5.356	
480139010000	HAPLOSCOLOPLOS SP.	06/11/78	2	2	0.09	0.016	0.02	4	0.032	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	1	1	0.04	0.035	0.05	2	0.070	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	4	1	0.04	0.013	0.02	2	0.026	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	3	2	0.09	0.014	0.02	4	0.028	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	5	1	0.04	0.016	0.02	2	0.032	
		SUBTOTAL		5	0.22	0.078	0.12	10	0.156	
480139030000	SCOLOPLOS FULIGINOSA	06/11/78	4	17	0.74	0.148	0.22	34	0.296	
480139030000	SCOLOPLOS FULIGINOSA	06/11/78	1	11	0.48	0.051	0.08	22	0.102	
		SUBTOTAL		28	1.21	0.199	0.30	56	0.398	
480142000FO	SPIONIDAE FRAGS	06/11/78	3	1	0.04	0.035	0.05	2	0.070	
480142040000	POLYDORA SP.	06/11/78	3	2	0.09	0.009	0.01	4	0.018	
480142040000	POLYDORA SP.	06/11/78	4	1	0.04	0.006	0.01	2	0.012	
480142040000	POLYDORA SP.	06/11/78	5	14	0.61	0.045	0.07	28	0.090	
480142040000	POLYDORA SP.	06/11/78	1	1	0.04	0.002	0.00	2	0.004	
480142040000	POLYDORA SP.	06/11/78	2	4	0.17	0.015	0.02	8	0.030	
		SUBTOTAL		22	0.95	0.077	0.11	44	0.154	
480142050000	PRIONOSPIO SP.	06/11/78	2	22	0.95	0.044	0.07	44	0.088	
480142050000	PRIONOSPIO SP.	06/11/78	4	3	0.13	0.010	0.01	6	0.020	
		SUBTOTAL		25	1.08	0.054	0.08	50	0.108	
480142050100	PRIONOSPIO MALMGRENI	06/11/78	4	52	2.25	0.406	0.60	104	0.812	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	3	41	1.78	0.115	0.17	82	0.230	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	5	150	6.50	0.164	0.24	300	0.328	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	2	23	1.00	0.101	0.15	46	0.202	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	1	25	1.08	0.092	0.14	50	0.184	X X X
		SUBTOTAL		291	12.61	0.878	1.31	582	1.756	

CRUISE 261 STATION 3

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480142050200	PRIONOSPIO CIRRIFERA	06/11/78	2	3	0.13	0.003	0.00	6	0.006	
480142050200	PRIONOSPIO CIRRIFERA	06/11/78	3	1	0.04	0.001	0.00	2	0.002	
		SUBTOTAL		4	0.17	0.004	0.01	8	0.008	
480142070100	SPIO FILICORNIS	06/11/78	3	27	1.17	0.110	0.16	54	0.220	
480142070100	SPIO FILICORNIS	06/11/78	5	46	1.99	0.246	0.37	92	0.492	
480142070100	SPIO FILICORNIS	06/11/78	2	11	0.48	0.088	0.13	22	0.176	
		SUBTOTAL		84	3.64	0.444	0.66	168	0.888	
480142100200	SPIOPHANES KROYERI	06/11/78	1	1	0.04	0.003	0.00	2	0.006	
480143010200	MAGELONA PACIFICA	06/11/78	1	4	0.17	0.015	0.02	8	0.030	
480143010200	MAGELONA PACIFICA	06/11/78	2	11	0.48	0.111	0.17	22	0.222	
480143010200	MAGELONA PACIFICA	06/11/78	5	15	0.65	0.131	0.20	30	0.262	
480143010200	MAGELONA PACIFICA	06/11/78	3	13	0.56	0.128	0.19	26	0.256	
480143010200	MAGELONA PACIFICA	06/11/78	4	4	0.17	0.048	0.07	8	0.096	
		SUBTOTAL		47	2.04	0.433	0.64	94	0.866	
480149000000	CIRRATULIDAE	06/11/78	5	21	0.91	0.037	0.06	42	0.074	X X X
480149000000	CIRRATULIDAE	06/11/78	2	16	0.69	0.093	0.14	32	0.186	X X X
		SUBTOTAL		37	1.60	0.130	0.19	74	0.260	
480149030000	THARYX SP.	06/11/78	1	7	0.30	0.029	0.04	14	0.058	X
480149030000	THARYX SP.	06/11/78	4	20	0.87	0.096	0.14	40	0.192	X
480149030000	THARYX SP.	06/11/78	3	17	0.74	0.078	0.12	34	0.156	X
		SUBTOTAL		44	1.91	0.203	0.30	88	0.406	
480149040F0	CHAETOZONE SP. FRAGS	06/11/78	2	1	0.04	0.008	0.01	2	0.016	
480149040100	CHAETOZONE SETOSA	06/11/78	5	3	0.13	0.014	0.02	6	0.028	
480152010300	BRADA INHABILIS	06/11/78	3	1	0.04	0.397	0.59	2	0.794	
480155010100	SCALIBREGMA INFLATUM	06/11/78	3	2	0.09	0.022	0.03	4	0.044	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/11/78	4	3	0.13	0.168	0.25	6	0.336	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/11/78	5	5	0.22	0.070	0.10	10	0.140	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/11/78	2	11	0.48	0.162	0.24	22	0.324	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/11/78	1	4	0.17	0.070	0.10	8	0.140	X X X X X
		SUBTOTAL		25	1.08	0.492	0.73	50	0.984	
480156010100	AMMOTRYPANE AULOGASTER	06/11/78	1	4	0.17	0.158	0.24	8	0.316	X
480156010100	AMMOTRYPANE AULOGASTER	06/11/78	2	2	0.09	0.049	0.07	4	0.098	X
480156010100	AMMOTRYPANE AULOGASTER	06/11/78	5	2	0.09	0.094	0.14	4	0.188	X
480156010100	AMMOTRYPANE AULOGASTER	06/11/78	4	2	0.09	0.254	0.38	4	0.508	X
480156010100	AMMOTRYPANE AULOGASTER	06/11/78	3	2	0.09	0.048	0.07	4	0.096	X
		SUBTOTAL		12	0.52	0.603	0.90	24	1.206	
480158000F0	CAPITELLIDAE FRAGS	06/11/78	3	1	0.04	0.008	0.01	2	0.016	
480158000F0	CAPITELLIDAE FRAGS	06/11/78	5	1	0.04	0.017	0.03	2	0.034	
		SUBTOTAL		2	0.09	0.025	0.04	4	0.050	

CRUISE 261 STATION 3

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480158000000	CAPITELLIDAE	06/11/78	2	7	0.30	0.010	0.01	14	0.020	
480158010100	CAPITELLA CAPITATA	06/11/78	1	3	0.13	0.028	0.04	6	0.056	X
480158010100	CAPITELLA CAPITATA	06/11/78	5	3	0.13	0.001	0.00	6	0.002	X
480158010100	CAPITELLA CAPITATA	06/11/78	4	1	0.04	0.005	0.01	2	0.010	X
		SUBTOTAL		7	0.30	0.034	0.05	14	0.068	
480158020000	HETEROMASTUS SP. FRAGS	06/11/78	3	1	0.04	0.002	0.00	2	0.004	
480158020100	HETEROMASTUS FILIFORMIS	06/11/78	3	7	0.30	0.011	0.02	14	0.022	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/11/78	4	2	0.09	0.005	0.01	4	0.010	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/11/78	5	71	3.08	0.030	0.04	142	0.060	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/11/78	2	6	0.26	0.010	0.01	12	0.020	X X X X
		SUBTOTAL		86	3.73	0.056	0.08	172	0.112	
480158030000	NOTOMASTUS SP.	06/11/78	2	2	0.09	0.009	0.01	4	0.018	
480158030000	NOTOMASTUS SP.	06/11/78	1	12	0.52	0.020	0.03	24	0.040	
480158030000	NOTOMASTUS SP.	06/11/78	4	6	0.26	0.020	0.03	12	0.040	
		SUBTOTAL		20	0.87	0.049	0.07	40	0.098	
480158030600	NOTOMASTUS LAERIATUS	06/11/78	3	15	0.65	0.051	0.08	30	0.102	
480158030600	NOTOMASTUS LAERIATUS	06/11/78	5	35	1.52	0.108	0.16	70	0.216	
		SUBTOTAL		50	2.17	0.159	0.24	100	0.318	
480161000000	MALDANIDAE	06/11/78	5	29	1.26	2.311	3.44	58	4.622	X X
480161000000	MALDANIDAE	06/11/78	2	29	1.26	4.429	6.60	58	8.858	X X
		SUBTOTAL		58	2.51	6.740	10.04	116	13.480	
480161080100	AXIOTHELLA CATENATA	06/11/78	1	12	0.52	1.032	1.54	24	2.064	
480161080100	AXIOTHELLA CATENATA	06/11/78	3	13	0.56	1.315	1.96	26	2.630	
480161080100	AXIOTHELLA CATENATA	06/11/78	4	8	0.35	0.828	1.23	16	1.656	
		SUBTOTAL		33	1.43	3.175	4.73	66	6.350	
480161100200	RHODINE GRACILIOR	06/11/78	5	1	0.04	0.002	0.00	2	0.004	
480163010200	IDANTHYRSUS ARMATUS	06/11/78	5	11	0.48	0.140	0.21	22	0.280	
480163010200	IDANTHYRSUS ARMATUS	06/11/78	3	3	0.13	0.020	0.03	6	0.040	
		SUBTOTAL		14	0.61	0.160	0.24	28	0.320	
480165020100	AMPHARETE ARCTICA	06/11/78	3	7	0.30	0.009	0.01	14	0.018	
480165020100	AMPHARETE ARCTICA	06/11/78	5	14	0.61	0.010	0.01	28	0.020	
480165020100	AMPHARETE ARCTICA	06/11/78	1	1	0.04	0.001	0.00	2	0.002	
		SUBTOTAL		22	0.95	0.020	0.03	44	0.040	
480165040100	LYSIPPE LABIATA	06/11/78	1	2	0.09	0.013	0.02	4	0.026	
480165040100	LYSIPPE LABIATA	06/11/78	5	4	0.17	0.034	0.05	8	0.068	
480165040100	LYSIPPE LABIATA	06/11/78	3	2	0.09	0.045	0.07	4	0.090	
480165040100	LYSIPPE LABIATA	06/11/78	4	2	0.09	0.023	0.03	4	0.046	
		SUBTOTAL		10	0.43	0.115	0.17	20	0.230	

CRUISE 261 STATION 3

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480165050100	MELINNA CRISTATA	06/11/78	3	1	0.04	0.022	0.03	2	0.044	
480165050100	MELINNA CRISTATA	06/11/78	1	1	0.04	0.008	0.01	2	0.016	
		SUBTOTAL		2	0.09	0.030	0.04	4	0.060	
480167010100	TEREBELLIDES STROEMII	06/11/78	2	1	0.04	0.144	0.21	2	0.288	
480168010300	CHONE CINCTA	06/11/78	2	9	0.39	0.170	0.25	18	0.340	
480168010300	CHONE CINCTA	06/11/78	1	3	0.13	0.026	0.04	6	0.052	
480168010300	CHONE CINCTA	06/11/78	3	13	0.56	0.258	0.38	26	0.516	
480168010300	CHONE CINCTA	06/11/78	4	3	0.13	0.102	0.15	6	0.204	
480168010300	CHONE CINCTA	06/11/78	5	18	0.78	0.311	0.46	36	0.622	
		SUBTOTAL		46	1.99	0.867	1.29	92	1.734	
490400000000	PELECYPODA	06/11/78	5	1	0.04	1.239	1.85	2	2.478	
490402020100	NUCULA TENUIS	06/11/78	5	2	0.09	0.006	0.01	4	0.012	
490402020100	NUCULA TENUIS	06/11/78	4	3	0.13	0.008	0.01	6	0.016	
490402020100	NUCULA TENUIS	06/11/78	3	9	0.39	0.013	0.02	18	0.026	
490402020100	NUCULA TENUIS	06/11/78	1	6	0.26	0.011	0.02	12	0.022	
490402020100	NUCULA TENUIS	06/11/78	2	4	0.17	0.011	0.02	8	0.022	
		SUBTOTAL		24	1.04	0.049	0.07	48	0.098	
490403000000	NUCULANIDAE	06/11/78	4	2	0.09	0.001	0.00	4	0.002	
490403020300	NUCULANA FOSSA	06/11/78	4	11	0.48	1.544	2.30	22	3.088	X X
490403020300	NUCULANA FOSSA	06/11/78	3	37	1.60	2.950	4.39	74	5.900	X X
490403020300	NUCULANA FOSSA	06/11/78	5	7	0.30	0.978	1.46	14	1.956	X X
490403020300	NUCULANA FOSSA	06/11/78	2	18	0.78	1.834	2.73	36	3.668	X X
490403020300	NUCULANA FOSSA	06/11/78	1	13	0.56	1.378	2.05	26	2.756	X X
		SUBTOTAL		86	3.73	8.684	12.93	172	17.368	
490415020000	AXINOPSIDA SP.	06/11/78	1	146	6.33	0.834	1.24	292	1.668	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	2	150	6.50	0.600	0.89	300	1.200	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	5	84	3.64	0.473	0.70	168	0.946	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	3	137	5.94	0.734	1.09	274	1.468	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	4	190	8.24	0.974	1.45	380	1.948	X X X X
		SUBTOTAL		707	30.65	3.615	5.38	1414	7.230	
490415030100	THYASIRA FLEXUOSA	06/11/78	4	5	0.22	0.153	0.23	10	0.306	
490415030100	THYASIRA FLEXUOSA	06/11/78	5	1	0.04	0.025	0.04	2	0.050	
490415030100	THYASIRA FLEXUOSA	06/11/78	2	1	0.04	0.018	0.03	2	0.036	
490415030100	THYASIRA FLEXUOSA	06/11/78	1	3	0.13	0.186	0.28	6	0.372	
		SUBTOTAL		10	0.43	0.382	0.57	20	0.764	
490420010100	CLINOCARDIUM CILIATUM	06/11/78	5	6	0.26	9.255	13.78	12	18.510	X X
490420010100	CLINOCARDIUM CILIATUM	06/11/78	3	3	0.13	0.545	0.81	6	1.090	X X
		SUBTOTAL		9	0.39	9.800	14.60	18	19.600	
490424010000	MACOMA SP.	06/11/78	3	1	0.04	1.697	2.53	2	3.394	X X
490424010000	MACOMA SP.	06/11/78	5	4	0.17	1.629	2.43	8	3.258	X X
490424010000	MACOMA SP.	06/11/78	2	3	0.13	2.082	3.10	6	4.164	X X
		SUBTOTAL		8	0.35	5.408	8.05	16	10.816	

CRUISE 261 STATION 3

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490424010100	MACOMA CALCAREA	06/11/78	1	4	0.17	2.338	3.48	8	4.676	X	X
490424010100	MACOMA CALCAREA	06/11/78	4	1	0.04	1.987	2.96	2	3.974	X	X
		SUBTOTAL		5	0.22	4.325	6.44	10	8.650		
490428000000	MYIDAE	06/11/78	1	1	0.04	0.012	0.02	2	0.024		
490506040000	SOLARIELLA SP.	06/11/78	1	1	0.04	0.008	0.01	2	0.016		
490506040000	SOLARIELLA SP.	06/11/78	4	2	0.09	0.027	0.04	4	0.054		
		SUBTOTAL		3	0.13	0.035	0.05	6	0.070		
490506040200	SOLARIELLA OBSCURA	06/11/78	3	2	0.09	0.022	0.03	4	0.044		
490506040200	SOLARIELLA OBSCURA	06/11/78	2	4	0.17	0.140	0.21	8	0.280		
		SUBTOTAL		6	0.26	0.162	0.24	12	0.324		
532800000000	CUMACEA	06/11/78	1	1	0.04	0.001	0.00	2	0.002		
532804030400	EUDORELLOPSIS DEFORMIS	06/11/78	3	1	0.04	0.001	0.00	2	0.002		
533100000000	AMPHIPODA	06/11/78	3	27	1.17	0.175	0.26	54	0.350		
533100000000	AMPHIPODA	06/11/78	5	11	0.48	0.021	0.03	22	0.042		
533100000000	AMPHIPODA	06/11/78	2	1	0.04	0.001	0.00	2	0.002		
		SUBTOTAL		39	1.69	0.197	0.29	78	0.394		
533300000000	DECAPODA	06/11/78	2	1	0.04	0.002	0.00	2	0.004		
590101010100	GOLFINGIA MARGARITACEA	06/11/78	2	1	0.04	0.013	0.02	2	0.026		
590101010100	GOLFINGIA MARGARITACEA	06/11/78	1	2	0.09	0.004	0.01	4	0.008		
590101010100	GOLFINGIA MARGARITACEA	06/11/78	5	6	0.26	0.025	0.04	12	0.050		
590101010100	GOLFINGIA MARGARITACEA	06/11/78	3	5	0.22	0.108	0.16	10	0.216		
		SUBTOTAL		14	0.61	0.150	0.22	28	0.300		
680309000000	OPHIURIDAE	06/11/78	5	3	0.13	0.926	1.38	6	1.852		
680309000000	OPHIURIDAE	06/11/78	4	1	0.04	0.001	0.00	2	0.002		
		SUBTOTAL		4	0.17	0.927	1.38	8	1.854		
9999999999F0	UNIDENTIFIED FRAGS.	06/11/78	5	1	0.04	0.056	0.08	2	0.112		
	STATION TOTAL			2307		67.145		4614	134.290		

SIMPSON INDEX 0.136190 SHANNON DIVERSITY INDEX 2.746546

CRUISE 761 STATION 3A

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
330100000000	HYDROZOA	06/11/78	2	1	0.04	0.001	0.00	2	0.002	
40000000000F0	RHYNCHOCOELA FRAGS.	06/11/78	2	1	0.04	0.010	0.02	2	0.020	X X
40000000000F0	RHYNCHOCOELA FRAGS.	06/11/78	1	1	0.04	0.008	0.01	2	0.016	X X
		SUBTOTAL		2	0.08	0.018	0.03	4	0.036	
400000000000	RHYNCHOCOELA	06/11/78	1	3	0.11	0.016	0.02	6	0.032	
400000000000	RHYNCHOCOELA	06/11/78	2	1	0.04	0.001	0.00	2	0.002	
400000000000	RHYNCHOCOELA	06/11/78	3	1	0.04	0.001	0.00	2	0.002	
		SUBTOTAL		5	0.19	0.018	0.03	10	0.036	
48010000000F0	POLYCHAETA FRAG.	06/11/78	4	1	0.04	0.017	0.03	2	0.034	X
48010000000F0	POLYCHAETA FRAG.	06/11/78	2	1	0.04	0.159	0.25	2	0.318	X
48010000000F0	POLYCHAETA FRAG.	06/11/78	5	1	0.04	0.208	0.32	2	0.416	X
		SUBTOTAL		3	0.11	0.384	0.59	6	0.768	
480105010100	PHLOE MINUTA	06/11/78	5	3	0.11	0.003	0.00	6	0.006	X
480105010100	PHLOE MINUTA	06/11/78	2	1	0.04	0.002	0.00	2	0.004	X
480105010100	PHLOE MINUTA	06/11/78	3	4	0.15	0.006	0.01	8	0.012	X
		SUBTOTAL		8	0.30	0.011	0.02	16	0.022	
4801120205F0	ETEONE LONGA FRAGS	06/11/78	2	1	0.04	0.001	0.00	2	0.002	
480112020500	ETEONE LONGA	06/11/78	5	1	0.04	0.007	0.01	2	0.014	
480122020000	SYLLIS SP.	06/11/78	2	1	0.04	0.002	0.00	2	0.004	
480123000000	NEREIDAE	06/11/78	3	1	0.04	0.003	0.00	2	0.006	
480124010000	NEPHTYS SP.	06/11/78	1	2	0.08	2.345	3.61	4	4.690	
480124011100	NEPHTYS FERRUGINEA	06/11/78	3	5	0.19	0.031	0.05	10	0.062	
480124011100	NEPHTYS FERRUGINEA	06/11/78	4	3	0.11	0.055	0.08	6	0.110	
480124011100	NEPHTYS FERRUGINEA	06/11/78	2	2	0.08	0.088	0.14	4	0.176	
480124011100	NEPHTYS FERRUGINEA	06/11/78	5	6	0.23	0.022	0.03	12	0.044	
		SUBTOTAL		16	0.61	0.196	0.30	32	0.392	
480127010100	GLYCINDE PICTA	06/11/78	5	6	0.23	0.180	0.28	12	0.360	X
480127010100	GLYCINDE PICTA	06/11/78	2	8	0.30	0.149	0.23	16	0.298	X
480127010100	GLYCINDE PICTA	06/11/78	4	10	0.38	0.207	0.32	20	0.414	X
480127010100	GLYCINDE PICTA	06/11/78	3	10	0.38	0.168	0.26	20	0.336	X
480127010100	GLYCINDE PICTA	06/11/78	1	5	0.19	0.061	0.09	10	0.122	X
		SUBTOTAL		39	1.48	0.765	1.18	78	1.530	
480128010300	ONUPHIS IRIDESCENS	06/11/78	3	1	0.04	0.126	0.19	2	0.252	
480130011900	LUMBRINERIS LUTI	06/11/78	3	37	1.41	0.490	0.76	74	0.980	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	4	22	0.84	0.247	0.38	44	0.494	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	2	30	1.14	0.356	0.55	60	0.712	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	5	40	1.52	0.486	0.75	80	0.972	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	1	67	2.55	0.690	1.06	134	1.380	X X X
		SUBTOTAL		196	7.45	2.269	3.50	392	4.538	

CRUISE 261 STATION 3A

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	1	6	0.23	0.125	0.19	12	0.250	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	5	8	0.30	0.166	0.26	16	0.332	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	2	7	0.27	0.180	0.28	14	0.360	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	4	8	0.30	0.356	0.55	16	0.712	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	3	8	0.30	0.211	0.33	16	0.422	
		SUBTOTAL		37	1.41	1.038	1.60	74	2.076	
480140020400	ARICIDEA JEFFREYSII	06/11/78	3	1	0.04	0.001	0.00	2	0.002	
480140020400	ARICIDEA JEFFREYSII	06/11/78	2	1	0.04	0.002	0.00	2	0.004	
		SUBTOTAL		2	0.08	0.003	0.00	4	0.006	
480142040000	POLYDORA SP.	06/11/78	2	1	0.04	0.003	0.00	2	0.006	
480142050100	PRIONOSPIO MALMGRENI	06/11/78	2	11	0.42	0.101	0.16	22	0.202	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	3	5	0.19	0.019	0.03	10	0.038	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	5	4	0.15	0.038	0.06	8	0.076	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	4	6	0.23	0.043	0.07	12	0.086	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	1	1	0.04	0.008	0.01	2	0.016	X X X
		SUBTOTAL		27	1.03	0.209	0.32	54	0.418	
480142070100	SPIO FILICORNIS	06/11/78	1	3	0.11	0.019	0.03	6	0.038	
480142070100	SPIO FILICORNIS	06/11/78	4	2	0.08	0.003	0.00	4	0.006	
480142070100	SPIO FILICORNIS	06/11/78	5	1	0.04	0.007	0.01	2	0.014	
480142070100	SPIO FILICORNIS	06/11/78	3	1	0.04	0.002	0.00	2	0.004	
		SUBTOTAL		7	0.27	0.031	0.05	14	0.062	
480142100000	SPIOPHANES SP.	06/11/78	5	1	0.04	0.003	0.00	2	0.006	
480142100100	SPIOPHANES BOMBYX	06/11/78	3	1	0.04	0.001	0.00	2	0.002	
480143010200	MAGELONA PACIFICA	06/11/78	4	1	0.04	0.005	0.01	2	0.010	
480143010200	MAGELONA PACIFICA	06/11/78	1	2	0.08	0.032	0.05	4	0.064	
		SUBTOTAL		3	0.11	0.037	0.06	6	0.074	
480149000000	CIRRATULIDAE	06/11/78	1	3	0.11	0.013	0.02	6	0.026	X X X
480149000000	CIRRATULIDAE	06/11/78	4	3	0.11	0.022	0.03	6	0.044	X X X
480149000000	CIRRATULIDAE	06/11/78	5	6	0.23	0.034	0.05	12	0.068	X X X
480149000000	CIRRATULIDAE	06/11/78	3	5	0.19	0.035	0.05	10	0.070	X X X
480149000000	CIRRATULIDAE	06/11/78	2	2	0.08	0.004	0.01	4	0.008	X X X
		SUBTOTAL		19	0.72	0.108	0.17	38	0.216	
480155010100	SCALIBREGMA INFLATUM	06/11/78	2	2	0.08	0.147	0.23	4	0.294	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/11/78	5	2	0.08	0.046	0.07	4	0.092	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/11/78	4	1	0.04	0.026	0.04	2	0.052	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/11/78	1	1	0.04	0.007	0.01	2	0.014	X X X X X
		SUBTOTAL		6	0.23	0.226	0.35	12	0.452	
480156010100	AMMOTRYPANE AULOGASTER	06/11/78	4	1	0.04	0.093	0.14	2	0.186	X

CRUISE 261 STATION 3A

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480158010100	CAPITELLA CAPITATA	06/11/78	2	1	0.04	0.003	0.00	2	0.006	X
480158020100	HETEROMASTUS FILIFORMIS	06/11/78	4	1	0.04	0.002	0.00	2	0.004	X X X X
480158020200	HETEROMASTUS GIGANTEUS	06/11/78	5	1	0.04	0.004	0.01	2	0.008	
480158030600	NOTOMASTUS LAERIATUS	06/11/78	5	3	0.11	0.010	0.02	6	0.020	
480158030600	NOTOMASTUS LAERIATUS	06/11/78	3	1	0.04	0.003	0.00	2	0.006	
		SUBTOTAL		4	0.15	0.013	0.02	8	0.026	
480161000000	MALDANIDAE	06/11/78	3	1	0.04	0.027	0.04	2	0.054	X X
480161000000	MALDANIDAE	06/11/78	4	1	0.04	0.004	0.01	2	0.008	X X
		SUBTOTAL		2	0.08	0.031	0.05	4	0.062	
480162020100	MYRIOCHELE HEERI	06/11/78	5	1	0.04	0.021	0.03	2	0.042	
480165020100	AMPHARETE ARCTICA	06/11/78	2	1	0.04	0.005	0.01	2	0.010	
480165020100	AMPHARETE ARCTICA	06/11/78	1	1	0.04	0.002	0.00	2	0.004	
		SUBTOTAL		2	0.08	0.007	0.01	4	0.014	
480165050100	MELINNA CRISTATA	06/11/78	3	1	0.04	0.007	0.01	2	0.014	
480165050100	MELINNA CRISTATA	06/11/78	5	1	0.04	0.004	0.01	2	0.008	
		SUBTOTAL		2	0.08	0.011	0.02	4	0.022	
480168000F0	SABELLIDAE FRAGS.	06/11/78	1	1	0.04	0.001	0.00	2	0.002	
480168010300	CHONE CINCTA	06/11/78	3	1	0.04	0.018	0.03	2	0.036	
480168010300	CHONE CINCTA	06/11/78	2	2	0.08	0.004	0.01	4	0.008	
		SUBTOTAL		3	0.11	0.022	0.03	6	0.044	
490402020100	NUCULA TENUIS	06/11/78	2	3	0.11	0.013	0.02	6	0.026	
490402020100	NUCULA TENUIS	06/11/78	3	2	0.08	0.006	0.01	4	0.012	
		SUBTOTAL		5	0.19	0.019	0.03	10	0.038	
490403020300	NUCULANA FOSSA	06/11/78	2	3	0.11	0.427	0.66	6	0.854	X X
490403020300	NUCULANA FOSSA	06/11/78	5	1	0.04	0.053	0.08	2	0.106	X X
490403020300	NUCULANA FOSSA	06/11/78	1	2	0.08	0.075	0.12	4	0.150	X X
		SUBTOTAL		6	0.23	0.555	0.86	12	1.110	
490403050000	YOLDIA SP.	06/11/78	4	3	0.11	0.004	0.01	6	0.008	
490403050000	YOLDIA SP.	06/11/78	3	1	0.04	0.001	0.00	2	0.002	
		SUBTOTAL		4	0.15	0.005	0.01	8	0.010	
490415020000	AXINOPSIDA SP.	06/11/78	3	457	17.38	1.469	2.26	914	2.938	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	2	440	16.73	1.247	1.92	880	2.494	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	4	505	19.20	1.927	2.97	1010	3.854	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	5	260	9.89	0.978	1.51	520	1.956	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	1	299	11.37	1.398	2.15	598	2.796	X X X X
		SUBTOTAL		1961	74.56	7.019	10.82	3922	14.038	

CRUISE 261 STATION 3A

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA	
490415030100	THYASIRA FLEXUOSA	06/11/78	1	9	0.34	0.137	0.21	18	0.274		
490420010000	CLINOCARDIUM SP.	06/11/78	1	2	0.08	0.004	0.01	4	0.008		
490420010000	CLINOCARDIUM SP.	06/11/78	5	1	0.04	0.010	0.02	2	0.020		
490420010000	CLINOCARDIUM SP.	06/11/78	4	2	0.08	0.009	0.01	4	0.018		
		SUBTOTAL		5	0.19	0.023	0.04	10	0.046		
490420020100	SERRIPES GROENLANDICUS	06/11/78	3	1	0.04	0.211	0.33	2	0.422		
490423010000	SPISULA SP.	06/11/78	3	16	0.61	0.032	0.05	32	0.064	X	X
490423010000	SPISULA SP.	06/11/78	2	8	0.30	0.010	0.02	16	0.020	X	X
490423010000	SPISULA SP.	06/11/78	4	2	0.08	0.003	0.00	4	0.006	X	X
490423010000	SPISULA SP.	06/11/78	5	15	0.57	0.031	0.05	30	0.062	X	X
490423010000	SPISULA SP.	06/11/78	1	1	0.04	0.002	0.00	2	0.004	X	X
		SUBTOTAL		42	1.60	0.078	0.12	84	0.156		
490424010000	MACOMA SP.	06/11/78	1	5	0.19	1.284	1.98	10	2.568	X	X
490424010000	MACOMA SP.	06/11/78	5	3	0.11	0.024	0.04	6	0.048	X	X
490424010000	MACOMA SP.	06/11/78	4	4	0.15	6.757	10.42	8	13.514	X	X
490424010000	MACOMA SP.	06/11/78	2	2	0.08	0.003	0.00	4	0.006	X	X
490424010000	MACOMA SP.	06/11/78	3	1	0.04	0.	0.	2	0.	X	X
		SUBTOTAL		15	0.57	8.068	12.44	30	16.136		
490428020000	MYA SP.	06/11/78	3	12	0.46	0.023	0.04	24	0.046		
490428020000	MYA SP.	06/11/78	2	5	0.19	0.009	0.01	10	0.018		
490428020000	MYA SP.	06/11/78	4	9	0.34	0.039	0.06	18	0.078		
490428020000	MYA SP.	06/11/78	5	12	0.46	0.024	0.04	24	0.048		
490428020000	MYA SP.	06/11/78	1	1	0.04	0.002	0.00	2	0.004		
		SUBTOTAL		39	1.48	0.097	0.15	78	0.194		
490500000000	GASTROPODA	06/11/78	1	1	0.04	0.004	0.01	2	0.008		
490506040200	SOLARIELLA OBSCURA	06/11/78	5	15	0.57	1.202	1.85	30	2.404		
490506040200	SOLARIELLA OBSCURA	06/11/78	4	3	0.11	0.088	0.14	6	0.176		
490506040200	SOLARIELLA OBSCURA	06/11/78	2	14	0.53	0.904	1.39	28	1.808		
490506040200	SOLARIELLA OBSCURA	06/11/78	1	20	0.76	0.951	1.47	40	1.902		
490506040200	SOLARIELLA OBSCURA	06/11/78	3	13	0.49	0.779	1.20	26	1.558		
		SUBTOTAL		65	2.47	3.924	6.05	130	7.848		
490511010000	SOLARIELLA SP.	06/11/78	2	1	0.04	0.010	0.02	2	0.020		
490511010000	SOLARIELLA SP.	06/11/78	4	1	0.04	0.019	0.03	2	0.038		
		SUBTOTAL		2	0.08	0.029	0.04	4	0.058		
530200000000	ANOSTRACA	06/11/78	2	1	0.04	0.001	0.00	2	0.002		
531802010000	BALANUS SP.	06/11/78	4	20	0.76	36.116	55.67	40	72.232	X	X
532800000000	CUMACEA	06/11/78	4	1	0.04	0.001	0.00	2	0.002		
532800000000	CUMACEA	06/11/78	5	1	0.04	0.002	0.00	2	0.004		
		SUBTOTAL		2	0.08	0.003	0.00	4	0.006		

CRUISE 261 STATION 3A

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
533100000000	AMPHIPODA	06/11/78	5	12	0.46	0.036	0.06	24	0.072	
533100000000	AMPHIPODA	06/11/78	4	21	0.80	0.031	0.05	42	0.062	
533100000000	AMPHIPODA	06/11/78	2	5	0.19	0.068	0.10	10	0.136	
533100000000	AMPHIPODA	06/11/78	1	1	0.04	0.001	0.00	2	0.002	
533100000000	AMPHIPODA	06/11/78	3	5	0.19	0.029	0.04	10	0.058	
		SUBTOTAL		44	1.67	0.165	0.25	88	0.330	
6803090000F0	OPHIURIDAE FRAGS	06/11/78	1	1	0.04	0.040	0.06	2	0.080	
6803090000F0	OPHIURIDAE FRAGS	06/11/78	5	1	0.04	0.298	0.46	2	0.596	
		SUBTOTAL		2	0.08	0.338	0.52	4	0.676	
680309000000	OPHIURIDAE	06/11/78	4	2	0.08	0.017	0.03	4	0.034	
680309000000	OPHIURIDAE	06/11/78	3	4	0.15	0.055	0.08	8	0.110	
		SUBTOTAL		6	0.23	0.072	0.11	12	0.144	
		STATION TOTAL		2630		64.877		5260	129.754	

SIMPSON INDEX 0.563487 SHANNON DIVERSITY INDEX 1.279623

CRUISE 261 STATION 38

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
4000000000F0	RHYNCHOCOELA FRAGS.	06/11/78	1	1	0.07	0.192	0.19	2	0.384	X X
4000000000F0	RHYNCHOCOELA FRAGS.	06/11/78	5	1	0.07	0.016	0.02	2	0.032	X X
4000000000F0	RHYNCHOCOELA FRAGS.	06/11/78	4	1	0.07	0.083	0.08	2	0.166	X X
4000000000F0	RHYNCHOCOELA FRAGS.	06/11/78	3	1	0.07	0.097	0.09	2	0.194	X X
		SUBTOTAL		4	0.27	0.388	0.37	8	0.776	
4000000000000	RHYNCHOCOELA	06/11/78	2	3	0.21	0.057	0.06	6	0.114	
4000000000000	RHYNCHOCOELA	06/11/78	5	3	0.21	0.043	0.04	6	0.086	
4000000000000	RHYNCHOCOELA	06/11/78	1	1	0.07	0.001	0.00	2	0.002	
		SUBTOTAL		7	0.48	0.101	0.10	14	0.202	
4801000000F0	POLYCHAETA FRAG.	06/11/78	1	1	0.07	0.048	0.05	2	0.096	X
4801000000F0	POLYCHAETA FRAG.	06/11/78	5	1	0.07	0.029	0.03	2	0.058	X
4801000000F0	POLYCHAETA FRAG.	06/11/78	2	1	0.07	0.008	0.01	2	0.016	X
4801000000F0	POLYCHAETA FRAG.	06/11/78	4	1	0.07	0.027	0.03	2	0.054	X
		SUBTOTAL		4	0.27	0.112	0.11	8	0.224	
480101000000	POLYNOIDAE	06/11/78	4	2	0.14	0.006	0.01	4	0.012	
480101000000	POLYNOIDAE	06/11/78	2	1	0.07	0.030	0.03	2	0.060	
480101000000	POLYNOIDAE	06/11/78	1	1	0.07	0.001	0.00	2	0.002	
		SUBTOTAL		4	0.27	0.037	0.04	8	0.074	
480101050500	EUNOE OERSTEDI	06/11/78	4	1	0.07	0.016	0.02	2	0.032	
480105000000	SIGALIONIDAE	06/11/78	5	4	0.27	0.024	0.02	8	0.048	
480112010000	ANAITIDES SP.	06/11/78	4	1	0.07	0.028	0.03	2	0.056	
480112020500	ETEONE LONGA	06/11/78	1	1	0.07	0.002	0.00	2	0.004	
480120010200	GYPTIS BREVIPAIPA	06/11/78	1	1	0.07	0.003	0.00	2	0.006	
480120010200	GYPTIS BREVIPAIPA	06/11/78	5	1	0.07	0.004	0.00	2	0.008	
		SUBTOTAL		2	0.14	0.007	0.01	4	0.014	
480124010400	NEPHTYS CORNUTA	06/11/78	5	2	0.14	0.002	0.00	4	0.004	X X X X X
480124010400	NEPHTYS CORNUTA	06/11/78	4	11	0.75	0.018	0.02	22	0.036	X X X X X
480124010400	NEPHTYS CORNUTA	06/11/78	2	3	0.21	0.002	0.00	6	0.004	X X X X X
480124010400	NEPHTYS CORNUTA	06/11/78	3	2	0.14	0.006	0.01	4	0.012	X X X X X
480124010400	NEPHTYS CORNUTA	06/11/78	1	2	0.14	0.003	0.00	4	0.006	X X X X X
		SUBTOTAL		20	1.37	0.031	0.03	40	0.062	
480124010500	NEPHTYS PUNCTATA	06/11/78	1	1	0.07	1.514	1.46	2	3.028	
480124010500	NEPHTYS PUNCTATA	06/11/78	2	1	0.07	6.205	5.99	2	12.410	
		SUBTOTAL		2	0.14	7.719	7.45	4	15.438	
480126010100	GLYCERA CAPITATA	06/11/78	3	1	0.07	0.065	0.06	2	0.130	
480127010100	GLYCINDE PICTA	06/11/78	4	7	0.48	0.081	0.08	14	0.162	X
480127010100	GLYCINDE PICTA	06/11/78	2	2	0.14	0.032	0.03	4	0.064	X
480127010100	GLYCINDE PICTA	06/11/78	5	2	0.14	0.026	0.03	4	0.052	X
480127010100	GLYCINDE PICTA	06/11/78	1	3	0.21	0.018	0.02	6	0.036	X
		SUBTOTAL		14	0.96	0.157	0.15	28	0.314	

CRUISE 261 STATION 3B

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
4801300111900	LUMBRINERIS LUTI	06/11/78	1	22	1.51	0.298	0.29	44	0.596	X X X
4801300111900	LUMBRINERIS LUTI	06/11/78	5	40	2.74	0.471	0.45	80	0.942	X X X
4801300111900	LUMBRINERIS LUTI	06/11/78	2	24	1.64	0.369	0.36	48	0.738	X X X
4801300111900	LUMBRINERIS LUTI	06/11/78	4	28	1.92	0.460	0.44	56	0.920	X X X
4801300111900	LUMBRINERIS LUTI	06/11/78	3	21	1.44	0.272	0.26	42	0.544	X X X
		SUBTOTAL		135	9.25	1.870	1.80	270	3.740	
4801390102OO	HAPLOSCOLOPLOS ELONGATUS	06/11/78	4	2	0.14	0.087	0.08	4	0.174	
4801390102OO	HAPLOSCOLOPLOS ELONGATUS	06/11/78	2	1	0.07	0.004	0.00	2	0.008	
4801390102OO	HAPLOSCOLOPLOS ELONGATUS	06/11/78	5	2	0.14	0.042	0.04	4	0.084	
4801390102OO	HAPLOSCOLOPLOS ELONGATUS	06/11/78	1	4	0.27	0.176	0.17	8	0.352	
		SUBTOTAL		9	0.62	0.309	0.30	18	0.618	
4801390300OO	SCOLOPLOS FULIGINOSA	06/11/78	5	1	0.07	0.015	0.01	2	0.030	
4801420501OO	PRIONOSPIO MALMGREN	06/11/78	5	14	0.96	0.148	0.14	28	0.296	X X X
4801420501OO	PRIONOSPIO MALMGREN	06/11/78	2	7	0.48	0.124	0.12	14	0.248	X X X
4801420501OO	PRIONOSPIO MALMGREN	06/11/78	4	42	2.88	0.425	0.41	84	0.850	X X X
4801420501OO	PRIONOSPIO MALMGREN	06/11/78	3	10	0.69	0.088	0.08	20	0.176	X X X
4801420501OO	PRIONOSPIO MALMGREN	06/11/78	1	14	0.96	0.165	0.16	28	0.330	X X X
		SUBTOTAL		87	5.96	0.950	0.92	174	1.900	
4801420502OO	PRIONOSPIO CIRRIFERA	06/11/78	4	1	0.07	0.002	0.00	2	0.004	
4801421002OO	SPIOPHANES KROYER	06/11/78	4	6	0.41	0.110	0.11	12	0.220	
4801421002OO	SPIOPHANES KROYER	06/11/78	3	3	0.21	0.028	0.03	6	0.056	
4801421002OO	SPIOPHANES KROYER	06/11/78	2	3	0.21	0.090	0.09	6	0.180	
4801421002OO	SPIOPHANES KROYER	06/11/78	5	4	0.27	0.130	0.13	8	0.260	
4801421002OO	SPIOPHANES KROYER	06/11/78	1	4	0.27	0.085	0.08	8	0.170	
		SUBTOTAL		20	1.37	0.443	0.43	40	0.886	
4801430102OO	MAGELONA PACIFICA	06/11/78	1	2	0.14	0.024	0.02	4	0.048	
4801430102OO	MAGELONA PACIFICA	06/11/78	5	6	0.41	0.092	0.09	12	0.184	
4801430102OO	MAGELONA PACIFICA	06/11/78	2	2	0.14	0.015	0.01	4	0.030	
4801430102OO	MAGELONA PACIFICA	06/11/78	3	2	0.14	0.021	0.02	4	0.042	
		SUBTOTAL		12	0.82	0.152	0.15	24	0.304	
4801490000OO	CIRRATULIDAE	06/11/78	3	5	0.34	0.026	0.03	10	0.052	X X X
4801490000OO	CIRRATULIDAE	06/11/78	4	14	0.96	0.122	0.12	28	0.244	X X X
4801490000OO	CIRRATULIDAE	06/11/78	2	7	0.48	0.070	0.07	14	0.140	X X X
4801490000OO	CIRRATULIDAE	06/11/78	5	10	0.69	0.107	0.10	20	0.214	X X X
4801490000OO	CIRRATULIDAE	06/11/78	1	7	0.48	0.052	0.05	14	0.104	X X X
		SUBTOTAL		43	2.95	0.377	0.36	86	0.754	
4801550101OO	SCALIBREGMA INFLATUM	06/11/78	1	2	0.14	0.070	0.07	4	0.140	X X X X X
4801550101OO	SCALIBREGMA INFLATUM	06/11/78	5	2	0.14	0.097	0.09	4	0.194	X X X X X
4801550101OO	SCALIBREGMA INFLATUM	06/11/78	2	2	0.14	0.046	0.04	4	0.092	X X X X X
4801550101OO	SCALIBREGMA INFLATUM	06/11/78	4	4	0.27	0.273	0.26	8	0.546	X X X X X
4801550101OO	SCALIBREGMA INFLATUM	06/11/78	3	3	0.21	0.177	0.17	6	0.354	X X X X X
		SUBTOTAL		13	0.89	0.663	0.64	26	1.326	

CRUISE 261 STATION 3B

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480156010100	AMMOTRYPANE AULOGASTER	06/11/78	4	5	0.34	0.297	0.29	10	0.594	X
480156010100	AMMOTRYPANE AULOGASTER	06/11/78	5	1	0.07	0.063	0.06	2	0.126	X
480156010100	AMMOTRYPANE AULOGASTER	06/11/78	1	2	0.14	0.112	0.11	4	0.224	X
		SUBTOTAL		8	0.55	0.472	0.46	16	0.944	
480158010100	CAPITELLA CAPITATA	06/11/78	1	4	0.27	0.020	0.02	8	0.040	X
480158010100	CAPITELLA CAPITATA	06/11/78	2	3	0.21	0.134	0.13	6	0.268	X
		SUBTOTAL		7	0.48	0.154	0.15	14	0.308	
480158020100	HETEROMASTUS FILIFORMIS	06/11/78	3	7	0.48	0.186	0.18	14	0.372	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/11/78	5	7	0.48	0.267	0.26	14	0.534	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/11/78	4	9	0.62	0.096	0.09	18	0.192	X X X X
		SUBTOTAL		23	1.58	0.549	0.53	46	1.098	
480158030000	NOTOMASTUS SP.	06/11/78	4	6	0.41	0.025	0.02	12	0.050	
480158030000	NOTOMASTUS SP.	06/11/78	5	6	0.41	0.027	0.03	12	0.054	
480158030000	NOTOMASTUS SP.	06/11/78	3	3	0.21	0.012	0.01	6	0.024	
480158030000	NOTOMASTUS SP.	06/11/78	2	1	0.07	0.005	0.00	2	0.010	
480158030000	NOTOMASTUS SP.	06/11/78	1	6	0.41	0.021	0.02	12	0.042	
		SUBTOTAL		22	1.51	0.090	0.09	44	0.180	
480161080100	AXIOTHELLA CATENATA	06/11/78	1	9	0.62	1.344	1.30	18	2.688	
480161080100	AXIOTHELLA CATENATA	06/11/78	2	10	0.69	1.300	1.25	20	2.600	
480161080100	AXIOTHELLA CATENATA	06/11/78	3	7	0.48	0.423	0.41	14	0.846	
480161080100	AXIOTHELLA CATENATA	06/11/78	5	14	0.96	1.496	1.44	28	2.992	
480161080100	AXIOTHELLA CATENATA	06/11/78	4	13	0.89	1.804	1.74	26	3.608	
		SUBTOTAL		53	3.63	6.367	6.14	106	12.734	
480163010200	IDANTHYRSUS ARMATUS	06/11/78	4	1	0.07	0.009	0.01	2	0.018	
480165000000	AMPHARETIDAE	06/11/78	1	1	0.07	0.002	0.00	2	0.004	
480165020100	AMPHARETE ARCTICA	06/11/78	4	2	0.14	0.006	0.01	4	0.012	
480165020100	AMPHARETE ARCTICA	06/11/78	5	2	0.14	0.004	0.00	4	0.008	
		SUBTOTAL		4	0.27	0.010	0.01	8	0.020	
480165040100	LYSIPPE LABIATA	06/11/78	4	7	0.48	0.034	0.03	14	0.068	
480165040100	LYSIPPE LABIATA	06/11/78	3	3	0.21	0.005	0.00	6	0.010	
		SUBTOTAL		10	0.69	0.039	0.04	20	0.078	
480168010300	CHONE CINCTA	06/11/78	1	1	0.07	0.021	0.02	2	0.042	
480168010300	CHONE CINCTA	06/11/78	5	2	0.14	0.051	0.05	4	0.102	
		SUBTOTAL		3	0.21	0.072	0.07	6	0.144	
480168140100	LAONOME KROYERI	06/11/78	4	1	0.07	0.002	0.00	2	0.004	
480170000000	SERPULIDAE	06/11/78	4	2	0.14	0.001	0.00	4	0.002	
480175010100	COSSURA LONGOCIRRATA	06/11/78	5	1	0.07	0.001	0.00	2	0.002	

CRUISE 261 STATION 38

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
490402020100	NUCULA TENUIS	06/11/78	5	9	0.62	0.013	0.01	18	0.026	
490402020100	NUCULA TENUIS	06/11/78	4	4	0.27	0.005	0.00	8	0.010	
490402020100	NUCULA TENUIS	06/11/78	1	1	0.07	0.001	0.00	2	0.002	
490402020100	NUCULA TENUIS	06/11/78	2	2	0.14	0.002	0.00	4	0.004	
		SUBTOTAL		16	1.10	0.021	0.02	32	0.042	
490403020300	NUCULANA FOSSA	06/11/78	2	2	0.14	0.223	0.22	4	0.446	X X
490403020300	NUCULANA FOSSA	06/11/78	1	3	0.21	0.252	0.24	6	0.504	X X
490403020300	NUCULANA FOSSA	06/11/78	3	3	0.21	0.070	0.07	6	0.140	X X
490403020300	NUCULANA FOSSA	06/11/78	4	3	0.21	0.125	0.12	6	0.250	X X
490403020300	NUCULANA FOSSA	06/11/78	5	9	0.62	0.877	0.85	18	1.754	X X
		SUBTOTAL		20	1.37	1.547	1.49	40	3.094	
490407060100	MODIOLUS MODIOLUS	06/11/78	3	1	0.07	0.004	0.00	2	0.008	
490407060100	MODIOLUS MODIOLUS	06/11/78	2	1	0.07	0.001	0.00	2	0.002	
		SUBTOTAL		2	0.14	0.005	0.00	4	0.010	
490415020000	AXINOPSIDA SP.	06/11/78	2	72	4.93	0.308	0.30	144	0.616	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	1	204	13.98	0.737	0.71	408	1.474	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	3	209	14.32	0.785	0.76	418	1.570	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	5	253	17.34	0.763	0.74	506	1.526	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	4	130	8.91	0.698	0.67	260	1.396	X X X X
		SUBTOTAL		868	59.49	3.291	3.18	1736	6.582	
490415030100	THYASIRA FLEXUOSA	06/11/78	4	2	0.14	0.050	0.05	4	0.100	
490415030100	THYASIRA FLEXUOSA	06/11/78	5	1	0.07	0.145	0.14	2	0.290	
490415030100	THYASIRA FLEXUOSA	06/11/78	1	1	0.07	0.429	0.41	2	0.858	
		SUBTOTAL		4	0.27	0.624	0.60	8	1.248	
490424010100	MACOMA CALCAREA	06/11/78	1	3	0.21	22.318	21.54	6	44.636	X X
490424010100	MACOMA CALCAREA	06/11/78	3	1	0.07	3.807	3.67	2	7.614	X X
490424010100	MACOMA CALCAREA	06/11/78	5	3	0.21	4.156	4.01	6	8.312	X X
490424010100	MACOMA CALCAREA	06/11/78	4	3	0.21	8.380	8.09	6	16.760	X X
		SUBTOTAL		10	0.69	38.661	37.31	20	77.322	
490424010300	MACOMA BROTA	06/11/78	3	1	0.07	37.685	36.37	2	75.370	X X
490504010000	ACMAEA SP.	06/11/78	5	1	0.07	0.001	0.00	2	0.002	
531802010000	BALANUS SP.	06/11/78	4	1	0.07	0.025	0.02	2	0.050	X X
533100000000	AMPHIPODA	06/11/78	4	2	0.14	0.004	0.00	4	0.008	
533100000000	AMPHIPODA	06/11/78	5	3	0.21	0.013	0.01	6	0.026	
533100000000	AMPHIPODA	06/11/78	3	1	0.07	0.002	0.00	2	0.004	
		SUBTOTAL		6	0.41	0.019	0.02	12	0.038	
533311020000	PAGURUS SP.	06/11/78	4	3	0.21	0.170	0.16	6	0.340	
533321030000	PINNIXA SP.	06/11/78	4	1	0.07	0.016	0.02	2	0.032	

CRUISE 261 STATION 38

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME
680309000000	OPHIURIDAE
680309000000	OPHIURIDAE

SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERI.
06/11/78	4	2	0.14	0.071	0.07	4	0.142	
06/11/78	1	2	0.14	0.242	0.23	4	0.484	
SUBTOTAL		4	0.27	0.313	0.30	8	0.626	
STATION TOTAL		1459		103.614		2918	207.228	

SIMPSON INDEX 0.369512 SHANNON DIVERSITY INDEX 1.849111

CRUISE 261 STATION 3BF

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
340000000000	CTENOPHORA	06/12/78	3	1	0.20	1.574	7.91	3	5.247	
400000000F0	RHYNCHOCOELA FRAGS.	06/12/78	3	1	0.20	0.170	0.85	3	0.567	X X
4801003000F0	POLYCHAETA FRAG.	06/12/78	3	1	0.20	0.050	0.25	3	0.167	X
4801000000F0	POLYCHAETA FRAG.	06/12/78	2	1	0.20	0.049	0.25	3	0.163	X
4801000000F0	POLYCHAETA FRAG.	06/12/78	1	1	0.20	0.046	0.23	3	0.153	X
		SUBTOTAL		3	0.61	0.145	0.73	10	0.483	
480101000000	POLYNOIDAE	06/12/78	3	1	0.20	0.009	0.05	3	0.030	
480101150200	POLYNOE GRACILIS	06/12/78	1	3	0.61	0.020	0.10	10	0.067	
480105010100	PHLOE MINUTA	06/12/78	1	1	0.20	0.002	0.01	3	0.007	X
480112020500	ETEONE LONGA	06/12/78	1	4	0.81	0.006	0.03	13	0.020	
480112020500	ETEONE LONGA	06/12/78	2	2	0.40	0.003	0.02	7	0.010	
		SUBTOTAL		6	1.21	0.009	0.05	20	0.030	
480124010400	NEPHTYS CORNUTA	06/12/78	2	20	4.05	0.040	0.20	67	0.133	X X X X X
480124010400	NEPHTYS CORNUTA	06/12/78	3	22	4.45	0.056	0.28	73	0.187	X X X X X
480124010400	NEPHTYS CORNUTA	06/12/78	1	54	10.93	0.175	0.88	180	0.583	X X X X X
		SUBTOTAL		96	19.43	0.271	1.36	320	0.903	
480127010100	GLYCINDE PICTA	06/12/78	1	2	0.40	0.075	0.38	7	0.250	X
480127010100	GLYCINDE PICTA	06/12/78	3	1	0.20	0.011	0.06	3	0.037	X
480127010100	GLYCINDE PICTA	06/12/78	2	3	0.61	0.016	0.08	10	0.053	X
		SUBTOTAL		6	1.21	0.102	0.51	20	0.340	
480130011900	LUMBRINERIS LUTI	06/12/78	2	1	0.20	0.002	0.01	3	0.007	X X X
480130011900	LUMBRINERIS LUTI	06/12/78	3	4	0.81	0.065	0.33	13	0.217	X X X
480130011900	LUMBRINERIS LUTI	06/12/78	1	2	0.40	0.028	0.14	7	0.093	X X X
		SUBTOTAL		7	1.42	0.095	0.48	23	0.317	
480140000000	PARAONIDAE	06/12/78	2	1	0.20	0.006	0.03	3	0.020	
480140020400	ARICIDEA JEFFREYSII	06/12/78	1	1	0.20	0.002	0.01	3	0.007	•
480142050100	PRIONOSPIO MALMGRENI	06/12/78	1	5	1.01	0.015	0.08	17	0.050	X X X
480142050100	PRIONOSPIO MALMGRENI	06/12/78	2	9	1.82	0.066	0.33	30	0.220	X X X
480142050100	PRIONOSPIO MALMGRENI	06/12/78	3	6	1.21	0.021	0.11	20	0.070	X X X
		SUBTOTAL		20	4.05	0.102	0.51	67	0.340	
480142050200	PRIONOSPIO CIRRIFERA	06/12/78	3	3	0.61	0.002	0.01	10	0.007	
480142050200	PRIONOSPIO CIRRIFERA	06/12/78	1	12	2.43	0.010	0.05	40	0.033	
		SUBTOTAL		15	3.04	0.012	0.06	50	0.040	
480142100200	SPIOPHANES KROYERI	06/12/78	2	1	0.20	0.002	0.01	3	0.007	

CRUISE 261 STATION 3BF

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480149000000	CIRRATULIDAE	06/12/78	2	11	2.23	0.028	0.14	37	0.093	X X X
480149000000	CIRRATULIDAE	06/12/78	3	18	3.64	0.068	0.34	60	0.227	X X X
480149000000	CIRRATULIDAE	06/12/78	1	36	7.29	0.086	0.43	120	0.287	X X X
		SUBTOTAL		65	13.16	0.182	0.92	217	0.607	
480149040100	CHAETOZONE SETOSA	06/12/78	1	7	1.42	0.042	0.21	23	0.140	
480149040100	CHAETOZONE SETOSA	06/12/78	3	3	0.61	0.022	0.11	10	0.073	
480149040100	CHAETOZONE SETOSA	06/12/78	2	1	0.20	0.004	0.02	3	0.013	
		SUBTOTAL		11	2.23	0.068	0.34	37	0.227	
480155010100	SCALIBREGMA INFLATUM	06/12/78	2	1	0.20	0.053	0.27	3	0.177	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/12/78	3	12	2.43	2.118	10.65	40	7.060	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/12/78	1	11	2.23	2.321	11.67	37	7.737	X X X X X
		SUBTOTAL		24	4.86	4.492	22.59	80	14.973	
480158010100	CAPITELLA CAPITATA	06/12/78	2	2	0.40	0.008	0.04	7	0.027	X
480158020100	HETEROMASTUS FILIFORMIS	06/12/78	2	32	6.48	0.918	4.62	107	3.060	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/12/78	3	66	13.36	3.677	18.49	220	12.257	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/12/78	1	42	8.50	3.776	18.99	140	12.587	X X X X
		SUBTOTAL		140	28.34	8.371	42.09	467	27.903	
480175010100	COSSURA LONGOCIRRATA	06/12/78	1	3	0.61	0.001	0.01	10	0.003	
480175010100	COSSURA LONGOCIRRATA	06/12/78	3	2	0.40	0.001	0.01	7	0.003	
		SUBTOTAL		5	1.01	0.002	0.01	17	0.007	
490402020100	NUCULA TENUIS	06/12/78	2	1	0.20	0.002	0.01	3	0.007	
490402020100	NUCULA TENUIS	06/12/78	1	1	0.20	0.001	0.01	3	0.003	
		SUBTOTAL		2	0.40	0.003	0.02	7	0.010	
490403040000	TINDARIA SP.	06/12/78	3	4	0.81	0.007	0.04	13	0.023	
490403050700	YOLDIA THRACIAEFORMIS	06/12/78	3	1	0.20	1.201	6.04	3	4.003	X
490415020000	AXINOPSIDA SP.	06/12/78	3	20	4.05	0.166	0.83	67	0.553	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	2	35	7.09	0.220	1.11	117	0.733	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	1	15	3.04	0.080	0.40	50	0.267	X X X X
		SUBTOTAL		70	14.17	0.466	2.34	233	1.553	
490424010000	MACOMA SP.	06/12/78	2	1	0.20	0.004	0.02	3	0.013	X X
490424010000	MACOMA SP.	06/12/78	3	1	0.20	0.001	0.01	3	0.003	X X
		SUBTOTAL		2	0.40	0.005	0.03	7	0.017	
530000000000	CRUSTACEA	06/12/78	2	2	0.40	2.558	12.86	7	8.527	X
533100000000	AMPHIPODA	06/12/78	3	2	0.40	0.003	0.02	7	0.010	
680309000FO	OPHIURIDAE FRAGS	06/12/78	1	1	0.20	0.001	0.01	3	0.003	
	STATION TOTAL			494		19.888		1647	66.293	

SIMPSON INDEX 0.160046 SHANNON DIVERSITY INDEX 2.226502

CRUISE 261 STATION 3C

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
3303000000F0	ANTHOZOA FRAGS	06/12/78	5	1	0.12	0.461	0.13	2	0.922	
3303000000000	ANTHOZOA	06/12/78	5	1	0.12	191.000	54.67	2	382.000	X X
4000000000F0	RHYNCHOCOELA FRAGS.	06/12/78	5	1	0.12	0.082	0.02	2	0.164	X X
4000000000F0	RHYNCHOCOELA FRAGS.	06/12/78	4	1	0.12	0.183	0.05	2	0.366	X X
4000000000F0	RHYNCHOCOELA FRAGS.	06/12/78	3	1	0.12	0.214	0.06	2	0.428	X X
4000000000F0	RHYNCHOCOELA FRAGS.	06/12/78	1	1	0.12	0.036	0.01	2	0.072	X X
4000000000F0	RHYNCHOCOELA FRAGS.	06/12/78	2	1	0.12	0.123	0.04	2	0.246	X X
		SUBTOTAL		5	0.61	0.638	0.18	10	1.276	
4000000000000	RHYNCHOCOELA	06/12/78	4	1	0.12	0.002	0.00	2	0.004	
4400000000000	NEMATODA	06/12/78	5	7	0.85	0.002	0.00	14	0.004	
4801000000F0	POLYCHAETA FRAG.	06/12/78	5	1	0.12	0.027	0.01	2	0.054	X
4801000000F0	POLYCHAETA FRAG.	06/12/78	4	1	0.12	0.152	0.04	2	0.304	X
4801000000F0	POLYCHAETA FRAG.	06/12/78	3	1	0.12	0.038	0.01	2	0.076	X
4801000000F0	POLYCHAETA FRAG.	06/12/78	2	1	0.12	0.086	0.02	2	0.172	X
4801000000F0	POLYCHAETA FRAG.	06/12/78	1	1	0.12	0.060	0.02	2	0.120	X
		SUBTOTAL		5	0.61	0.363	0.10	10	0.726	
4801010000000	POLYNOIDAE	06/12/78	1	1	0.12	0.002	0.00	2	0.004	
4801010000000	POLYNOIDAE	06/12/78	2	5	0.61	0.082	0.02	10	0.164	
4801010000000	POLYNOIDAE	06/12/78	3	4	0.49	0.017	0.00	8	0.034	
4801010000000	POLYNOIDAE	06/12/78	4	2	0.24	0.020	0.01	4	0.040	
4801010000000	POLYNOIDAE	06/12/78	5	3	0.37	0.051	0.01	6	0.102	
		SUBTOTAL		15	1.83	0.172	0.05	30	0.344	
4801050101000	PHLOE MINUTA	06/12/78	4	1	0.12	0.004	0.00	2	0.008	X
4801200102000	GYPTIS BREVIPALPA	06/12/78	1	1	0.12	0.003	0.00	2	0.006	
4801240104000	NEPHTYS CORNUTA	06/12/78	1	6	0.73	0.020	0.01	12	0.040	X X X X X
4801240104000	NEPHTYS CORNUTA	06/12/78	2	23	2.80	0.064	0.02	46	0.128	X X X X X
4801240104000	NEPHTYS CORNUTA	06/12/78	4	29	3.54	0.091	0.03	58	0.182	X X X X X
4801240104000	NEPHTYS CORNUTA	06/12/78	3	5	0.61	0.018	0.01	10	0.036	X X X X X
4801240104000	NEPHTYS CORNUTA	06/12/78	5	27	3.29	0.084	0.02	54	0.168	X X X X X
		SUBTOTAL		90	10.98	0.277	0.08	180	0.554	
4801240105000	NEPHTYS PUNCTATA	06/12/78	1	1	0.12	9.358	2.68	2	18.716	
4801260000000	GLYCERIDAE	06/12/78	5	1	0.12	0.002	0.00	2	0.004	
4801260000000	GLYCERIDAE	06/12/78	3	2	0.24	0.016	0.00	4	0.032	
		SUBTOTAL		3	0.37	0.018	0.01	6	0.036	
4801270101000	GLYCINDE PICTA	06/12/78	2	2	0.24	0.009	0.00	4	0.018	X
4801300119000	LUMBRINERIS LUTI	06/12/78	2	1	0.12	0.009	0.00	2	0.018	X X X
4801300119000	LUMBRINERIS LUTI	06/12/78	1	1	0.12	0.007	0.00	2	0.014	X X X
4801300119000	LUMBRINERIS LUTI	06/12/78	4	1	0.12	0.013	0.00	2	0.026	X X X
4801300119000	LUMBRINERIS LUTI	06/12/78	5	2	0.24	0.038	0.01	4	0.076	X X X
		SUBTOTAL		5	0.61	0.067	0.02	10	0.134	

CRUISE 261 STATION 3C

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480142000000	SPIONIDAE	06/12/78	1	1	0.12	0.012	0.00	2	0.024	
480142020000	LAONICE SP.	06/12/78	2	1	0.12	0.002	0.00	2	0.004	
480142050100	PRIONOSPIO MALMGRENI	06/12/78	2	9	1.10	0.040	0.01	18	0.080	X X X
480142050100	PRIONOSPIO MALMGRENI	06/12/78	1	1	0.12	0.021	0.01	2	0.042	X X X
480142050100	PRIONOSPIO MALMGRENI	06/12/78	5	10	1.22	0.064	0.02	20	0.128	X X X
480142050100	PRIONOSPIO MALMGRENI	06/12/78	4	10	1.22	0.084	0.02	20	0.168	X X X
480142050100	PRIONOSPIO MALMGRENI	06/12/78	3	2	0.24	0.003	0.00	4	0.006	X X X
		SUBTOTAL		32	3.90	0.212	0.06	64	0.424	
480142050200	PRIONOSPIO CIRRIFERA	06/12/78	4	12	1.46	0.010	0.00	24	0.020	
480142050200	PRIONOSPIO CIRRIFERA	06/12/78	1	1	0.12	0.001	0.00	2	0.002	
		SUBTOTAL		13	1.59	0.011	0.00	26	0.022	
480142100100	SPIOPHANES BOMBYX	06/12/78	1	1	0.12	0.001	0.00	2	0.002	
480142100200	SPIOPHANES KROYERI	06/12/78	2	1	0.12	0.043	0.01	2	0.086	
480142100200	SPIOPHANES KROYERI	06/12/78	5	2	0.24	0.007	0.00	4	0.014	
		SUBTOTAL		3	0.37	0.050	0.01	6	0.100	
480149000000	CIRRATULIDAE	06/12/78	5	25	3.05	0.129	0.04	50	0.258	X X X
480149000000	CIRRATULIDAE	06/12/78	2	35	4.27	0.200	0.06	70	0.400	X X X
480149000000	CIRRATULIDAE	06/12/78	4	31	3.78	0.128	0.04	62	0.256	X X X
480149000000	CIRRATULIDAE	06/12/78	3	12	1.46	0.078	0.02	24	0.156	X X X
480149000000	CIRRATULIDAE	06/12/78	1	22	2.68	0.096	0.03	44	0.192	X X X
		SUBTOTAL		125	15.24	0.631	0.18	250	1.262	
480149040100	CHAETOZONE SETOSA	06/12/78	1	3	0.37	0.041	0.01	6	0.082	
480149040100	CHAETOZONE SETOSA	06/12/78	5	3	0.37	0.030	0.01	6	0.060	
480149040100	CHAETOZONE SETOSA	06/12/78	4	7	0.85	0.047	0.01	14	0.094	
		SUBTOTAL		13	1.59	0.118	0.03	26	0.236	
480155010100	SCALIBREGMA INFLATUM	06/12/78	4	19	2.32	2.863	0.82	38	5.726	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/12/78	5	19	2.32	1.802	0.52	38	3.604	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/12/78	3	37	4.51	4.280	1.23	74	8.560	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/12/78	2	24	2.93	4.068	1.16	48	8.136	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/12/78	1	21	2.56	1.881	0.54	42	3.762	X X X X X
		SUBTOTAL		120	14.63	14.894	4.26	240	29.788	
480156010100	AMMOTRYPANE AULOGASTER	06/12/78	2	2	0.24	0.141	0.04	4	0.282	X
480156010100	AMMOTRYPANE AULOGASTER	06/12/78	5	1	0.12	0.055	0.02	2	0.110	X
		SUBTOTAL		3	0.37	0.196	0.06	6	0.392	
480158020100	HETEROMASTUS FILIFORMIS	06/12/78	5	81	9.88	2.480	0.71	162	4.960	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/12/78	4	49	5.98	0.320	0.09	98	0.640	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/12/78	2	56	6.83	2.475	0.71	112	4.950	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/12/78	3	96	11.71	5.436	1.56	192	10.872	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/12/78	1	25	3.05	1.310	0.37	50	2.620	X X X X
		SUBTOTAL		307	37.44	12.021	3.44	614	24.042	

CRUISE 261 STATION 3C

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480175010100	COSSURA LONGOCIRRATA	06/12/78	4	2	0.24	0.001	0.00	4	0.002	
490403000000	NUCULANIDAE	06/12/78	5	2	0.24	0.005	0.00	4	0.010	
490403000000	NUCULANIDAE	06/12/78	3	1	0.12	0.001	0.00	2	0.002	
490403000000	NUCULANIDAE	06/12/78	2	4	0.49	0.009	0.00	8	0.018	
490403000000	NUCULANIDAE	06/12/78	1	3	0.37	0.005	0.00	6	0.010	
		SUBTOTAL		10	1.22	0.020	0.01	20	0.040	
490403020300	NUCULANA FOSSA	06/12/78	4	1	0.12	0.016	0.00	2	0.032	X X
490403050700	YOLDIA THRACIAFFORMIS	06/12/78	4	1	0.12	19.485	5.58	2	38.970	X
490403050700	YOLDIA THRACIAFFORMIS	06/12/78	5	1	0.12	19.791	5.67	2	39.582	X
490403050700	YOLDIA THRACIAFFORMIS	06/12/78	2	1	0.12	8.042	2.30	2	16.084	X
		SUBTOTAL		3	0.37	47.318	13.55	6	94.636	
490415020000	AXINOPSIDA SP.	06/12/78	2	8	0.98	0.070	0.02	16	0.140	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	3	7	0.85	0.107	0.03	14	0.214	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	5	1	0.12	0.001	0.00	2	0.002	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	4	8	0.98	0.073	0.02	16	0.146	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	1	5	0.61	0.022	0.01	10	0.044	X X X X
		SUBTOTAL		29	3.54	0.273	0.08	58	0.546	
490423010000	SPISULA SP.	06/12/78	4	1	0.12	0.001	0.00	2	0.002	X X
490424010100	MACOMA CALCAREA	06/12/78	1	1	0.12	3.701	1.06	2	7.402	X X
490424010300	MACOMA BROTA	06/12/78	3	1	0.12	41.655	11.92	2	83.310	X X
490424010300	MACOMA BROTA	06/12/78	2	1	0.12	24.846	7.11	2	49.692	X X
		SUBTOTAL		2	0.24	66.501	19.04	4	133.002	
490424011300	MACOMA CARLOTTENSIS	06/12/78	2	1	0.12	0.558	0.16	2	1.116	
490500000000	GASTROPODA	06/12/78	4	2	0.24	0.002	0.00	4	0.004	
533100000000	AMPHIPODA	06/12/78	4	6	0.73	0.011	0.00	12	0.022	
533100000000	AMPHIPODA	06/12/78	5	1	0.12	0.002	0.00	2	0.004	
		SUBTOTAL		7	0.85	0.013	0.00	14	0.026	
533300000000	DECAPODA	06/12/78	4	1	0.12	0.288	0.08	2	0.576	
9999999999F0	UNIDENTIFIED FRAGS.	06/12/78	5	1	0.12	0.123	0.04	2	0.246	
999999999900	UNIDENTIFIED	06/12/78	1	2	0.24	0.002	0.00	4	0.004	
		STATION TOTAL		820		349.339		1640	698.678	

SIMPSON INDEX 0.200015 SHANNON DIVERSITY INDEX 2.134240

CRUISE 261 STATION 3E

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
999900000000	NO FAUNA COLLECTED IN THIS GRAB	06/11/78	1	0	******	0.	******	0	0.	X X X X

CRUISE 261 STATION 3F

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
310431000000	FORAMINIFERA	06/11/78	2	1	0.04	0.001	0.00	2	0.002	X X
400000000000	RHYNCHOCOELA	06/11/78	5	2	0.09	0.041	0.04	4	0.082	
480000000FF0	ANNELIDA FRAGS	06/11/78	2	1	0.04	0.818	0.83	2	1.636	
480000000FF0	ANNELIDA FRAGS	06/11/78	1	1	0.04	0.622	0.63	2	1.244	
		SUBTOTAL		2	0.09	1.440	1.45	4	2.880	
4801000000F0	POLYCHAETA FRAG.	06/11/78	5	1	0.04	0.183	0.18	2	0.366	X
4801000000F0	POLYCHAETA FRAG.	06/11/78	4	1	0.04	0.124	0.13	2	0.248	X
		SUBTOTAL		2	0.09	0.307	0.31	4	0.614	
480101000000	POLYNOIDAE	06/11/78	1	3	0.13	0.021	0.02	6	0.042	
480101000000	POLYNOIDAE	06/11/78	2	3	0.13	0.019	0.02	6	0.038	
480101000000	POLYNOIDAE	06/11/78	3	7	0.31	0.020	0.02	14	0.040	
		SUBTOTAL		13	0.57	0.060	0.06	26	0.120	
480101020000	NEMIDIA SP.	06/11/78	4	1	0.04	0.005	0.01	2	0.010	
480120010200	GYPTIS BREVIPALPA	06/11/78	5	2	0.09	0.003	0.00	4	0.006	
480124010400	NEPHTYS CORNUTA	06/11/78	4	2	0.09	0.004	0.00	4	0.008	X X X X X
480124010400	NEPHTYS CORNUTA	06/11/78	3	1	0.04	0.001	0.00	2	0.002	X X X X X
480124010400	NEPHTYS CORNUTA	06/11/78	2	1	0.04	0.001	0.00	2	0.002	X X X X X
		SUBTOTAL		4	0.17	0.006	0.01	8	0.012	
480124010500	NEPHTYS PUNCTATA	06/11/78	1	1	0.04	2.123	2.14	2	4.246	
480124010500	NEPHTYS PUNCTATA	06/11/78	4	1	0.04	0.733	0.74	2	1.466	
		SUBTOTAL		2	0.09	2.856	2.88	4	5.712	
480126010100	GLYCERA CAPITATA	06/11/78	4	2	0.09	0.065	0.07	4	0.130	
480126010100	GLYCERA CAPITATA	06/11/78	2	1	0.04	0.066	0.07	2	0.132	
		SUBTOTAL		3	0.13	0.131	0.13	6	0.262	
480127010100	GLYCINDE PICTA	06/11/78	2	16	0.70	0.236	0.24	32	0.472	X
480127010100	GLYCINDE PICTA	06/11/78	1	7	0.31	0.214	0.22	14	0.428	X
480127010100	GLYCINDE PICTA	06/11/78	3	4	0.17	0.110	0.11	8	0.220	X
480127010100	GLYCINDE PICTA	06/11/78	4	4	0.17	0.072	0.07	8	0.144	X
480127010100	GLYCINDE PICTA	06/11/78	5	8	0.35	0.095	0.10	16	0.190	X
		SUBTOTAL		39	1.70	0.727	0.73	78	1.454	
480127010300	GLYCINDE ARMIGERA	06/11/78	5	1	0.04	0.002	0.00	2	0.004	
480130010FF0	LUMBRINERIS SP. FRAGS.	06/11/78	5	1	0.04	0.292	0.29	2	0.584	
480130011900	LUMBRINERIS LUTI	06/11/78	5	71	3.10	0.453	0.46	142	0.906	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	4	22	0.96	0.307	0.31	44	0.614	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	3	21	0.92	0.142	0.14	42	0.284	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	1	72	3.15	0.554	0.56	144	1.108	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	2	62	2.71	0.595	0.60	124	1.190	X X X
		SUBTOTAL		248	10.83	2.051	2.07	496	4.102	

CRUISE 261 STATION 3F

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	2	5	0.22	0.304	0.31	10	0.608	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	1	4	0.17	0.122	0.12	8	0.244	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	3	1	0.04	0.021	0.02	2	0.042	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	5	7	0.31	0.325	0.33	14	0.650	
		SUBTOTAL		17	0.74	0.772	0.78	34	1.544	
480139030000	SCOLOPLOS FULIGINOSA	06/11/78	1	1	0.04	0.017	0.02	2	0.034	
480139030000	SCOLOPLOS FULIGINOSA	06/11/78	2	2	0.09	0.011	0.01	4	0.022	
		SUBTOTAL		3	0.13	0.028	0.03	6	0.056	
480142000F0	SPIONIDAE FRAGS	06/11/78	5	1	0.04	0.590	0.60	2	1.180	
480142000F0	SPIONIDAE FRAGS	06/11/78	4	1	0.04	0.109	0.11	2	0.218	
		SUBTOTAL		2	0.09	0.699	0.71	4	1.398	
480142040000	POLYDORA SP.	06/11/78	1	2	0.09	0.027	0.03	4	0.054	
480142050100	PRIONOSPIO MALMGRENI	06/11/78	1	28	1.22	0.126	0.13	56	0.252	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	2	21	0.92	0.158	0.16	42	0.316	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	3	16	0.70	0.159	0.16	32	0.318	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	4	12	0.52	0.078	0.08	24	0.156	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	5	34	1.49	0.189	0.19	68	0.378	X X X
		SUBTOTAL		111	4.85	0.710	0.72	222	1.420	
480142070100	SPIO FILICORNIS	06/11/78	5	7	0.31	0.046	0.05	14	0.092	
480142100200	SPIOPHANES KROYERI	06/11/78	3	8	0.35	0.344	0.35	16	0.688	
480142100200	SPIOPHANES KROYERI	06/11/78	2	64	2.80	2.401	2.42	128	4.802	
480142100200	SPIOPHANES KROYERI	06/11/78	1	36	1.57	0.855	0.86	72	1.710	
		SUBTOTAL		108	4.72	3.600	3.63	216	7.200	
480142100300	SPIOPHANES CIRRATA	06/11/78	5	27	1.18	0.695	0.70	54	1.390	
480142100300	SPIOPHANES CIRRATA	06/11/78	4	15	0.66	0.174	0.18	30	0.348	
		SUBTOTAL		42	1.83	0.869	0.88	84	1.738	
480143010200	MAGELONA PACIFICA	06/11/78	4	7	0.31	0.039	0.04	14	0.078	
480143010200	MAGELONA PACIFICA	06/11/78	5	11	0.48	0.120	0.12	22	0.240	
480143010200	MAGELONA PACIFICA	06/11/78	1	2	0.09	0.014	0.01	4	0.028	
480143010200	MAGELONA PACIFICA	06/11/78	2	8	0.35	0.085	0.09	16	0.170	
480143010200	MAGELONA PACIFICA	06/11/78	3	1	0.04	0.011	0.01	2	0.022	
		SUBTOTAL		29	1.27	0.269	0.27	58	0.538	
480149000000	CIRRATULIDAE	06/11/78	5	15	0.66	0.129	0.13	30	0.258	X X X
480149030000	THARYX SP.	06/11/78	4	9	0.39	0.027	0.03	18	0.054	X
480149030000	THARYX SP.	06/11/78	3	21	0.92	0.120	0.12	42	0.240	X
480149030000	THARYX SP.	06/11/78	2	16	0.70	0.080	0.08	32	0.160	X
480149030000	THARYX SP.	06/11/78	1	23	1.00	0.160	0.16	46	0.320	X
		SUBTOTAL		69	3.01	0.387	0.39	138	0.774	

CRUISE 261 STATION 3F PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480155010100	SCALIBREGMA INFLATUM	06/11/78	1	10	0.44	0.583	0.59	20	1.166	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/11/78	2	9	0.39	0.317	0.32	18	0.634	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/11/78	3	11	0.48	1.284	1.30	22	2.568	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/11/78	4	4	0.17	0.116	0.12	8	0.232	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/11/78	5	17	0.74	0.684	0.69	34	1.368	X X X X X
		SUBTOTAL		51	2.23	2.984	3.01	102	5.968	
480156010100	AMMOTRYPANE AULOGASTER	06/11/78	5	1	0.04	0.067	0.07	2	0.134	X
480156010100	AMMOTRYPANE AULOGASTER	06/11/78	3	1	0.04	0.067	0.07	2	0.134	X
		SUBTOTAL		2	0.09	0.134	0.14	4	0.268	
480158000FO	CAPITELLIDAE FRAGS	06/11/78	4	1	0.04	0.106	0.11	2	0.212	
480158000000	CAPITELLIDAE	06/11/78	5	1	0.04	0.003	0.00	2	0.006	
480158010100	CAPITELLA CAPITATA	06/11/78	3	22	0.96	0.420	0.42	44	0.840	X
480158010100	CAPITELLA CAPITATA	06/11/78	2	10	0.44	0.124	0.13	20	0.248	X
480158010100	CAPITELLA CAPITATA	06/11/78	1	5	0.22	0.118	0.12	10	0.236	X
		SUBTOTAL		37	1.62	0.662	0.67	74	1.324	
480158020000	HETEROMASTUS SP. FRAGS	06/11/78	2	4	0.17	0.013	0.01	8	0.026	
480158020000	HETEROMASTUS SP. FRAGS	06/11/78	5	3	0.13	0.004	0.00	6	0.008	
480158020000	HETEROMASTUS SP. FRAGS	06/11/78	4	5	0.22	0.129	0.13	10	0.258	
		SUBTOTAL		12	0.52	0.146	0.15	24	0.292	
480158020100	HETEROMASTUS FILIFORMIS	06/11/78	4	9	0.39	0.198	0.20	18	0.396	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/11/78	5	21	0.92	0.171	0.17	42	0.342	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/11/78	3	9	0.39	0.307	0.31	18	0.614	X X X X
		SUBTOTAL		39	1.70	0.676	0.68	78	1.352	
480158030000	NOTOMASTUS SP.	06/11/78	1	3	0.13	0.006	0.01	6	0.012	
480158030000	NOTOMASTUS SP.	06/11/78	4	2	0.09	0.009	0.01	4	0.018	
		SUBTOTAL		5	0.22	0.015	0.02	10	0.030	
480158030600	NOTOMASTUS LAERIATUS	06/11/78	5	5	0.22	0.041	0.04	10	0.082	
480161000FO	MALDANIDAE FRAGS.	06/11/78	5	1	0.04	1.143	1.15	2	2.286	
480161080100	AXIOTHELLA CATENATA	06/11/78	5	1	0.04	0.657	0.66	2	1.314	
480161080100	AXIOTHELLA CATENATA	06/11/78	1	9	0.39	2.864	2.89	18	5.728	
480161080100	AXIOTHELLA CATENATA	06/11/78	2	15	0.66	2.605	2.63	30	5.210	
		SUBTOTAL		25	1.09	6.126	6.19	50	12.252	
480161090200	PRAXILLELLA PRAETERMISSA	06/11/78	4	7	0.31	0.347	0.35	14	0.694	
480165000000	AMPHARETIDAE	06/11/78	2	1	0.04	0.005	0.01	2	0.010	
480165020100	AMPHARETE ARCTICA	06/11/78	2	2	0.09	0.007	0.01	4	0.014	
480165020100	AMPHARETE ARCTICA	06/11/78	5	4	0.17	0.008	0.01	8	0.016	
		SUBTOTAL		6	0.26	0.015	0.02	12	0.030	

CRUISE 261 STATION 3F

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
4801680103 00	CHONE CINCTA	06/11/78	5	17	0.74	0.490	0.49	34	0.980	
4801680103 00	CHONE CINCTA	06/11/78	4	1	0.04	0.023	0.02	2	0.046	
4801680103 00	CHONE CINCTA	06/11/78	2	20	0.87	0.531	0.54	40	1.062	
4801680103 00	CHONE CINCTA	06/11/78	3	2	0.09	0.013	0.01	4	0.026	
4801680103 00	CHONE CINCTA	06/11/78	1	13	0.57	0.410	0.41	26	0.820	
		SUBTOTAL		53	2.32	1.467	1.48	106	2.934	
4904000000F0	PELECYPODA FRAGS.	06/11/78	3	1	0.04	0.340	0.34	2	0.680	
4904020201 00	NUCULA TENUIS	06/11/78	4	1	0.04	0.001	0.00	2	0.002	
4904020201 00	NUCULA TENUIS	06/11/78	2	3	0.13	0.006	0.01	6	0.012	
		SUBTOTAL		4	0.17	0.007	0.01	8	0.014	
4904030000 00	NUCULANIDAE	06/11/78	2	1	0.04	0.001	0.00	2	0.002	
4904030000 00	NUCULANIDAE	06/11/78	1	4	0.17	0.008	0.01	8	0.016	
4904030000 00	NUCULANIDAE	06/11/78	3	4	0.17	0.003	0.00	8	0.006	
4904030000 00	NUCULANIDAE	06/11/78	5	2	0.09	0.004	0.00	4	0.008	
		SUBTOTAL		11	0.48	0.016	0.02	22	0.032	
4904030203 00	NUCULANA FOSSA	06/11/78	5	13	0.57	1.128	1.14	26	2.256	X X
4904030203 00	NUCULANA FOSSA	06/11/78	3	1	0.04	0.048	0.05	2	0.096	X X
4904030203 00	NUCULANA FOSSA	06/11/78	4	1	0.04	0.087	0.09	2	0.174	X X
4904030203 00	NUCULANA FOSSA	06/11/78	1	3	0.13	0.094	0.09	6	0.188	X X
4904030203 00	NUCULANA FOSSA	06/11/78	2	8	0.35	1.012	1.02	16	2.024	X X
		SUBTOTAL		26	1.14	2.369	2.39	52	4.738	
4904030400 00	TINDARIA SP.	06/11/78	4	4	0.17	0.008	0.01	8	0.016	
4904150200 00	AXINOPSIDA SP.	06/11/78	4	185	8.08	0.877	0.89	370	1.754	X X X X
4904150200 00	AXINOPSIDA SP.	06/11/78	3	137	5.99	0.819	0.83	274	1.638	X X X X
4904150200 00	AXINOPSIDA SP.	06/11/78	5	350	15.29	1.488	1.50	700	2.976	X X X X
4904150200 00	AXINOPSIDA SP.	06/11/78	2	264	11.53	1.013	1.02	528	2.026	X X X X
4904150200 00	AXINOPSIDA SP.	06/11/78	1	313	13.67	1.330	1.34	626	2.660	X X X X
		SUBTOTAL		1249	54.57	5.527	5.58	2498	11.054	
4904240101 00	MACOMA CALCAREA	06/11/78	2	3	0.13	1.998	2.02	6	3.996	X X
4904240101 00	MACOMA CALCAREA	06/11/78	3	3	0.13	5.315	5.37	6	10.630	X X
4904240101 00	MACOMA CALCAREA	06/11/78	4	2	0.09	14.352	14.49	4	28.704	X X
		SUBTOTAL		8	0.35	21.665	21.87	16	43.330	
4904240103 00	MACOMA BROTA	06/11/78	3	2	0.09	39.726	40.11	4	79.452	X X
4905000000F0	GASTROPODA FRAGS	06/11/78	2	1	0.04	0.001	0.00	2	0.002	
5312000000 00	CYCLOPOIDA	06/11/78	2	1	0.04	0.001	0.00	2	0.002	
5901010101 00	GOLFINGIA MARGARITACEA	06/11/78	2	6	0.26	0.028	0.03	12	0.056	
5901010101 00	GOLFINGIA MARGARITACEA	06/11/78	1	2	0.09	0.020	0.02	4	0.040	
5901010101 00	GOLFINGIA MARGARITACEA	06/11/78	5	2	0.09	0.005	0.01	4	0.010	
		SUBTOTAL		10	0.44	0.053	0.05	20	0.106	
STATION TOTAL				2289		99.041		4578	198.082	

SIMPSON INDEX 0.317553 SHANNON DIVERSITY INDEX 1.990431

CRUISE 261 STATION 36

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480000000OF0	ANNELIDA FRAGS	06/11/78	3	1	0.28	0.834	2.05	2	1.668	
4801000000F0	POLYCHAETA FRAG.	06/11/78	4	1	0.28	0.001	0.00	2	0.002	X
480100000000	POLYCHAETA	06/11/78	5	1	0.28	0.003	0.01	2	0.006	
480124010400	NEPHTYS CORNUTA	06/11/78	5	1	0.28	0.002	0.00	2	0.004	X X X X X
480124010400	NEPHTYS CORNUTA	06/11/78	1	5	1.40	0.007	0.02	10	0.014	X X X X X
480124010400	NEPHTYS CORNUTA	06/11/78	2	1	0.28	0.002	0.00	2	0.004	X X X X X
		SUBTOTAL		7	1.97	0.011	0.03	14	0.022	
480126000000	GLYCERIDAE	06/11/78	3	1	0.28	0.003	0.01	2	0.006	
480127010100	GLYCINDE PICTA	06/11/78	3	2	0.56	0.031	0.08	4	0.062	X
480127010100	GLYCINDE PICTA	06/11/78	5	1	0.28	0.034	0.08	2	0.068	X
		SUBTOTAL		3	0.84	0.065	0.16	6	0.130	
480130011900	LUMBRINERIS LUTI	06/11/78	5	1	0.28	0.061	0.15	2	0.122	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	3	45	12.64	0.990	2.44	90	1.980	X X X
		SUBTOTAL		46	12.92	1.051	2.59	92	2.102	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	3	11	3.09	0.894	2.20	22	1.788	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	5	4	1.12	0.382	0.94	8	0.764	
		SUBTOTAL		15	4.21	1.276	3.14	30	2.552	
480142050100	PRIONOSPIO MALMGRENI	06/11/78	5	9	2.53	0.020	0.05	18	0.040	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	3	41	11.52	0.186	0.46	82	0.372	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	1	3	0.84	0.005	0.01	6	0.010	X X X
		SUBTOTAL		53	14.89	0.211	0.52	106	0.422	
480142100100	SPIOPHANES BOMBYX	06/11/78	3	1	0.28	0.010	0.02	2	0.020	
480143010200	MAGELONA PACIFICA	06/11/78	3	7	1.97	0.078	0.19	14	0.156	
480149030000	THARYX SP.	06/11/78	3	9	2.53	0.054	0.13	18	0.108	X
480149030000	THARYX SP.	06/11/78	5	17	4.78	0.112	0.28	34	0.224	X
		SUBTOTAL		26	7.30	0.166	0.41	52	0.332	
480158000OF0	CAPITELLIDAE FRAGS	06/11/78	2	1	0.28	0.133	0.33	2	0.266	
480158000OF0	CAPITELLIDAE FRAGS	06/11/78	1	1	0.28	0.116	0.29	2	0.232	
		SUBTOTAL		2	0.56	0.249	0.61	4	0.498	
480158000000	CAPITELLIDAE	06/11/78	3	1	0.28	0.001	0.00	2	0.002	
480158020000	HETEROMASTUS SP. FRAGS	06/11/78	4	1	0.28	0.073	0.18	2	0.146	
480158020000	HETEROMASTUS SP. FRAGS	06/11/78	5	2	0.56	0.053	0.13	4	0.106	
		SUBTOTAL		3	0.84	0.126	0.31	6	0.252	
4904000000F0	PELECYPODA FRAGS.	06/11/78	3	1	0.28	0.005	0.01	2	0.010	

CRUISE 261 STATION 3G

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
490403020000	NUCULANA SP.	06/11/78	3	1	0.28	0.595	1.47	2	1.190	
490403060000	YOLDIELLA SP.	06/11/78	5	1	0.28	0.003	0.01	2	0.006	
490414000000	LUCINIDAE	06/11/78	3	6	1.69	0.009	0.02	12	0.018	
490415020000	AXINOPSIDA SP.	06/11/78	3	83	23.31	0.124	0.31	166	0.248	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	4	5	1.40	0.005	0.01	10	0.010	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	5	25	7.02	0.093	0.23	50	0.186	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	2	26	7.30	0.054	0.13	52	0.108	X X X X
	SUBTOTAL			139	39.04	0.276	0.68	278	0.552	
490415030100	THYASIRA FLEXUOSA	06/11/78	5	1	0.28	0.043	0.11	2	0.086	
490415030100	THYASIRA FLEXUOSA	06/11/78	3	6	1.69	0.220	0.54	12	0.440	
	SUBTOTAL			7	1.97	0.263	0.65	14	0.526	
490417000000	KELLIIDAE	06/11/78	3	7	1.97	0.009	0.02	14	0.018	
490424010100	MACOMA CALCAREA	06/11/78	3	1	0.28	0.356	0.88	2	0.712	X X
490424010300	MACOMA BROTA	06/11/78	1	1	0.28	34.902	85.97	2	69.804	X X
490428000000	MYIDAE	06/11/78	3	13	3.65	0.027	0.07	26	0.054	
490428020000	MYA SP.	06/11/78	5	7	1.97	0.011	0.03	14	0.022	
490428020000	MYA SP.	06/11/78	2	2	0.56	0.005	0.01	4	0.010	
	SUBTOTAL			9	2.53	0.016	0.04	18	0.032	
490506040000	SOLARIELLA SP.	06/11/78	3	1	0.28	0.051	0.13	2	0.102	
490511010000	SOLARIELLA SP.	06/11/78	4	1	0.28	0.002	0.00	2	0.004	
STATION TOTAL				356		40.599		712	81.198	

SIMPSON INDEX 0.200253 SHANNON DIVERSITY INDEX 2.155550

CRUISE 761 STATION 3H

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480000000FO	ANNELIDA FRAGS	06/11/78	5	1	1.52	0.014	0.05	3	0.047	
480124010400	NEPHTYS CORNUTA	06/11/78	5	43	65.15	0.069	0.26	143	0.230	X X X X X
480124010400	NEPHTYS CORNUTA	06/11/78	2	1	1.52	0.005	0.02	3	0.017	X X X X X
		SUBTOTAL		44	66.67	0.074	0.27	147	0.247	
480142050100	PRIONOSPIO MALMGRENI	06/11/78	5	3	4.55	0.004	0.01	10	0.013	X X X
480149030000	THARYX SP.	06/11/78	5	8	12.12	0.009	0.03	27	0.030	X
480158000000	CAPITELLIDAE	06/11/78	5	4	6.06	0.733	2.72	13	2.443	
4904000000FO	PELECYPODA FRAGS.	06/11/78	5	1	1.52	0.002	0.01	3	0.007	
490415020000	AXINOPSIDA SP.	06/11/78	5	2	3.03	0.006	0.02	7	0.020	X X X X
490416010000	DIPLODONTA SP.	06/11/78	5	1	1.52	0.001	0.00	3	0.003	
490424010300	MACOMA BROTA	06/11/78	5	1	1.52	24.372	90.53	3	81.240	X X
533304010600	PANDALUS HYPSINOTUS	06/11/78	5	1	1.52	1.705	6.33	3	5.683	
999900000000	NO FAUNA COLLECTED IN THIS GRAB	06/11/78	1	0	0.	0.	0.	0	0.	X X X X
STATION TOTAL				66		26.920		220	89.733	

SIMPSON INDEX 0.458741 SHANNON DIVERSITY INDEX 1.259849

CRUISE 261 STATION 31

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA	
400000000FO	RHYNCHOCOELA FRAGS.	06/11/78	3	1	0.07	0.108	0.00	2	0.216		X X
400000000FO	RHYNCHOCOELA FRAGS.	06/11/78	1	1	0.07	0.121	0.00	2	0.242		X X
400000000FO	RHYNCHOCOELA FRAGS.	06/11/78	4	1	0.07	0.014	0.00	2	0.028		X X
		SUBTOTAL		3	0.20	0.243	0.01	6	0.486		
480100000FO	POLYCHAETA FRAG.	06/11/78	1	1	0.07	0.190	0.01	2	0.380	X	
480100000FO	POLYCHAETA FRAG.	06/11/78	3	1	0.07	0.138	0.00	2	0.276	X	
480100000FO	POLYCHAETA FRAG.	06/11/78	2	1	0.07	0.076	0.00	2	0.152	X	
480100000FO	POLYCHAETA FRAG.	06/11/78	4	1	0.07	0.107	0.00	2	0.214	X	
		SUBTOTAL		4	0.27	0.511	0.02	8	1.022		
480100000000	POLYCHAETA	06/11/78	3	3	0.20	0.003	0.00	6	0.006		
480101000000	POLYNOIDAE	06/11/78	2	1	0.07	0.072	0.00	2	0.144		
480101000000	POLYNOIDAE	06/11/78	1	2	0.14	0.003	0.00	4	0.006		
		SUBTOTAL		3	0.20	0.075	0.00	6	0.150		
480101050200	EUNOE DEPRESSA	06/11/78	1	1	0.07	0.002	0.00	2	0.004		
480101050500	EUNOE OERSTEDI	06/11/78	1	1	0.07	0.131	0.00	2	0.262		
480101050500	EUNOE OERSTEDI	06/11/78	2	2	0.14	0.048	0.00	4	0.096		
		SUBTOTAL		3	0.20	0.179	0.01	6	0.358		
480101080300	HARMOTHOE EXTENUATA	06/11/78	1	1	0.07	0.012	0.00	2	0.024		
480101080600	HARMOTHOE IMBRICATA	06/11/78	1	1	0.07	0.121	0.00	2	0.242		
480102010100	PEISIDICE ASPERA	06/11/78	2	2	0.14	0.006	0.00	4	0.012		
480102010100	PEISIDICE ASPERA	06/11/78	3	7	0.47	0.056	0.00	14	0.112		
480102010100	PEISIDICE ASPERA	06/11/78	1	6	0.41	0.038	0.00	12	0.076		
		SUBTOTAL		15	1.01	0.100	0.00	30	0.200		
490105010100	PHLOE MINUTA	06/11/78	3	5	0.34	0.006	0.00	10	0.012	X	
480105010100	PHLOE MINUTA	06/11/78	2	1	0.07	0.001	0.00	2	0.002	X	
		SUBTOTAL		6	0.41	0.007	0.00	12	0.014		
480107010100	PALEANOTUS BELLIS	06/11/78	1	1	0.07	0.001	0.00	2	0.002		
480107010100	PALEANOTUS BELLIS	06/11/78	2	1	0.07	0.002	0.00	2	0.004		
		SUBTOTAL		2	0.14	0.003	0.00	4	0.006		
480112010000	ANAITIDES SP.	06/11/78	3	4	0.27	0.001	0.00	8	0.002		
480112010000	ANAITIDES SP.	06/11/78	1	4	0.27	0.002	0.00	8	0.004		
480112010000	ANAITIDES SP.	06/11/78	4	1	0.07	0.001	0.00	2	0.002		
		SUBTOTAL		9	0.61	0.004	0.00	18	0.008		
480112020000	ETEONE SP.	06/11/78	4	3	0.20	0.027	0.00	6	0.054		
480112020000	ETEONE SP.	06/11/78	3	4	0.27	0.005	0.00	8	0.010		
		SUBTOTAL		7	0.47	0.032	0.00	14	0.064		

CRUISE 261 STATION 31

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480112020500	ETEONE LONGA	06/11/78	2	1	0.07	0.003	0.00	2	0.006	
480112020500	ETEONE LONGA	06/11/78	1	3	0.20	0.003	0.00	6	0.006	
		SUBTOTAL		4	0.27	0.006	0.00	8	0.012	
480122020100	PIONOSYLLIS GIGANTEA	06/11/78	2	1	0.07	0.002	0.00	2	0.004	
480122070200	EXOGONE GEMMIFERA	06/11/78	3	2	0.14	0.001	0.00	4	0.002	
480122070400	EXOGONE MOLESTA	06/11/78	1	1	0.07	0.001	0.00	2	0.002	
490123040000	NEREIS SP.	06/11/78	3	1	0.07	0.001	0.00	2	0.002	
480124010400	NEPHTYS CORNUTA	06/11/78	2	1	0.07	0.001	0.00	2	0.002	X X X X X
480124011100	NEPHTYS FERRUGINEA	06/11/78	2	1	0.07	0.132	0.00	2	0.264	
480126010100	GLYCERA CAPITATA	06/11/78	1	1	0.07	0.002	0.00	2	0.004	
480126010100	GLYCERA CAPITATA	06/11/78	3	1	0.07	0.004	0.00	2	0.008	
480126010100	GLYCERA CAPITATA	06/11/78	2	2	0.14	0.020	0.00	4	0.040	
480126010100	GLYCERA CAPITATA	06/11/78	4	1	0.07	0.010	0.00	2	0.020	
		SUBTOTAL		5	0.34	0.036	0.00	10	0.072	
480127010100	GLYCINDE PICTA	06/11/78	5	1	0.07	0.004	0.00	2	0.008	X
480127010100	GLYCINDE PICTA	06/11/78	2	4	0.27	0.009	0.00	8	0.018	X
480127010100	GLYCINDE PICTA	06/11/78	4	6	0.41	0.158	0.01	12	0.316	X
480127010100	GLYCINDE PICTA	06/11/78	1	4	0.27	0.241	0.01	8	0.482	X
480127010100	GLYCINDE PICTA	06/11/78	3	7	0.47	0.132	0.00	14	0.264	X
		SUBTOTAL		22	1.49	0.544	0.02	44	1.088	
490127010300	GLYCINDE ARMIGERA	06/11/78	4	1	0.07	0.036	0.00	2	0.072	
480130011900	LUMBRINERIS LUTI	06/11/78	1	3	0.20	0.022	0.00	6	0.044	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	2	1	0.07	0.008	0.00	2	0.016	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	3	1	0.07	0.004	0.00	2	0.008	X X X
480130011900	LUMBRINERIS LUTI	06/11/78	4	4	0.27	0.055	0.00	8	0.110	X X X
		SUBTOTAL		9	0.61	0.089	0.00	18	0.178	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	4	10	0.68	0.282	0.01	20	0.564	
480139010200	HAPLOSCOLOPLOS ELONGATUS	06/11/78	1	1	0.07	0.056	0.00	2	0.112	
		SUBTOTAL		11	0.74	0.338	0.01	22	0.676	
480142000000	SPIONIDAE	06/11/78	2	5	0.34	0.002	0.00	10	0.004	
480142040000	POLYDORA SP.	06/11/78	1	1	0.07	0.004	0.00	2	0.008	
480142040000	POLYDORA SP.	06/11/78	4	2	0.14	0.004	0.00	4	0.008	
		SUBTOTAL		3	0.20	0.008	0.00	6	0.016	
480142040500	POLYDORA CILIATA	06/11/78	3	1	0.07	0.001	0.00	2	0.002	

CRUISE 261 STATION 31

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480142041500	POLYDORA LIMICOLA	06/11/78	1	7	0.47	0.007	0.00	14	0.014	
480142050100	PRIONOSPIO MALMGRENI	06/11/78	2	71	4.80	0.097	0.00	142	0.194	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	3	94	6.35	0.159	0.01	188	0.318	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	1	75	5.07	0.167	0.01	150	0.334	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	4	36	2.43	0.060	0.00	72	0.120	X X X
480142050100	PRIONOSPIO MALMGRENI	06/11/78	5	1	0.07	0.002	0.00	2	0.004	X X X
		SUBTOTAL		277	18.72	0.485	0.02	554	0.970	
480142050200	PRIONOSPIO CIRRIFERA	06/11/78	5	1	0.07	0.001	0.00	2	0.002	
480142050200	PRIONOSPIO CIRRIFERA	06/11/78	3	10	0.68	0.002	0.00	20	0.004	
480142050200	PRIONOSPIO CIRRIFERA	06/11/78	1	3	0.20	0.004	0.00	6	0.008	
480142050200	PRIONOSPIO CIRRIFERA	06/11/78	2	4	0.27	0.004	0.00	8	0.008	
		SUBTOTAL		18	1.22	0.011	0.00	36	0.022	
480142070100	SPIO FILICORNIS	06/11/78	3	2	0.14	0.001	0.00	4	0.002	
480142070100	SPIO FILICORNIS	06/11/78	2	4	0.27	0.003	0.00	8	0.006	
480142070100	SPIO FILICORNIS	06/11/78	5	3	0.20	0.001	0.00	6	0.002	
480142070100	SPIO FILICORNIS	06/11/78	4	13	0.88	0.052	0.00	26	0.104	
		SUBTOTAL		22	1.49	0.057	0.00	44	0.114	
480149000000	CIRRATULIDAE	06/11/78	4	20	1.35	0.062	0.00	40	0.124	X X X
480149000000	CIRRATULIDAE	06/11/78	5	1	0.07	0.010	0.00	2	0.020	X X X
480149000000	CIRRATULIDAE	06/11/78	3	5	0.34	0.051	0.00	10	0.102	X X X
480149000000	CIRRATULIDAE	06/11/78	1	6	0.41	0.020	0.00	12	0.040	X X X
		SUBTOTAL		32	2.16	0.143	0.01	64	0.286	
480149040100	CHAETOZONE SETOSA	06/11/78	3	1	0.07	0.003	0.00	2	0.006	
480149040100	CHAETOZONE SETOSA	06/11/78	4	6	0.41	0.055	0.00	12	0.110	
		SUBTOTAL		7	0.47	0.058	0.00	14	0.116	
480156010100	AMMOTRYPANE AULOGASTER	06/11/78	3	2	0.14	0.049	0.00	4	0.098	X
480158010100	CAPITELLA CAPITATA	06/11/78	1	1	0.07	0.001	0.00	2	0.002	X
480158010100	CAPITELLA CAPITATA	06/11/78	4	1	0.07	0.003	0.00	2	0.006	X
480158010100	CAPITELLA CAPITATA	06/11/78	5	1	0.07	0.032	0.00	2	0.064	X
		SUBTOTAL		3	0.20	0.036	0.00	6	0.072	•
480158020000	HETEROMASTUS SP. FRAGS	06/11/78	1	12	0.81	0.011	0.00	24	0.022	
480159020100	HETEROMASTUS FILIFORMIS	06/11/78	3	17	1.15	0.019	0.00	34	0.038	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/11/78	2	1	0.07	0.001	0.00	2	0.002	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/11/78	4	6	0.41	0.002	0.00	12	0.004	X X X X
		SUBTOTAL		24	1.62	0.022	0.00	48	0.044	
480162010200	OWENIA FUSIFORMIS	06/11/78	3	1	0.07	0.048	0.00	2	0.096	
480162010200	OWENIA FUSIFORMIS	06/11/78	1	2	0.14	0.140	0.01	4	0.280	
480162010200	OWENIA FUSIFORMIS	06/11/78	2	2	0.14	0.008	0.00	4	0.016	
480162010200	OWENIA FUSIFORMIS	06/11/78	4	3	0.20	0.010	0.00	6	0.020	
		SUBTOTAL		8	0.54	0.206	0.01	16	0.412	

CRUISE 261 STATION 31

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480162020100	MYRIOCHELE HEERI	06/11/78	1	3	0.20	0.017	0.00	6	0.034	
480162020100	MYRIOCHELE HEERI	06/11/78	4	14	0.95	0.207	0.01	28	0.414	
480162020100	MYRIOCHELE HEERI	06/11/78	2	2	0.14	0.008	0.00	4	0.016	
480162020100	MYRIOCHELE HEERI	06/11/78	3	1	0.07	0.002	0.00	2	0.004	
		SUBTOTAL		20	1.35	0.234	0.01	40	0.468	
480163010200	IDANTHYRSUS ARMATUS	06/11/78	3	33	2.23	0.138	0.00	66	0.276	
480163010200	IDANTHYRSUS ARMATUS	06/11/78	2	3	0.20	0.031	0.00	6	0.062	
480163010200	IDANTHYRSUS ARMATUS	06/11/78	1	81	5.47	1.206	0.04	162	2.412	
		SUBTOTAL		117	7.91	1.375	0.05	234	2.750	
480164030300	PECTINARIA GRANULATA	06/11/78	2	5	0.34	0.262	0.01	10	0.524	
480164030300	PECTINARIA GRANULATA	06/11/78	3	4	0.27	0.490	0.02	8	0.980	
480164030300	PECTINARIA GRANULATA	06/11/78	1	2	0.14	0.096	0.00	4	0.192	
		SUBTOTAL		11	0.74	0.848	0.03	22	1.696	
480165020000	AMPHARETE SP.	06/11/78	2	5	0.34	0.032	0.00	10	0.064	
480165020100	AMPHARETE ARCTICA	06/11/78	5	4	0.27	0.021	0.00	8	0.042	
480165020100	AMPHARETE ARCTICA	06/11/78	1	3	0.20	0.042	0.00	6	0.084	
		SUBTOTAL		7	0.47	0.063	0.00	14	0.126	
480165040100	LYSIPPE LABIATA	06/11/78	1	2	0.14	0.003	0.00	4	0.006	
480168000000	SABELLIDAE	06/11/78	3	1	0.07	0.001	0.00	2	0.002	
480168000000	SABELLIDAE	06/11/78	4	13	0.88	0.017	0.00	26	0.034	
480168000000	SABELLIDAE	06/11/78	1	1	0.07	0.001	0.00	2	0.002	
		SUBTOTAL		15	1.01	0.019	0.00	30	0.038	
480168140100	LAONOME KROYERI	06/11/78	4	6	0.41	0.030	0.00	12	0.060	
480170010200	CHITINOPOMA GROENLANDICA	06/11/78	3	2	0.14	0.001	0.00	4	0.002	
480170010200	CHITINOPOMA GROENLANDICA	06/11/78	1	2	0.14	0.002	0.00	4	0.004	
		SUBTOTAL		4	0.27	0.003	0.00	8	0.006	
480170040000	SERPULA SP.	06/11/78	1	1	0.07	0.017	0.00	2	0.034	
480170050300	SPIRORBIS SEMIDENTATUS	06/11/78	3	9	0.61	0.003	0.00	18	0.006	
480170050300	SPIRORBIS SEMIDENTATUS	06/11/78	1	12	0.81	0.044	0.00	24	0.088	
		SUBTOTAL		21	1.42	0.047	0.00	42	0.094	
480200000000	OLIGOCHAETA	06/11/78	1	7	0.47	0.002	0.00	14	0.004	
480200000000	OLIGOCHAETA	06/11/78	2	4	0.27	0.004	0.00	8	0.008	
		SUBTOTAL		11	0.74	0.006	0.00	22	0.012	
490300000000	POLYPLACOPHORA	06/11/78	1	1	0.07	0.031	0.00	2	0.062	
490402020100	NUCULA TENUIS	06/11/78	3	1	0.07	0.001	0.00	2	0.002	

CRUISE 761 STATION 31

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
490403050000	YOLDIA SP.	06/11/78	3	1	0.07	0.045	0.00	2	0.090	
490403050000	YOLDIA SP.	06/11/78	2	1	0.07	0.003	0.00	2	0.006	
		SUBTOTAL		2	0.14	0.048	0.00	4	0.096	
490407020100	CRENELLA DESSUCATA	06/11/78	2	1	0.07	0.002	0.00	2	0.004	
490407060000	MODIOLUS SP.	06/11/78	3	1	0.07	0.018	0.00	2	0.036	
490407060000	MODIOLUS SP.	06/11/78	2	3	0.20	0.071	0.00	6	0.142	
490407060000	MODIOLUS SP.	06/11/78	1	2	0.14	0.227	0.01	4	0.454	
		SUBTOTAL		6	0.41	0.316	0.01	12	0.632	
490410010100	PODODESMUS MACROCHISMA	06/11/78	3	1	0.07	0.001	0.00	2	0.002	
490415020000	AXINOPSIDA SP.	06/11/78	3	14	0.95	0.133	0.00	28	0.266	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	2	27	1.82	0.220	0.01	54	0.440	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	1	6	0.41	0.066	0.00	12	0.132	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	5	1	0.07	0.002	0.00	2	0.004	X X X X
490415020000	AXINOPSIDA SP.	06/11/78	4	176	11.89	0.823	0.03	352	1.646	X X X X
		SUBTOTAL		224	15.14	1.244	0.04	448	2.488	
490420010000	CLINOCARDIUM SP.	06/11/78	1	1	0.07	0.006	0.00	2	0.012	
490420010000	CLINOCARDIUM SP.	06/11/79	2	22	1.49	0.346	0.01	44	0.692	
		SUBTOTAL		23	1.55	0.352	0.01	46	0.704	
490424010000	MACOMA SP.	06/11/79	3	15	1.01	0.200	0.01	30	0.400	X X
490424010000	MACOMA SP.	06/11/78	1	9	0.61	0.340	0.01	18	0.680	X X
490424010000	MACOMA SP.	06/11/79	2	15	1.01	0.228	0.01	30	0.456	X X
490424010000	MACOMA SP.	06/11/78	4	8	0.54	0.610	0.02	16	1.220	X X
490424010000	MACOMA SP.	06/11/78	5	1	0.07	0.002	0.00	2	0.004	X X
		SUBTOTAL		48	3.24	1.380	0.05	96	2.760	
490428020000	MYA SP.	06/11/78	2	3	0.20	0.043	0.00	6	0.086	
490428020000	MYA SP.	06/11/78	3	2	0.14	0.016	0.00	4	0.032	
490428020000	MYA SP.	06/11/78	1	2	0.14	0.020	0.00	4	0.040	
		SUBTOTAL		7	0.47	0.079	0.00	14	0.158	
490429020000	HIATELLA SP.	06/11/79	1	14	0.95	1.283	0.05	28	2.566	
490429020000	HIATELLA SP.	06/11/78	3	6	0.41	0.168	0.01	12	0.336	
490429020000	HIATELLA SP.	06/11/78	2	10	0.68	0.592	0.02	20	1.184	
490429020000	HIATELLA SP.	06/11/78	4	1	0.07	0.011	0.00	2	0.022	
		SUBTOTAL		31	2.09	2.054	0.07	62	4.108	
490500000000	GASTROPODA	06/11/78	4	1	0.07	0.009	0.00	2	0.018	
490500000000	GASTROPODA	06/11/78	2	1	0.07	0.002	0.00	2	0.004	
490500000000	GASTROPODA	06/11/78	3	1	0.07	0.005	0.00	2	0.010	
		SUBTOTAL		3	0.20	0.016	0.00	6	0.032	
490504020000	COLISELLA SP.	06/11/78	3	1	0.07	0.002	0.00	2	0.004	

CRUISE 261 STATION 31

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
490505010100	CRYPTOBRANCHIA CONCENTRICA	06/11/78	3	12	0.81	1.571	0.06	24	3.142	
490505010100	CRYPTOBRANCHIA CONCENTRICA	06/11/78	1	19	1.28	1.374	0.05	38	2.748	
490505010100	CRYPTOBRANCHIA CONCENTRICA	06/11/78	2	2	0.14	0.010	0.00	4	0.020	
		SUBTOTAL		33	2.23	2.955	0.11	66	5.910	
490506040200	SOLARIELLA OBSCURA	06/11/78	2	4	0.27	0.507	0.02	8	1.014	
490506040200	SOLARIELLA OBSCURA	06/11/78	3	2	0.14	0.095	0.00	4	0.190	
		SUBTOTAL		6	0.41	0.602	0.02	12	1.204	
490507020100	MOELLERIA QUADRAI	06/11/78	2	1	0.07	0.003	0.00	2	0.006	
490511010000	SOLARIELLA SP.	06/11/78	3	3	0.20	0.027	0.00	6	0.054	
490511010000	SOLARIELLA SP.	06/11/78	1	1	0.07	0.012	0.00	2	0.024	
490511010000	SOLARIELLA SP.	06/11/78	2	1	0.07	0.005	0.00	2	0.010	
		SUBTOTAL		5	0.34	0.044	0.00	10	0.088	
490530040000	TROPHONOPSIS SP.	06/11/78	2	1	0.07	0.032	0.00	2	0.064	
490576010000	SIPHONARIA SP.	06/11/78	3	1	0.07	0.006	0.00	2	0.012	
530000000000 CRUSTACEA		06/11/78	3	1	0.07	0.268	0.01	2	0.536	X
530000000000 CRUSTACEA		06/11/78	5	1	0.07	0.002	0.00	2	0.004	X
		SUBTOTAL		2	0.14	0.270	0.01	4	0.540	
531802010000	BALANUS SP.	06/11/78	3	9	0.61	1.204	0.04	18	2.408	X X
531802010400	BALANUS CRENATUS	06/11/78	1	182	12.301	720.000	62.02	364344	0.000	X X X X
531802010400	BALANUS CRENATUS	06/11/78	2	58	3.921	031.500	37.19	116206	3.000	X X X X
		SUBTOTAL		240	16.222	751.500	99.22	480550	3.000	
532800000000 CUMACEA		06/11/78	2	1	0.07	0.001	0.00	2	0.002	
532800000000 CUMACEA		06/11/78	3	2	0.14	0.003	0.00	4	0.006	
		SUBTOTAL		3	0.20	0.004	0.00	6	0.008	
533100000000 AMPHIPODA		06/11/78	4	1	0.07	0.008	0.00	2	0.016	
533100000000 AMPHIPODA		06/11/78	5	1	0.07	0.001	0.00	2	0.002	
533100000000 AMPHIPODA		06/11/78	3	23	1.55	0.028	0.00	46	0.056	
533100000000 AMPHIPODA		06/11/78	2	23	1.55	0.179	0.01	46	0.358	
533100000000 AMPHIPODA		06/11/78	1	14	0.95	0.019	0.00	28	0.038	
		SUBTOTAL		62	4.19	0.235	0.01	124	0.470	
533311000000 PAGURIDAE		06/11/78	3	1	0.07	0.026	0.00	2	0.052	
533311000000 PAGURIDAE		06/11/78	2	1	0.07	0.693	0.02	2	1.386	
		SUBTOTAL		2	0.14	0.719	0.03	4	1.438	
533311020000	PAGURUS SP.	06/11/78	1	1	0.07	0.295	0.01	2	0.590	
533317010100	OREGONIA GRACILIS	06/11/78	3	1	0.07	2.978	0.11	2	5.956	

CRUISE 261 STATION 31

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA	
590101020100	PHASCOLION STROMBI	06/11/78	1	1	0.07	0.007	0.00	2	0.014		
680204010100	ALLOCENTROTUS FRAGILIS	06/11/78	1	3	0.20	0.199	0.01	6	0.398		
680309000000	OPHIURIDAE	06/11/78	2	1	0.07	0.006	0.00	2	0.012		
791613000000	PHOLOIDAE	06/11/78	2	1	0.07	0.419	0.02	2	0.838	X	X
		STATION TOTAL		1480		2773.256		29605546.512			

SIMPSON INDEX 0.096444 SHANNON DIVERSITY INDEX 3.014152

CRUISE 261 STATION 7

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
4801000000F0	POLYCHAETA FRAG.	06/12/78	2	1	0.09	0.015	0.01	2	0.030	X
4801000000F0	POLYCHAETA FRAG.	06/12/78	5	1	0.09	0.036	0.02	2	0.072	X
4801000000F0	POLYCHAETA FRAG.	06/12/78	3	1	0.09	0.139	0.08	2	0.278	X
4801000000F0	POLYCHAETA FRAG.	06/12/78	4	1	0.09	0.023	0.01	2	0.046	X
4801000000F0	POLYCHAETA FRAG.	06/12/78	1	1	0.09	0.012	0.01	2	0.024	X
		SUBTOTAL		5	0.43	0.225	0.13	10	0.450	
4801010003000	POLYNOIDAE	06/12/78	1	4	0.34	0.022	0.01	8	0.044	
4801010000000	POLYNOIDAE	06/12/78	4	2	0.17	0.021	0.01	4	0.042	
4801010000000	POLYNOIDAE	06/12/78	3	5	0.43	0.053	0.03	10	0.106	
		SUBTOTAL		11	0.94	0.096	0.06	22	0.192	
4801010202000	ANTINOELLA SARSI	06/12/78	2	2	0.17	0.023	0.01	4	0.046	
4801011502000	POLYNOE GRACILIS	06/12/78	5	2	0.17	0.010	0.01	4	0.020	
4801050101000	PHLOE MINUTA	06/12/78	1	1	0.09	0.020	0.01	2	0.040	X
4801050101000	PHLOE MINUTA	06/12/78	5	1	0.09	0.001	0.00	2	0.002	X
		SUBTOTAL		2	0.17	0.021	0.01	4	0.042	
4801120205000	ETEONE LONGA	06/12/78	5	1	0.09	0.001	0.00	2	0.002	
4801200102000	GYPTIS BREVIPALPA	06/12/78	3	1	0.09	0.004	0.00	2	0.008	
4801200102000	GYPTIS BREVIPALPA	06/12/78	5	1	0.09	0.001	0.00	2	0.002	
		SUBTOTAL		2	0.17	0.005	0.00	4	0.010	
4801240104000	NEPHTYS CORNUTA	06/12/78	5	15	1.28	0.049	0.03	30	0.098	X X X X X
4801240104000	NEPHTYS CORNUTA	06/12/78	1	4	0.34	0.009	0.01	8	0.018	X X X X X
4801240104000	NEPHTYS CORNUTA	06/12/78	3	15	1.28	0.042	0.03	30	0.084	X X X X X
4801240104000	NEPHTYS CORNUTA	06/12/78	2	2	0.17	0.004	0.00	4	0.008	X X X X X
4801240104000	NEPHTYS CORNUTA	06/12/78	4	11	0.94	0.045	0.03	22	0.090	X X X X X
		SUBTOTAL		47	4.00	0.149	0.09	94	0.298	
4801240111000	NEPHTYS FERRUGINEA	06/12/78	1	2	0.17	1.641	0.98	4	3.282	
4801270101000	GLYCINDE PICTA	06/12/78	3	1	0.09	0.002	0.00	2	0.004	X
4801300119000	LUMBRINERIS LUTI	06/12/78	2	4	0.34	0.100	0.06	8	0.200	X X X
4801300119000	LUMBRINERIS LUTI	06/12/78	5	10	0.85	0.063	0.04	20	0.126	X X X
4801300119000	LUMBRINERIS LUTI	06/12/78	4	5	0.43	0.049	0.03	10	0.098	X X X
4801300119000	LUMBRINERIS LUTI	06/12/78	3	5	0.43	0.045	0.03	10	0.090	X X X
4801300119000	LUMBRINERIS LUTI	06/12/78	1	11	0.94	0.145	0.09	22	0.290	X X X
		SUBTOTAL		35	2.98	0.402	0.24	70	0.804	
4801390102000	HAPLOSCOLOPLOS ELONGATUS	06/12/78	2	1	0.09	0.035	0.02	2	0.070	
4801390102000	HAPLOSCOLOPLOS ELONGATUS	06/12/78	5	3	0.26	0.074	0.04	6	0.148	
4801390102000	HAPLOSCOLOPLOS ELONGATUS	06/12/78	1	2	0.17	0.041	0.02	4	0.082	
		SUBTOTAL		6	0.51	0.150	0.09	12	0.300	

CRUISE 261 STATION 7

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
480140020400	ARICIDEA JEFFREYSII	06/12/78	4	5	0.43	0.015	0.01	10	0.030	
480140020400	ARICIDEA JEFFREYSII	06/12/78	3	3	0.26	0.008	0.00	6	0.016	
480140020400	ARICIDEA JEFFREYSII	06/12/78	5	15	1.28	0.041	0.02	30	0.082	
480140020400	ARICIDEA JEFFREYSII	06/12/78	2	4	0.34	0.020	0.01	8	0.040	
480140020400	ARICIDEA JEFFREYSII	06/12/78	1	5	0.43	0.011	0.01	10	0.022	
		SUBTOTAL		32	2.72	0.095	0.06	64	0.190	
480142050100	PRIONOSPIO MALMGRENI	06/12/78	2	5	0.43	0.051	0.03	10	0.102	X X X
480142050100	PRIONOSPIO MALMGRENI	06/12/78	5	2	0.17	0.004	0.00	4	0.008	X X X
480142050100	PRIONOSPIO MALMGRENI	06/12/78	1	3	0.26	0.038	0.02	6	0.076	X X X
480142050100	PRIONOSPIO MALMGRENI	06/12/78	4	3	0.26	0.029	0.02	6	0.058	X X X
480142050100	PRIONOSPIO MALMGRENI	06/12/78	3	4	0.34	0.071	0.04	8	0.142	X X X
		SUBTOTAL		17	1.45	0.193	0.12	34	0.386	
480142050200	PRIONOSPIO CIRRIFERA	06/12/78	4	7	0.60	0.005	0.00	14	0.010	
480142050200	PRIONOSPIO CIRRIFERA	06/12/78	1	1	0.09	0.008	0.00	2	0.016	
480142050200	PRIONOSPIO CIRRIFERA	06/12/78	3	1	0.09	0.002	0.00	2	0.004	
480142050200	PRIONOSPIO CIRRIFERA	06/12/78	5	6	0.51	0.004	0.00	12	0.008	
		SUBTOTAL		15	1.28	0.019	0.01	30	0.038	
480149000000	CIRRATULIDAE	06/12/78	2	2	0.17	0.009	0.01	4	0.018	X X X
480149000000	CIRRATULIDAE	06/12/78	4	1	0.09	0.002	0.00	2	0.004	X X X
480149000000	CIRRATULIDAE	06/12/78	1	3	0.26	0.008	0.00	6	0.016	X X X
480149000000	CIRRATULIDAE	06/12/78	5	1	0.09	0.002	0.00	2	0.004	X X X
480149000000	CIRRATULIDAE	06/12/78	3	1	0.09	0.002	0.00	2	0.004	X X X
		SUBTOTAL		8	0.68	0.023	0.01	16	0.046	
480149040100	CHAETOZONE SETOSA	06/12/78	1	1	0.09	0.001	0.00	2	0.002	
480155010100	SCALIBREGMA INFLATUM	06/12/78	4	96	8.16	6.899	4.11	192	13.798	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/12/78	5	228	19.39	24.708	14.73	456	49.416	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/12/78	1	220	18.71	10.238	6.11	440	20.476	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/12/78	2	172	14.63	16.272	9.70	344	32.544	X X X X X
480155010100	SCALIBREGMA INFLATUM	06/12/78	3	69	5.87	5.126	3.06	138	10.252	X X X X X
		SUBTOTAL		785	66.75	63.243	37.71	1570	126.486	
480156010100	AMMOTRYPANE AULOGASTER	06/12/78	1	1	0.09	0.081	0.05	2	0.162	X
480156010100	AMMOTRYPANE AULOGASTER	06/12/78	4	6	0.51	0.302	0.18	12	0.604	X
480156010100	AMMOTRYPANE AULOGASTER	06/12/78	3	6	0.51	0.273	0.16	12	0.546	X
480156010100	AMMOTRYPANE AULOGASTER	06/12/78	5	12	1.02	0.646	0.39	24	1.292	X
480156010100	AMMOTRYPANE AULOGASTER	06/12/78	2	2	0.17	0.098	0.06	4	0.196	X
		SUBTOTAL		27	2.30	1.400	0.83	54	2.800	
480158020100	HETEROMASTUS FILIFORMIS	06/12/78	5	25	2.13	0.193	0.12	50	0.386	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/12/78	2	19	1.62	0.498	0.30	38	0.996	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/12/78	3	14	1.19	0.686	0.41	28	1.372	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/12/78	4	23	1.96	0.087	0.05	46	0.174	X X X X
480158020100	HETEROMASTUS FILIFORMIS	06/12/78	1	9	0.77	0.516	0.31	18	1.032	X X X X
		SUBTOTAL		90	7.65	1.980	1.18	180	3.960	

CRUISE 261 STATION 7

PERCENTS REFER TO TOTAL COLLECTIONS AT THIS STATION

TAXON CODE	TAXON NAME	SAMPLE DATE	SAMP NO.	COUNT NO.	COUNT PCT	WET WEIGHT GRAMS	WET WEIGHT PCT	PER SQ METER NO.	PER SQ METER WWGT	BIT CRITERIA
4904000000F0	PELECYPODA FRAGS.	06/12/78	3	1	0.09	0.647	0.39	2	1.294	
4904000000F0	PELECYPODA FRAGS.	06/12/78	1	1	0.09	0.037	0.02	2	0.074	
		SUBTOTAL		2	0.17	0.684	0.41	4	1.368	
490400000000	PELECYPODA	06/12/78	2	1	0.09	0.159	0.09	2	0.318	
490403020300	NUCULANA FOSSA	06/12/78	3	1	0.09	0.056	0.03	2	0.112	X X
490403050000	YOLDIA SP.	06/12/78	1	1	0.09	0.003	0.00	2	0.006	
490403050000	YOLDIA SP.	06/12/78	3	3	0.26	0.006	0.00	6	0.012	
490403050000	YOLDIA SP.	06/12/78	4	2	0.17	0.004	0.00	4	0.008	
490403050000	YOLDIA SP.	06/12/78	5	1	0.09	0.003	0.00	2	0.006	
		SUBTOTAL		7	0.60	0.016	0.01	14	0.032	
490415020000	AXINOPSIDA SP.	06/12/73	5	21	1.79	0.103	0.06	42	0.206	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	4	14	1.19	0.034	0.02	28	0.068	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	1	8	0.68	0.016	0.01	16	0.032	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	3	16	1.36	0.037	0.02	32	0.074	X X X X
490415020000	AXINOPSIDA SP.	06/12/78	2	2	0.17	0.018	0.01	4	0.036	X X X X
		SUBTOTAL		61	5.19	0.208	0.12	122	0.416	
490424010000	MACOMA SP.	06/12/78	1	1	0.09	13.650	8.14	2	27.300	X X
490424010000	MACOMA SP.	06/12/78	3	2	0.17	14.846	8.85	4	29.692	X X
490424010000	MACOMA SP.	06/12/78	4	1	0.09	61.274	36.54	2	122.548	X X
490424010000	MACOMA SP.	06/12/78	5	2	0.17	7.101	4.23	4	14.202	X X
		SUBTOTAL		6	0.51	96.871	57.77	12	193.742	
530000000000	CRUSTACEA	06/12/78	5	1	0.09	0.005	0.00	2	0.010	X
530000000000	CRUSTACEA	06/12/78	4	1	0.09	0.005	0.00	2	0.010	X
		SUBTOTAL		2	0.17	0.010	0.01	4	0.020	
533100000000	AMPHIPODA	06/12/78	4	3	0.26	0.012	0.01	6	0.024	
533100000000	AMPHIPODA	06/12/78	5	1	0.09	0.001	0.00	2	0.002	
533100000000	AMPHIPODA	06/12/78	1	1	0.09	0.001	0.00	2	0.002	
		SUBTOTAL		5	0.43	0.014	0.01	10	0.028	
		STATION TOTAL		1176		167.697		2352	335.394	

SIMPSON INDEX 0.458069 SHANNON DIVERSITY INDEX 1.469269

SUCCESSFUL EOJ.

APPENDIX B

TAXON CODES AND SPECIES NAMES USED IN THE CLUSTER ANALYSES DESCRIBED IN THIS REPORT

TAXON CODES IN SORTED ORDER	TAXA
4801010200	NEMIDIA SP.
4801010202	ANTINOELLA SARSI
4801010502	EUNOE DEPRESSA
4801010505	EUNOE OERSTEDI
4801010803	HARMOTHOE EXTENUATA
4801010806	HARMOTHOE IMBRICATA
4801011502	POLYNOE GRACILIS
4801011701	HESPERONOE COMPLANATA
4801020101	PETSIDICE ASPERA
4801050101	PHOLOE MINUTA
4801050300	STHENELAIS SP.
4801050400	SIGALION SP.
4801070101	PAIEANOTUS BELLIS
4801120100	ANAITIDES SP.
4801120200	ETEONE SP.
4801120205	ETEONE LONGA
4801200102	GYPTIS BREVIPALPA
4801220200	SYLLIS SP.
4801220201	PIONOSYLLIS GIGANTEA
4801220702	EXOGONE GEMMIFERA
4801220704	EXOGONE MOLESTA
4801230400	NEPEIS SP.
4801240104	NEPHTYS CORNUTA
4801240105	NEPHTYS PUNCTATA
4801240111	NEPHTYS FERRUGINEA
4801260101	GLYCERA CAPITATA
4801270101	GLYCINDE PICTA
4801270103	GLYCINDE ARMIGERA
4801270202	GONIADA MACULATA
4801280103	ONUPHIS IRIDESCENS
4801300101	LUMBRINERIS BICIRRATA
4801300119	LUMBRINERIS LUTI
4801390100	HAPLOSCOLOPLOS SP.
4801390102	HAPLOSCOLOPLOS ELONGATUS
4801390300	SCOLOPLOS FULIGINOSA
4801400204	ARTICIDEA JEFFREYSII
4801420200	LAONICE SP.
4801420405	POLYDORA CILIATA
4801420415	POLYDORA LIMICOLA
4801420500	PRIONOSPIO SP.
4801420501	PRIONOSPIO MALMGRENI
4801420502	PRIONOSPIO CIRRIFERA
4801420701	SPIO FILICORNIS
4801421000	SPIOPHANES SP.
4801421001	SPIOPHANES BOMBYX
4801421002	SPIOPHANES KROYERI
4801421003	SPIOPHANES CIRRATA
4801430102	MAGELONA PACIFICA
4801430105	MAGELONA LONGICORNIS
4801490300	THARYX SP.
4801490401	CHAETOZONE SETOSA
4801520103	BRADA INHABILIS
4801550101	SCALIBREGMA INFLATUM
4801560101	AMMOTRYPANE AULOGASTER
4801580101	CAPITELLA CAPITATA
4801580201	HETEROMASTUS FILIFORMIS
4801580202	HETEROMASTUS GIGANTEUS
4801580300	NOTOMASTUS SP.
4801580306	NOTOMASTUS LAERIATUS
4801610301	AXIOTHELLA CATENATA
4801610902	PRAXILLELLA PRAETERMISSA
4801620102	OWENIA FUSIFORMIS
4801620201	MYRIOCHELE HEERI

48016301020	IDANTHYRSUS ARMATUS
48016403030	PECTINARIA GRANULATA
48016502000	AMPHARETE SP.
48016502010	AMPHARETE ARCTICA
48016504010	LYSIPPE LABIATA
48016505010	MELINNA CRISTATA
48016701010	TEREBELLIDES STROEMII
48016801030	CHONE CINCTA
48016814010	LAONOME KROYERI
48017001020	CHITINOPOMA GROENLANDICA
48017004000	SERPULA SP.
48017005030	SPIRORBIS SEMIDENTATUS
48017501010	COSSURA LONGOCIRRATA
49040202010	NUCULA TENUIS
49040302000	NUCULANA SP.
49040302030	NUCULANA FOSSA
49040304000	TINDARIA SP.
49040305070	YOLDIA THRACIAEFORMIS
49040306000	YOLDIELLA SP.
49040702010	CRENELLA DECUSSATA
49040706000	MODIOLUS SP.
49040706010	MODIOLUS MODIOLUS
49041001010	PODODESMUS MACROCHISMA
49041502000	AXINOPSIDA SERRICATA
49041503010	THYASIRA FLEXUOSA
49041601000	DIPLODONTA SP.
49041601020	DIPLODONTA ALEUTICA
49041801000	MYSELLA SP.
49042001000	CLINOCARDIUM SP.
49042001010	CLINOCARDIUM CILIATUM
49042002010	SERRIPES GROENLANDICUS
49042105010	PSEPHIDIA LORDI
49042301000	SPISULA SP.
49042301010	SPISULA POLYNYMA
49042401010	MACOMA CALCAREA
49042401030	MACOMA BROTA
49042401070	MACOMA MOESTA MOESTA
49042401130	MACOMA CARLOTTENSIS
49042402010	TELLINA LUTEA
49042802000	MYA SP.
49042902000	HIATELLA SP.
49043302000	LYONSIA SP.
49043502000	THRACIA SP.
49043502050	THRACIA BERINGI
49050401000	ACMAEA SP.
49050402000	COLISELLA SP.
49050501010	CRYPTOBRANCHIA CONCENTRICA
49050604000	SOLARIELLA SP.
49050604020	SOLARIELLA OBSCURA
49050702010	MOELLERIA QUADRAI
49051101000	SOLARIELLA SP.
49051103000	CINGULA SP.
49053004000	TROPHONOPSIS SP.
49054104000	OENOPOTA SP.
49054501000	RETUSA SP.
49057601000	SIPHONARIA SP.
53180201000	BALANUS SP.
53180201040	BALANUS CRENATUS
53280403040	EUDORELLOPSIS DEFORMIS
53310201010	AMPELISCA MACROCEPHALA
53313414000	HIPPOMEDON
53313429000	ORCHOMENE SP.
53313708000	MONOCULODES SP.
53314207000	PARAPHOXUS SP.
53330401060	PANDALUS HYPSINOTUS
53331107000	PAGURUS SP.
53331701010	ORFGONIA GRACILIS
53332103000	PINNIXA SP.
59010101010	GOLFINGIA MARGARITACEA
59010102010	PHASCOLION STROMBI
68020101010	ECHINARACHNIUS PARMA
68020401010	ALLOCENTROTUS FRAGILIS

APPENDIX C

FEATURES OF STATIONS SAMPLED IN THE VICINITY OF DUTCH HARBOR, ALASKA 11-12 JUNE 1978, BY THE INSTITUTE OF MARINE SCIENCE, UNIVERSITY OF ALASKA, FAIRBANKS, ALASKA BASED ON FIELD NOTES OF H. FEDER, TELEVISION OBSERVATIONS AND DATA DERIVED FROM LABORATORY ANALYSIS OF GRAB SAMPLES. NOT ALL SAMPLES HAVE BEEN ANALYZED.

T.V. = Television Observation on Shipboard, Grab = van Veen Grab, Polychaetous Annelid = PA, C = Clam and S = Snail

A. Stations with samples processed, and taxonomic determinations, numbers of individuals and biomass available for this report. Stations are grouped according to cluster analysis of *ln* transformed data (see Fig. 4 and Table 17). All species in grab samples are included in Appendices A, B, and D.

STATION GROUP 1

Station DUT-0A, 29M

(1) T.V. - shell fragments noted on the bottom, a snow crab, *Chionoecetes* sp., observed moving on the bottom. Sand-shell; silty sand tan-brown to gray sticky.

(2) Grab - moderate sulfide odor; shell fragments. Few organisms observable in screened samples on shipboard.

(3) Laboratory analysis of grab samples - dominant species

Nephtys cornuta (PA) - Abundant
Scalibregma inflatum (PA) - Few
Axinopsida serricata (C) - Few
Ammotrypane aulogaster (PA) - Few
No other species present

Species present were primarily deposit feeders

Station DUT-02, 30M

(1) T.V. - a large amount of fine sediment observed as T.V. camera contacted bottom; bottom not as black as at DUT 01A (see below); sediment surface reflected some light.

(2) Grabs - black sediment with strong sulfide odor; screened more readily than DUT 01A. Shell common. No living organisms observable in screened sample on shipboard.

(3) Laboratory analysis of grab samples - dominant species

Nephtys cornuta (PA) - Abundant
Scalibregma inflatum (PA) - Few
No other species present

Species present were deposit feeders.

Station DUT 00, 34M

(1) TV - showed lighter bottom. A snow crab and several fish (round fish) observed.

(2) Grabs - sediment black; strong sulfide smell. No observable living organisms in screened samples on shipboard.

(3) Laboratory analysis - dominant species in grab samples.

Nephtys cornuta (PA) - Common
Unidentified crab - Few
No other species present

The one infaunal species present is a deposit feeder.

Station DUT 01A, Station in Dutch Harbor behind spit, 28M

(1) TV not able to show bottom - presumably due to black sulfide deposits.

(2) Grabs showed black sediment with very strong sulfide smell. Water during washing process was foamy black. Sediment fine and difficult to screen. One replicate had dead juvenile fish; moribund but fresh in appearance. Many clam shells. One replicate had no organisms.

Nephtys cornuta (PA) - Common
Spiophanes bombyx (PA) and *Capitella capitata* (PA) - Few; both deposit feeders
Only one other organism, a burrowing clam collected

Species present are deposit feeders.

STATION GROUP 2

Station 3H, 34M

(1) TV showed light colored bottom; observed 1 roundfish; particulate matter common.

(2) Four grabs were black; strong sulfide smell; sandy silt; large amount of macroalgal debris. One grab sandy with no sulfide odor detectable; very little plant material. One replicate had no organisms observable.

(3) Laboratory analysis of grab samples - dominant species.

Nephtys cornuta (PA) - Few to Common
Other polychaetous annelids - Few

Clams - Few
Pandalus hypsinotus (coonstripe shrimp) - Two specimens

Species present primarily deposit feeders.

STATION GROUP 3

Station 3BF, 58M

(1) TV - too deep for television

(2) Grabs - sandy-silt firmly held together; brownish gray with fine layer on top of tannish material (2-3 cm thick); fishy smell or marine organic smell. Large amount of terrestrial plant debris made samples difficult to wash. After washing, a large amount of debris was left behind (terrestrial plant). Very few organisms were observable in screened samples.

(3) Laboratory analysis of grab samples - dominant species

Four species of polychaetous annelids (Cirratulidae, *Chaetozone setosa*, *Scalibregma inflatum*, *Heteromastus filiformis*) - Common to Abundant
Two species of polychaetes - Few
Axinopsida serricata (C) - Common
Yoldia thraciaeformis (C) - One large individual
Three other species of clams - Few

Deposit - feeding polychaetous annelids and clams few to common.

Station 3C, 68M

(1) TV - too deep for television

(2) Grabs - silty sand, tan in color; mild organic smell, sticky. Shell common. Oxic.

(3) Laboratory analysis of grab samples - dominant species

Polychaetous annelids - Few to Abundant
- the most common polychaetes, were *Prionospio malmgreni*, Cirratulidae, *Scalibregma inflatum*, *Heteromastus filiformis*
Nuculanidae (C)- Common
Axinopsida serricata (C) - Common
Yoldia thraciaeformis, *Spisula* sp., *Macoma* spp. - Few
Gastropods, amphipods, decapods - Few

Deposit-feeding polychaetes and clams common to abundant.

Station HEL-7, 98M

(1) TV - too deep for television

(2) Grabs - grey-brown silt; no obvious odor; few *Macoma* fragments; sediment readily washed through screens.

(3) Laboratory analysis of grab samples - dominant species

Polychaetous annelids - Few to Abundant
- the most common polychaetes were *Nephtys cornuta, Lumbrineris luti, Scalibregma inflatum* (abundant) *Heteromastus filiformis*
Axinopsida serricata (C) - Common
Yoldia sp. (C) and *Macoma* sp. (C) - Few
Amphipod crustaceans - Few

Deposit-feeding polychaetes and clams common to abundant.

STATION GROUP 4

Station 3B, 51M

(1) TV - no observation made

(2) Grabs - silty sand; mild organic smell, but no sulfide odor. Sand color - tannish gray. Grabs were full, and difficult to wash through the screen. Shells of *Macoma* spp. common.

(3) Laboratory analysis of grab samples, - dominant species.

Polychaetous annelids - Few to Abundant
- the most common polychaetes were *Nephtys cornuta, Glycinde picta, Lumbrineris luti, Prionospio malmgreni, Spiophanes kroyeri,* Cirratulidae, *Scalibregma inflatum, Heteromastus filiformis, Notomastus* sp., *Axiothella catenata.*
Nucula tenuis (C) - Few
Nuculana fossa (C) - Few
Axinopsida serricata (C) - Abundant
Amphipods, hermit crabs, *Pinnixa* sp.
(pea crab), Ophiuroid (brittle star) - Few

Deposit-feeding polychaetes and clams few to common. Few large errant polychaetes.

Station 3F - Approximately 100M off underwater location of Vita Food Products Outfall, 51M. Pipe broken, and was apparently discharging onshore.

(1) TV - no observation made

(2) Grabs - sandy, clean. Organic smell but no sulfide odor detectable.

(3) Laboratory analysis of grab samples - dominant species.

Polychaetous annelids - Few to Abundant
- the most common polychaetes were *Glycinde picta, Lumbrineris luti, Prionospio malmgreni, Spiophanes kroyeri, S. cirrata, Magelona pacifica, Scalibregma inflatum, Capitella capitata, Heteromastus filiformis, Axiothella catenata, Chone cincta*

Clams present but only few of a variety of species such as *Nucula tunuis, Nuculana fossa, Axinopsida serricata, Macoma calcarea*
Golfingia margaritacea (sipunculid) - Few

A variety of deposit and suspension feeding species present.

Station HEL-3, 49M

(1) TV - no observations made

(2) Grabs - silt gray-brown in color; mild organic odor; sticky composition with *Chlamys beringana, Pandora gigantea, Macoma* spp., *Clinocardium* sp., *Nuculana* sp., *Mya* valves and shell fragments.

(3) Laboratory analysis of grab samples - dominant species

Polychaetous annelids - Few to Abundant
- the most common polychaetes were *Glycinde picta, Lumbrineris luti, Scoloplos fuliginosa, Polydora* sp., *Prionospio malmgreni, Spio filicornis, Magelona pacifica,* Cirratulidae, *Tharyx* sp., *Scalibregma inflatum, Heteromastus filiformis, Notomastus* sp., Maldanidae, *Axiothella catenata, Ampharete arctica, Chone cincta*

Clams - Common to Abundant
- the most common clams were *Nucula tenuis, Nuculana fossa, Axinopsida serricata*

Amphipods - Abundant
Golfingia margaritacea, brittle stars,
Solariella spp. - Few

Deposit feeders very common

Station HEL-3A, 40M

(1) TV - no observation

(2) Grabs - organic smell, no sulfide; silty-sand, tannish gray.

(3) Laboratory analysis of grab samples - dominant species

Polychaetes - Few to Abundant. Fewer species than Station HEL-3.
- the most common polychaetes were *Nephtys ferruginea, Glycinde picta, Lumbrineris luti, Haploscoloplos elongatus, Prionospio malmgreni*

Clams - Few to Abundant
- the most common clams were *Spisula* sp., *Macoma* sp., *Mya* sp.

Solariella obscura (S) - very common
Balanus sp. - abundant and found in only one replicate
Amphipoda - very common
Ophiuroids - few

Deposit and suspension feeding species common.

STATION GROUP 5

Station 3G, off Pan Alaska - Whitney Fidalgo Outfall, 31M

(1) TV - clean bottom, sandy-silt; small amount of fine sediment observable in overlying water after frame hit bottom. Just before frame contacted bottom, the camera passed through a school of shrimp (probably *Pandalus hypsinotus*, the coonstripe shrimp). When the frame settled down, fish moved into and out of the frame - possibly the eel pout *Lycodes diapterus*. The fish were vigorous. The area appeared healthy and surface was light and appeared oxic.

(2) Grabs - sandy, black sediment. Strong sulfide odor, but not as strong as at 3E. Reduced number of species.

(3) Laboratory analysis of grab samples - dominant species.

Polychaetes annelids - few to abundant, patchy. Fewer species than in 3F or 3A.
- the most common polychaetes were *Lumbrineris luti, Haploscoloplos elongatus, Prionospio malmgreni, Tharyx* sp.

Clams - few to common; the most abundant species were *Axinopsida serricata*
Mya sp. also common
Solariella sp. - few present

Deposit-feeding polychaetes dominant

STATION GROUP 6

Station 3I, 31M

(1) TV - showed dense population of shrimps - probably *Pandalus hypsinotus*.

(2) Grabs - all had small pebbles to large cobbles. No sulfide noted. Crushed shell and sand mixture. Small volume of samples ≈ 4-5L. Acorn barnacles numerous, limpets common. The most diverse station sampled.

(3) Laboratory analysis of grab samples - dominant species

Polychaetes annelids - few to abundant
- the most common polychaetes were *Glycinde picta, Prionospio malmgreni,* Cirratulidae, *Heteromastus filiformis, Myriochele heeri, Idanthyrus armatus,* Sabellidae, *Spirorbis semidentatus*

Clams - few to abundant
- the most common clams were *Axinopsida serricata, Clinocardium* sp., *Macoma* sp., *Hiatella* sp.

Limpets - few to common; *Cryptobranchia concentrica* - very common
Snails - few of several species; *Solariella* spp. most common
The barnacle *Balanus crenatus* - abundant
Amphipoda, hermit crabs, *Oregonia gracilis* (crab), *Allocentrotus fragilis* (sea urchin), brittle stars - few of each
Gunnel (fish) - 1 specimen

Suspension feeders common at this station.

STATION GROUP 7

Station DUT-0B, 22M

(1) TV - sandy bottom with humps that appear to be produced by animals. Some shell, some amphipods. Bottom appears clean. Species diversity high number of polychaete species reduced. Clams common.

(2) Grabs - very clean sand, no organic odor, some shell. Oxic.

(3) Laboratory analysis of grab samples - dominant species

Foraminifera - very abundant
Polychaetous annelids - few; number of species and number of individuals of each species low
- the most common polychaetes were *Nephtys ferruginea, Glycinde* spp., *Lumbrineris bicirrata, Haploscoloplos elongatus,* Spionidae, *Magelona longicornis,* Cirratulidae

Clams - few to very common
- the most common clams were *Spisula* sp., *Axinopsida serricata*
- also present were *Psephidia lordi, Macoma moesta, Lyonsia* sp., *Thracia* sp., *Tellina lutea*

Snails - few; *Solariella obscura* and *Cingula* sp., *Retusa* sp.
Cumaceans - few; *Eudorellopsis deformis*
Amphipoda - common
Sea urchins - few to common; includes *Allocentrotus fragilis*

Deposit and suspension feeding species common.

B. Station processed, but only one grab taken; not included in cluster analysis.

Station 02A, 27.5M

(1) TV - light, gray bottom, no sign of animal castings or burrows. Large amount of debris present in the water column.

(2) Grab - sulfide odor, but not strong as in 3DE or 3E (see below). One specimen of each of the following species of polychaetes present: *Pholoe minuta, Nephtys corruta, Scalibregma inflatum.*

C. Stations located on or immediately adjacent to the Universal Seafood Outfall.

Station 3E. Station was directly over the Universal Seafood Outfall; the discharge was periodic with crab debris welling up to the water surface. 11-16M

(1) TV - showed many crustacean fragments in water column. TV on bottom buried in sediment initially - when TV unit pulled up, could not see bottom due to black sediment. No living organisms observed.

(2) Grabs - only 1 grab taken; nauseating H_2S odor. Surface of grab material covered with several centimeters of fresh processing waste layered over many centimeters of old black waste and cobble. Difficult to wash. When washed only black shells, black debris, remained in screen. Strong sulfide smell. No organisms present.

(3) Laboratory analysis of grab samples - no organisms present.

Station 3DE, 28M

(1) TV - large amount of debris in water column indicating proximity to effluent outflow. When frame on bottom, it was apparent that it landed on an effluent pile (the effluent surface discharge was about 100 m off); large amounts of processing debris moved out to the water when the frame contacted the bottom.

(2) Grabs - came up full of processing wastes. No organisms present.

(3) Laboratory analysis of grab samples - no organisms present.

D. Stations unprocessed. Only field observations available.

Station 3J, 14M

(1) TV - showed very little.

(2) Grabs - Fine gravel and cobbles. Only 2 grabs obtained. Many grabs attempted.

- 1 polychaete
- 3 amphipods

Station 2A, 14-27.5M

(1) TV - No observations

(2) Grabs at 14M. Samples of rock collected; organism attached:

- coralline algae
- chitons
- few brittle stars
- compound tunicate

Grabs at 27.5M - Sulfide odor but not as strong as at Station 3E. No observation of screened material available.

Station 2B, 14M

(1) TV - No observation

(2) Grab - No grab samples. Large rocks only. No epifauna.

Station 3AG, 38M

(1) TV - considerable debris in water. On approach of camera to the bottom several fish swam away; as frame hit bottom fine sediments

were stirred up and soon settled revealing 18-20 *Pandalus hypsinotus* (coonstripe shrimp). The shrimp remained within the TV frame - some swimming in and out; as frame moved, shrimps moved. The impression is that the bottom has large numbers of these shrimp present. Impression of a clean silty-sand, oxic bottom.

(2) Grabs - Light colored, silty-sand (mainly sand); appears somewhat "gelatinous", very clean - oxic. Slight to strong organic odor. No sulfide odor. Considerable plant debris. No sign of processing wastes. Large *Macoma* shells common.

- few polychaetes
- few clams
- some large, healthy looking *Macoma* sp.

Station 3D, 57M

(1) TV - No TV

(2) Grabs - All grabs full with worm tubes projecting from the mud. Sediment - tannish with some black coloration; silty sand; "fishy" organic smell; in two grabs shell held grab jaws open slightly.

- in grabs: *Macoma* sp., *Pododesmus macrochisma* and *Mytilus* sp. shell fragments; some plant material (blackened); small amount unidentifiable black debris - none with sulfide odor. Noticeable fishy odor as material concentrated by washing in screen box. Sediments oxic with healthy appearing fauna in 3 replicates; sulfide smell in last 2 grabs, but fauna healthy and same as above. One grab had juvenile snow crab in sulfide - smelling sediment, crab healthy in appearance.
- Polychaetes - F to C; *Macoma* sp. - few; *Nuculana* sp. - few; Maldanidae - common; *Solariella* sp. - few.
- Several plastic garbage bags, strapping material, pieces of lumber (ship), piece of kelp.

Station 3C1, 48M

(1) No TV

(2) Grabs - Silty sand; brown-tan color; mild organic odor; sticky composition; numerous shell fragments.

- few anemones
- Maldanidae - common
- *Nephtys* sp. - rare

- polychaetes - common
- *Nuculana* sp. - common
- polychaete tubes - rare

Station HEL 2, 17M

(1) No TV observation

(2) No grab samples collected. Rocky bottom. Rocks had encrusting sponge, bryozoans, chitons.

Station 1A, 46M

(1) No TV

(2) Grabs - Bottom sandy, cobble

(3) No sulfide smell, organic smell. Clean area, very patchy.

- some replicates in sand, others in cobble. Species observed in replicates vary from one grab to another. A diversity of epifaunal (on rock) and infaunal species collected.
- many barnacles.
- 1 lg. *Serripes groenlandicus*
- few *Ophiura* sp.
- 1 *Cistenides* sp.
- few Bryozoa
- few *Macoma* spp.
- few *Laqueus*(?) sp.
- few polychaetes
- few chitons, limpets
- 1 *Natica* sp.

Station HEL 1, 80M

(1) No TV

(2) Grabs - Dark - sandy-silt - held together well.

(3) Rich organic odor but no sulfide. Rich fauna.

- few *Cyclocardia crassidens*?
- few *Clinocardium ciliatum*
- many polychaetes
- worm tubes
- *Nuculana* sp.
- 1 *Musculus* sp.
- few amphipods

Station 7A, 80M

(1) No TV

(2) Grabs - Silty-clay, black gray, mild organic odor. Sticky composition *Macoma, Nuculana* fragments unidentified shell fragments.

- common *Ophelia* sp.
- common polychaete
- rare *Macoma* sp.

Station 7B, 51M

(1) No TV

(2) Grabs - Sandy-silt; no odor; large amount of organic debris - mainly plant.

- polychaetes (Capitellidae, few *Scalibregma inflatum*, 1 large errant polychaete) - few to common

Station HEL-6, 132M

(1) No TV

(2) Grabs - Silt-clay, tan; sticky mud. No odor. Some plant debris. Oxic.

- polychaetes - common (*Scalibregma inflatum* and some Capitellidae)
- *Macoma* spp. - few to common
- *Axinopsida serricata* - few to common
- *Nuculana* sp. - few

Station HEL-4, 95M

(1) No TV

(2) Grabs - Silty-clay-sand, sticky composition, brown-black-gray, *Yoldia* and *Macoma* shell fragments, organic odor. No sulfide odor.

- polychaete worms - few
- Maldanidae
- *Macoma intermedia*?

Station HEL-4A, 78M

(1) No TV

(2) Grabs - One taken. No data available on biota.

APPENDIX D

DOMINANT SPECIES AT STATIONS WITHIN STATION GROUPS.
DOMINANCE OF SPECIES BY NUMBERS ONLY.

APPENDIX D

DOMINANT SPECIES AT STATIONS WITHIN STATION GROUPS.
DOMINANCE OF SPECIES BY NUMBERS ONLY.

Station	Abundant Species	Taxonomic Categories	Common Name
Station Group 1			
DUT 0A	*Nephtys cornuta*	Annelida, Polychaeta, Nephtyidae	Segmented Worm
DUT 02	*Nephtys cornuta*	Annelida, Polychaeta, Nephtyidae	Segmented Worm
DUT 00	*Nephtys cornuta*	Annelida, Polychaeta, Nephtyidae	Segmented Worm
DUT 01A	*Nephtys cornuta*	Annelida, Polychaeta, Nephtyidae	Segmented Worm
Station Group 2			
3H	*Nephtys cornuta*	Annelida, Polychaeta, Nephtyidae	Segmented Worm
Station Group 3			
3BF	*Nephtys cornuta*	Annelida, Polychaeta, Nephtyidae	Segmented Worm
	Prionospio spp.	Annelida, Polychaeta, Spionidae	Segmented Worm
	Cirratulidae	Annelida, Polychaeta, Cirratulidae	Segmented Worm
	Chaetozone setosa	Annelida, Polychaeta, Cirratulidae	Segmented Worm
	Scalibregma inflatum	Annelida, Polychaeta, Scalibregmidae	Segmented Worm
	Heteromastus filiformis	Annelida, Polychaeta, Capitellidae	Segmented Worm
	Axinopsida serricata	Mollusca, Pelecypoda Thyasiridae	Clam

Station	Abundant Species	Taxonomic Categories	Common Name
Station Group 3			
3C	*Nephtys cornuta*	Annelida, Polychaeta, Nephtyidae	Segmented Worm
	Prionospio malmgreni	Annelida, Polychaeta, Spionidae	Segmented Worm
	Cirratulidae	Annelida, Polychaeta, Cirratulidae	Segmented Worm
	Scalibregma inflatum	Annelida, Polychaeta, Scalibregmidae	Segmented Worm
	Heteromastus filiformis	Annelida, Polychaeta, Capitellidae	Segmented Worm
	Axinopsida serricata	Mollusca, Pelecypoda, Thyasiridae	Clam
HEL 7	*Nephtys cornuta*	Annelida, Polychaeta, Nephtyidae	Segmented Worm
	Lumbrineris luti	Annelida, Polychaeta, Lumbrineridae	Segmented Worm
	Aricidea jeffreysii	Annelida, Polychaeta, Paraonidae	Segmented Worm
	Scalibregma inflatum	Annelida, Polychaeta, Scalibregmidae	Segmented Worm
	Ammotrypane aulogaster	Annelida, Polychaeta, Opheliidae	Segmented Worm
	Heteromastus filiformis	Annelida, Polychaeta, Capitellidae	Segmented Worm
	Axinopsida serricata	Mollusca, Pelecypoda, Thyasiridae	Clam
Station Group 4			
3B	*Lumbrineris luti*	Annelida, Polychaeta, Lumbrineridae	Segmented Worm
	Prionospio malmgreni	Annelida, Polychaeta, Spionidae	Segmented Worm

Station	Abundant Species	Taxonomic Categories	Common Name
Station Group 4 (continued)			
3B	*Spiophanes kroyeri*	Annelida, Polychaeta, Spionidae	Segmented Worm
	Cirratulidae	Annelida, Polychaeta, Cirratulidae	Segmented Worm
	Heteromastus filiformis	Annelida, Polychaeta, Capitellidae	Segmented Worm
	Notomastus sp.	Annelida, Polychaeta, Capitellidae	Segmented Worm
	Axiothella catenata	Annelida, Polychaeta, Maldanidae	Segmented Worm
	Nucula tenuis	Mollusca, Pelecypoda, Nuculidae	Protobranch clam
	Nuculana fossa	Mollusca, Pelecypoda, Nuculanidae	Protobranch clam
	Axinopsida serricata	Mollusca, Pelecypoda, Thyasiridae	Clam
3F	*Glycinde picta*	Annelida, Polychaeta, Goniadidae	Segmented Worm
	Lumbrineris luti	Annelida, Polychaeta, Lumbrineridae	Segmented Worm
	Prionospio malmgreni	Annelida, Polychaeta, Spionidae	Segmented Worm
	Spiophanes kroyeri	Annelida, Polychaeta, Spionidae	Segmented Worm
	Spiophanes cirrata	Annelida, Polychaeta, Spionidae	Segmented Worm
	Magelona pacifica	Annelida, Polychaeta, Magelonidae	Segmented Worm
	Tharyx sp.	Annelida, Polychaeta, Cirratulidae	Segmented Worm
	Scalibregma inflatum	Annelida, Polychaeta, Scalibregmidae	Segmented Worm

Station	Abundant Species	Taxonomic Categories	Common Name
Station Group 4			
3F	*Capitella capitata*	Annelida, Polychaeta, Capitellidae	Segmented Worm
	Heteromastus filiformis	Annelida, Polychaeta, Capitellidae	Segmented Worm
	Axiothella catenata	Annelida, Polychaeta, Maldanidae	Segmented Worm
	Chone cincta	Annelida, Polychaeta, Sabellidae	Segmented Worm
	Nuculana fossa	Mollusca, Pelecypoda, Nuculanidae	Protobranch clam
	Axinopsida serricata	Mollusca, Pelecypoda, Thyasiridae	Clam
3	*Glycinde picta*	Annelida, Polychaeta, Goniadidae	Segmented Worm
	Lumbrineris luti	Annelida, Polychaeta, Lumbrineridae	Segmented Worm
	Scoloplos fuliginosa	Annelida, Polychaeta, Orbiniidae	Segmented Worm
	Spionidae	Annelida, Polychaeta, Spionidae	Segmented Worm
	Prionospio malmgreni	Annelida, Polychaeta, Spionidae	Segmented Worm
	Spio filicornis	Annelida, Polychaeta, Spionidae	Segmented Worm
	Magelona pacifica	Annelida, Polychaeta, Magelonidae	Segmented Worm
	Cirratulidae	Annelida, Polychaeta, Cirratulidae	Segmented Worm
	Scalibregma inflatum	Annelida, Polychaeta, Scalibregmidae	Segmented Worm
	Heteromastus filiformis	Annelida, Polychaeta, Capitellidae	Segmented Worm

Station	Abundant Species	Taxonomic Categories	Common Name
Station Group 4 (continued)			
3	Capitellidae	Annelida, Polychaeta, Capitellidae	Segmented Worm
	Maldanidae	Annelida, Polychaeta, Maldanidae	Segmented Worm
	Chone cincta	Annelida, Polychaeta, Sabellidae	Segmented Worm
	Nucula tenuis	Mollusca, Pelecypoda, Nuculidae	Protobranch clam
	Nuculana fossa	Mollusca, Pelecypoda, Nuculanidae	Protobranch clam
	Axinopsida serricata	Mollusca, Pelecypoda, Thyasiridae	Protobranch clam
	Amphipoda	Arthropoda, Crustacea	Sand flea
3A	*Glycinde picta*	Annelida, Polychaeta, Goniadidae	Segmented Worm
	Lumbrineris luti	Annelida, Polychaeta, Lumbrineridae	Segmented Worm
	Haploscoloplos elongatus	Annelida, Polychaeta, Orbiniidae	Segmented Worm
	Prionospio malmgreni	Annelida, Polychaeta, Spionidae	Segmented Worm
	Axinopsida serricata	Mollusca, Pelecypoda, Thyasiridae	Clam
	Spisula sp.	Mollusca, Pelecypoda, Mactridae	Clam
	Mya sp.	Mollusca, Pelecypoda, Myidae	Clam
	Solariella obscura	Mollusca, Gastropoda, Trochidae	Snail

Station	Abundant Species	Taxonomic Categories	Common Name
Station Group 4 (continued)			
3A	Amphipoda	Arthropoda, Crustacea	Sand flea
Station Group 5			
3G	*Lumbrineris luti*	Annelida, Polychaeta, Lumbrineridae	Segmented Worm
	Prionospio malmgreni	Annelida, Polychaeta, Spionidae	Segmented Worm
	Tharyx sp.	Annelida, Polychaeta, Cirratulidae	Segmented Worm
	Axinopsida serricata	Mollusca, Pelecypoda, Thyasiridae	Clam
Station Group 6			
3I	*Glycinde picta*	Annelida, Polychaeta, Goniadidae	Segmented Worm
	Prionospio malmgreni	Annelida, Polychaeta, Spionidae	Segmented Worm
	Spio filicornis	Annelida, Polychaeta, Spionidae	Segmented Worm
	Cirratulidae	Annelida, Polychaeta, Cirratulidae	Segmented Worm
	Heteromastus filiformis	Annelida, Polychaeta, Capitellidae	Segmented Worm
	Myriochele heeri	Annelida, Polychaeta, Owenidae	Segmented Worm
	Idanthyrus armatus	Annelida, Polychaeta, Sabellariidae	Segmented Worm
	Sabellidae	Annelida, Polychaeta, Sabellidae	Segmented Worm
	Spirorbis semidentatus	Annelida, Polychaeta, Serpulidae	Segmented Worm

Station	Abundant Species	Taxonomic Categories	Common Name
Station Group 6 (continued)			
3I	*Axinopsida serricata*	Mollusca, Pelecypoda, Thyasiridae	Clam
	Macoma sp.	Mollusca, Pelecypoda, Tellinidae	Clam
	Clinocardium sp.	Mollusca, Pelecypoda, Cardiidae	Cockle
	Hiatella sp.	Mollusca, Pelecypoda, Hiatellidae	Clam
	Cryptobranchia concentrica	Mollusca, Gastropoda, Lepetidae	Limpet
	Balanus crenatus	Arthropoda, Crustacea, Balanidae	Barnacle
	Amphipoda	Arthropoda, Crustacea,	Sand flea
Station Group 7			
DUT 0B	Foraminifera	Protozoa, Foraminifera	none
	Haploscoloplos elongatus	Annelida, Polychaeta, Orbiniidae	Segmented Worm
	Spiophanes bombyx	Annelida, Polychaeta, Spionidae	Segmented Worm
	Magelona longicornis	Annelida, Polychaeta, Magelonidae	Segmented Worm
	Cirratulidae	Annelida, Polychaeta, Cirratulidae	Segmented Worm
	Axinopsida serricata	Mollusca, Pelecypoda, Thyasiridae	Clam
	Spisula sp.	Mollusca, Pelecypoda, Mactridae	Clam
	Cingula sp.	Mollusca, Gastropoda, Littorinidae	Snail

Station	Abundant Species	Taxonomic Categories	Common Name
Station Group 7 (continued)			
DUT OB	*Eudorellopsis deformis*	Arthropoda, Crustacea, Cumacea	none
	Amphipoda	Arthropoda, Crustacea	Sand flea
	Strongylocentrotidae	Echinodermata, Echinoidea Strongylocentrotidae	Sea urchin

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Washington, D.C. 20235

October 5, 1979

F:PB:F7:YB

Mr. Albert J. Erickson
Acting, Deputy Assistant Administrator
for Water Planning and Standards
Environmental Protection Agency (WH-551)
401 M Street, S.W.
Washington, D.C. 20460

Dear Mr. Erickson:

As I indicated to Mr. Swep Davis in my letter of June 15, 1979, the National Marine Fisheries Service (NMFS) is interested in commenting on EPA's mandated report to Congress on the environmental impacts of seafood effluents (Section 74, Clean Water Act of 1977). Subsequently, we were informally requested by your staff to review the basic reports on which the final report is to be based.

As a result, we have made some general reviews of these reports, which I have enclosed. Our overall view is that although seafood processing wastes cannot be shown to be significantly beneficial to the environment, neither can it be said that they pose a uniform threat under conditions outlined in the studies. We feel that more data are needed to establish firm baselines upon which to draw these conclusions. Therefore, further and more comprehensive research is necessary. We would hope that such factors are noted in your summary report to Congress.

The environmental aspects of seafood waste discharges are of deep concern to this agency. We are striving to protect our nation's living marine resources and their habitats while at the same time not jeopardizing the development of our fishery resources. The conclusions drawn as a result of EPA's Section 74 seafood study could, therefore, be critical in formulating long range seafood waste disposal policies which adequately address environmental concerns in terms of full utilization of fishery resources, as well as costs in terms of impacts on the industry and the consumers.

We appreciate the opportunity to comment on these basic reports and look forward to reviewing and commenting on the final summary report to Congress.

Sincerely yours,

Terry L. Leitzell
Assistant Administrator
for Fisheries

Enclosure

National Marine Fisheries Service
Comments on Reports Submitted by Environment Protection Agency
Under Section 74 of PL 95-217

1. Benthic Macrofauna Sediment and Water Quality Near Seafood Cannery Outfalls in Kenai and Cordova, Alaska, final report, dated February 15, 1979, by SCS Engineers, Long Beach, California, under contract number 68-03-2578.

COMMENT:

An informative but hardly adequate study of the two areas considering the problems of sampling and the need at each site to reconcile observations with natural conditions. Particularly at Kenai, it appears that water and benthic sampling and analysis achieve little if not related to natural benthic conditions (page 86). In Cordova the observations of local waste accumulations with no observed effects on dissolved oxygen values simply verifies the stratification of water above the bottom in a tidal environment. The problem of how to distribute and minimize the benthic impact was not studied but should be if long-term solutions to waste handling are to be developed.

2. Benthic Macrofauna, Sediment and Water Quality Near Seafood Cannery Outfalls in Yaquina Bay, Oregon, dated January 29, 1979, by the Marine and Fresh Water Ecology Branch, Corvallis Environmental Research Laboratory, EPA, Marine Science Center, Newport, Oregon

COMMENT:

A brief but adequate study of the limited effects of waste discharge in a harbor with excellent flushing action. Although the visual or esthetic effects of the effluent plumes were noted, the investigators did not observe any biological or benthic effects with one exception. In their discussion (page 3 of Discussion and Conclusions) they suggest additional study of intertidal fauna and flora beneath the cannery docks. This would seem to be a useful extension of the work for a longer-term understanding of ecological effects in the harbor.

3. An Investigation of Certain Aspects of Crab Processing Wastes Disposal Practices: Insitu and in Vitro Responses of Vibrio Parahemoliticus and Vibrio Anguillarum, prepared by the University of Alaska.

COMMENT:

The first four conclusions of this study (page 2) are useful and factual; however, the extrapolation to "hazardous to humans" and "hazardous to fish and ....fauna" in Conclusions 5 and 6 are unwarranted interpretations. Obviously, vibria and other pathogenic organisms might be shown to survive and grow in the accumulated crab wastes; however, this knowledge does not create a hazard unless a reasonable probability or epidemiology can be constructed. This was not done by the investigators. The single finding of V. alginolytious is important but in our judgement is insufficient to raise the hazard flag.

4. Impact of Seafood Cannery Waste on the Benthic Biota and Adjacent Water at Dutch Harbor, Alaska, prepared by the Institute of Marine Science, University of Alaska under contract number R803922-03-1, dated April 1, 1979.

COMMENT:

The study clearly showed the adverse impact of accumulated wastes in the areas adjacent to the outfalls of the processing plants but also reported that the broad areas near outfalls were not impacted at present. The conclusion of the investigators is that eventually the broad areas will be adversely affected. This may be a reasonable assumption, but it appears that better documentation is needed. There should be a more adequate documentation of the ecological effects of continued dumping in the nearshore environment. The recommendations of the report (page 9) appear reasonable and suggest that studies should proceed to better evaluate the alternatives - i.e. ecology of important marine environments, industry economics, and other involved factors. We note that the investigators comment (page 23) that the anoxic bottom conditions observed are at least in part attributed to oceanographic-meteorological conditions not well understood, particularly since the sampling and field study has not been conducted on a year-round-basis. This also suggests that the longer-term study is needed. In the absence of a sanitary health crisis (suggested but not documented) or a broad ecological impact, some reasonable alternatives for amelioration of the industry dumping practices might be proposed while further studies proceed as recommended. Alternatively, the processors may be faced with difficult and uneconomic alternatives for either waste treatment or dumping in offshore distribution areas. This study does not provide the technological alternatives as suggested by Section 74. From an overall viewpoint the report appears to add no new understanding or dimensions to the problem of localized accumulations of processed waste in a discharge area of limited tidal-current flow. The study was short and intense (24 hours in June 1978) but extrapolates much based on previous limited studies and general understanding of the problem.

5. Draft Report Market Feasibility Study of Seafood Waste Reduction in Alaska, prepared by Development Planning and Research Associates, Manhattan, Kansas.

COMMENT:

The report lacks a summary and conclusions section. It also lacks a statement that tells the purpose of the study. The title implies it is a study on the feasibility of marketing fish meal and oil produced in Alaska.

Actually, the report is: (1) an estimate of the economic losses that would be incurred by fish-reduction operations in Alaska and (2) a comparison with the cost of barging seafoods wastes to dump sites. The report concludes that in three locations, Ketchikan, Seward, and Kodiak, it would probably be better to operate reduction plants than to barge the wastes to deep water. Just a cursory examination of the data presented leads the reader to question whether or not this conclusion is realistic. In table IV-10 on page IV-16 the Ketchikan plant size is given as 50 tons per day. In appendix Table II-1 the estimated seafood wastes are given at 7.3 million pounds. This waste is available during a 4-month period with the major amount available in August,

which is estimated at 3.7 million pounds. This would require a 50-ton-per-day plant to exceed its production capacity by about 10 tons a day during the entire month of August. Compare this with the Petersburg situations where waste is available year around and a reduction plant capable of handling most of the waste available already exists. Yet this plant has apparently not operated at a profit. Can a plant to be located in Ketchikan for only 4 months of the year be expected to turn a profit? How would operation of such a plant on a four months basis compare economically with operation of barge equipment on the same time frame?

6. Technology for Seafood Processing Waste Treatment and Utilization, Section 74 Seafood Processing Study, prepared by the E.C. Jordan Company, Portland, Maine, under contract number 68-01-4831, dated February 1979.

COMMENT:

A good survey of the alternatives for seafood waste control, treatment, and utilization, with no surprises or new solutions. The disposal of liquid wastes and sludges on land is reviewed, but the costs of pick-up and distribution and the limitation of its use on agricultural and forest lands are treated insufficiently, particularly the economics. The discussion of the need of industry to start with in-plant waste separation and control is good. More helpful would be detailed studies of specific plant operations and waste output in relation to costs. This is particularly important in relating alternatives for conversion of wastes to protein hydrolysates, silage, liquid fertilizers, and fish meal. The discussion of waste reduction in Alaska fails to emphasize the very real problem of high operating costs, low returns, and negative profit. Costs of barging in Alaska should be treated more realistically.

7. Ecological Changes in Outer Los Angeles-Long Beach Harbors Following Initiation of Secondary Waste Treatment and Cessation of Fish Cannery Waste Effluent by Dr. Dorothy Soule.

COMMENT:

In all fairness to Dr. Soule and her colleagues, it must be recognized that (1) the task attempted by her, conclusively demonstrating postcessation changes, is extremely difficult and (2) logic suggests that removing the energy rich cannery effluent should result in some of the changes she believes occurred. Because natural conditions vary so much, it is extremely difficult to describe a base line. Numerous years of study are needed and often a true base line may not exist. Yet Dr. Soule was forced to base her comparisons on just a few studies made before cessation and on studies made during a very brief period after cessation. Naturally, some differences were shown, but it would be virtually impossible--in the statistical and scientific sense--to prove conclusively that cessation caused the changes. The problem may not be whether or not organic wastes will result in bioenhancement, but, rather how much organic matter can a given body of water receive. The uniqueness of each body of water makes it difficult to pre-determine this amount of organic matter that can be placed in it without resulting in "too much" having been added.

Further, logic suggests that the addition and then removal of the energy rich cannery wastes from the system produce changes in the system. Fertilization, natural and artificial, is a well known and fairly well understood phenomenon. It is extremely unlikely that removal of the cannery wastes would not cause major changes in the system. We believe that the questions of what are these changes and how long will adjustment of the system take are not yet answered.

In our review of the Harbors Environmental Project report, we sought the answers to the following question:

1. Were there true differences between biological conditions before and after the cessation of dumping of cannery effluent into the harbor?

2. If there were differences, were these directly attributable to cessation?

And, finally, an entirely different type of question.

3. If differences attributable to cessation occurred, were they desirable or undesirable?

With respect to the first and second questions, our conclusion is that although some differences in pre- and post-cessation survey results exist, that, by and large, these cannot be conclusively attributed to removal of untreated cannery wastes from the system. Numerous factors influence fish distribution and abundance. Both the great decrease in larval abundance and the change in partyboat fishery success are better explained by other factors, year-class failure on the one hand, and long-term decline related to fishing pressure on the other. The "creel census" which purported to show decreased success of shore anglers appeared too imprecise to determine real change. It does seem possible that white croaker populations did decline but as mentioned by others, they also may have only dispersed after no attractant was available. Finally, fish populations vary in response to numerous factors which are often undetected by man. Changes of the magnitude described by Soule can be expected to occur normally.

The bird population "changes" are no more conclusive. About half of the species increased while major decreases were only in scoters and gulls. Migratory waterfowl are notably unpredictable and the scoter count offers little information about the local environment. Reductions in the number of gulls may have resulted from their dispersion after dumping ceased.

With reference to the third question posed, we believe that even if the harbor environment is less rich now than before dumping ceased, conditions over the long run may improve. It seems that too little time has been available for adjustment.

Finally, we believe that even if long-term changes have occurred as a result of cessation of dumping, these changes are not necessarily undesirable. Fertilization can enhance productivity, however, it also may create conditions that are undesirable for some species.

PACIFIC SEAFOOD PROCESSORS ASSOCIATION
1600 South Jackson Street
Seattle, Washington 98144
(206) 323-3540

April 16, 1979

Mr. Calvin J. Dysinger
Effluent Guidelines Divison (WH-552)
U.S. Environmental Protection Agency
Washington, D.C. 20460

Dear Cal:

Enclosed are comments by the Pacific Seafood Processors Association on the Section 74 Seafood Study reports titled:

- "Benthic Macrofanna, Sediment and Water Quality Near Seafood Cannery Outfalls in Kenai and Cordova, Alaska" by SCS Engineering, February 15, 1979.
- "An Investigation of Certain Aspects of Crab Processing Waste Disposal Practices: In Situ and in Vitro Responses of Vibrio Parahemoliticus and Vibrio Anuillarum", 1978.
- "Interim Report to Environmental Protection Agency of the Impact of Seafood Cannery Waste on the Benthic Biota and Adjacent Water at Dutch Harbor, Alaska" by Howard Feder and David Burrell, University of Alaska, October 1, 1978.
- "Benthic Macrofanna, Sediment and Water Quality Near Seafood Cannery Outfalls in Yaquina Bay, Oregon" by Environmental Protection Agency, Marine Science Center, Newport, Oregon, January 29, 1979.

Since these reports are site specific for Oregon and Alaska it was felt that comments by the Pacific Seafood Processors Association, whose members operate in these areas, would be most appropriate. These companies are also members of the Nationa Food Processors Association which has recently submitted comments on the other Section 74 contractor's reports that have nationwide implications.

In addition to our comments on the contractor's reports, we are including copies of the following additional material which we feel should be considered in the Section 74 Study.

- "Ecological Changes in Outer Los Angeles-Long Beach Harbors Following Initiation of Secondary Waste Treatment and

Cessation of Fish Cannery Waste Effluent" by Institute for Marine and Coastal Studies, A-lan Hancock Foundation, Los Angeles, California, April 1979.

"Biological and Water Quality Implications of Current Crab Processing Waste Disposal Practies in Dutch Harbor, Alaska", by Dr. Timothy J. Bechtel, March 1979.

"Investigation of Crab Waste Disposal Alternatives in Dutch Harbor, Alaska", by Brown and Caldwell Consulting Engineers, March 1979.

We with to thank you for keeping us involved in the study procedure and for the extention of the comment period which was necessary for the completion of our submission. We hope that when you have completed your review of the contractor's reports and the public comments, we will be given the opportunity to review and comment on your draft Section 74 Seafood Study Report.

Very truly yours,

Roger A. DeCamp
Technical Director

RAD/ch

encl.

Comments by the Pacific Seafood Processors Association on the Oregon and Alaska Site Specific Reports for the Section 74 Seafood Study.

The Pacific Seafood Processors Association represents the majority of the seafood processors in Alaska, Washington and Oregon. As such the Association is vitally concerned in the Section 74 Seafood Study mandated by Congress in the 1977 Clean Water Act, Public Law 95-217. This Act required the U. S. Environmental Protection Agency to conduct a study to determine the effects of seafood processing waste on the receiving waters as follows.

SEC. 74. The Administrator of the Environmental Protection Agency shall conduct a study to examine the geograpical, hydrological, and biological characteristics of marine waters to determine the effects of seafood processes which dispose of untreated natural wastes into such waters. In addition, such study shall examine technologies which may be used in such processes to facilitate the use of the nutrients in these wastes or to reduce the discharge of such wastes into the marine environment. The results of such study shall be submitted to Congress not later than January 1, 1979.

Comments on Report Titled "Benthic Macrofanna, Sediment and Water Quality Near Seafood Cannery Outfa-ls In Kenai and Cordova, Alaska" by SCS Engineering, February 15, 1979.

This report by SCS Engineering represents a significant portion of the Section 74 Study and, as such, the industry is most concerned about the conclusions drawn from this investigation. We have several general comments on the report and also several comments concerning specific points in the text.

General Comments

1. This study represents the worst possible conditions that would be encountered at the sites visited. The investigators arrived at the peak of the season or shortly thereafter and, because of this, they sampled at a time in which the impacts, if any, of the seafood waste would be most marked. Had the investigaors been able to continue the study over a longer time span, it is likely that the conditions observed would have been similar to those noted at the NEFCO outfalls which had not been operating for several months at the time of the study.

2. It must be noted that, although the study was limited to benthic organisms, there was abundant evidence of pelagic species and other marine life in the areas of the discharges which were not observed at the non-discharge sites. The final report should acknowledge the presence of these fishes and crustaceans as well as noting the results of the benthic studies.

3. It is most unfortunate that during the period the Cordova plants were visited, several of the plants were encountering mechanical difficulties with their waste-discharge systems. In

these instances, the study is actually more an indication of the effects of the discharge of whole, unground waste than that of the discharge of waste ground to the size required by the NPDS Permits for Remote Alaska locations, namely one-half inch in size.

Specific Comments

Page 3. It should be noted that both the 1966 University of Alaska Study and the Brickell and Goering Study were measuring the effects of unground waste discharged into Iliuliuk Bay which is an area of very poor water circulation. The industry has since moved its discharge points from this location to Unalaska Bay on the seaward side of Amaknak Island. This relocation was done by industry in an attempt to prevent a problem from developing in the Bay similar to that which occurred in Kodiak's St. Paul Harbor. Unalaska Bay has superior circulation and water exchange rate compared to Iliuliuk Bay. The conditions noted in these studies for that body of water no longer exist.

Page 3. The Brickell and Goering work at Little Port Walter shows that the Alaskan receiving waters naturally receive loadings of seafood material in excess of that discharged by seafood processing plants. It must be remembered that there are many more salmon spawning streams than there are processors in the state.

Page 4. The Dutch Harbor surveys mentioned will be discussed in the comments concerning the University of Alaska's Interim Interim Report to the EPA titled, "Impact of Seafood Cannery

Waste on the Benthic Biota and Adjacent Water at Dutch Harbor, Alaska" and in the additional material submitted by this Association.

Page 5. Reference is made to the EPA Region X Study on the Pollution Problem from Shellfish Processor Discharges in Kodiak Harbor, St. Paul Harbor and Gibson Cove, Alaska. It should be remembered that Kodiak represented a unique situation where a large number of processing plants were discharging into a body of water which had a poor circulation pattern. Moreover, these plants were unique in that they were operating on a year-round basis with shrimp and crab comprising the majority of the products processed. For these reasons, the Kodiak situation developed into a considerable problem. To remedy this situation tangential screens were installed by the Kodiak processors and, it should be noted, that conditions in the St. Paul Harbor area have improved considerably over those noted during the 1971 investigations.

A document which should have been included in the literature review was the report titled " Evaluation of Waste Disposal Practices of Alaska Seafood Processors from the National Field Investigations Center, Denver, Colorado, and Region X, Seattle, Washington, Offices of the Environmental Protection Agency", published in December 1974. This study investigated 26 Alaska seafood plants and included bottom samples in the areas of many of the plants. This study pointed out the benificial effects that grinding and discharge into areas of adequate tidal flushing have on seafood discharge into marine waters.

Kenai

Page 22. The values in both tables 1 and 2 represent the total waste from each of the product commodities listed. However, it should be noted that much of this waste is in the form of blood and other liquids and, as such, does not represent recoverable waste or waste which would have an effect on the benthis community. It is estimated by industry sources that while waste from a canned salmon process may represent 35% of the live weight, only 20% of this live weight is what is termed "recoverable waste". For a fresh and frozen operation, depending upon whether or not the fish are dressed heads on or heads off, only 10 to 15% of the live weight is recoverable waste. It must be remembered that the non-recoverable wastes are not affected by grinding or screening as they are either liquid or particles too fine to be affected by the action of the equipment.

Cordova

Page 43. The problem noted at the St. Elias dock with the dumping of whole crab shells must be recognized as not typical of plants complying with the Requirements of their NPDS permits.

Page 47. Reference is made to a "fully loaded tender boat". This is redundant as the industry use of the term "tender" connotates a boat and, thus, the term "boat" is not necessary. Also, the term "set" which follows tender boat has a unique meaning within the fishing industry. A set is the term used to describe the setting of a fishing net during the seining process, and as such, the terms either the "tender sat on the line" or the "tender went dry on the

on the line" instead of "set" should be substituted, unless the boat did actually release its net over the discharge pipe and this was the cause of the breakage.

Page 49. In reference to the North Pacific processors discharge pipe, the numberous fish tails and heads observed at the North Pacific processors discharge indicates that the grinder had not been working at this location for a considerable period of time. Had the grinder been working properly, the buildup might not have occurred.

Page 50. It should be noted that at several locations including the Morpac outfall there were very few flatfish. This compares markedly with the number of flatfish noted at the other plant discharges. It would appear that there is a difference as far as pelagic fish are concerned in the attractions by seafood waste depending upon the particle size and the manner in which it is discharged. We recognize that this study was limited to benthic organisms and we are familiar with the concerns over the fact that pelagic fish are migratory and do not necessarily prove that the environment is desirable. However, we do hope that the final report will note the presence of the pelagic fish and of starfish, crabs and sea anemone at the discharge sites from the seafood processing plants.

Page 51. It is noted that stations M, K and L had a very high incidence of empty mollusk shells and shell fragments, in some areas covering an estimated 50% of the area. The report does not make clear the area this actually represents and how large a portion

of the bottom was covered at each of the sites.

Page 54. An absence of waste debris at both NEFCO outfall sites was noted and it was suggested this was due to good flushing action. It is also very likely that this was due to proper operation of the grinder. Had the grinders been maintained at the two outfalls noted to have grinder problems, namely St. Elias and North Pacific Processors, it is very likely that no buildup would have occurred.

Pagd 54. The source of the higher water temperature is hard to determine. Normally, the seafood processing operation does not involve the introduction of much heat into the processing stream. In some processing plants, water is used to cool retorted cans. However, this would be an intermittant flow and would not cause a constant elevation of the discharge water temperature. It is more likely that the water source which raised the temperature was the Cordova City Municipal Water Collection System which discharges in the same general area. As this system handles domestic waste from the city as well as the processing plants, it is possible that the warmer water noted was from this source.

Page 83. The lack of sediment at both NEFCO sites, GT and N-O points out the importance of conducting a full cycle survey. It is unfortunate that SCS Engineering was unable to visit the plants prior to the beginning of the processing season to determine the amount of dissipation the waste experienced during the Fall, Winter and Spring of the year.

Pages 87, 88 and 89. The study demonstrates the necessity to maintain grinders in proper working order and the impact that unground seafood waste has on the ecosystem, as well as the need for the proper placement of the discharge pipes. Outfalls must be placed in an area receiving adequate tidal flushing to prevent the possibility of waste buildup. It should be noted that tidal flushing is peculiar for each location and is not necessarily indicated by a single, arbitrary depth.

General Comments on Methodology of Biological Assay

It is difficult to compare the results of the SCS study with those of the EPA group in Yaquina Bay and the University of Alaska group in Dutch Harbor due to the SCS use of a second screening of 0.5 mm mesh after the primary screening of 1.0 mm used. To maintain consistency, we would recommend that the agency used the 1.0 mm mesh screening results throughout its final report. It is also unfortunate that the Yaquina Bay study and the Alaska study utilized different methods for the determination of species density as well as different indices of species dominance. It is unclear how Simpson's Index of Dominance and the Bray-Curtis Dissimilarity Coefficient used in the Yaquina Bay study compare with the Shannon-Wiener formula and the Czekanowski Coefficient used by SCS. It is hoped that the agency will utilize a standard set of methods in analyzing the data.

Comments on Report Titled "An Investigation of Certain Aspects of Crab Processing Waste Disposal Practices: In Situ and In Vitro Responses of Vibrio Parahemoliticus and Vibrio Anguillarum", 1978.

This study is highly speculative in nature and is limited primarily to laboratory work. Its application to a study of the effects of seafood waste on receiving water is of limited value. The EPA in its Denver report already considered vibrio as a pollution indicator and in that document dismissed it as being of insignificant consequence. There were four major problems with the study as presented.

1. None of the samples from any of the locations investigated were positive for either Vibrio parahemoliticus or Vibrio anguillarum. A third vibrio species was discussed throughout most of the report but its relationship to the two organisms which were the subject of this report was never explained.

2. The study utilized crab meal rather than actual crab processing waste. Since the crab meal has already been broken down to a certain extent and has had other nutrients released, it can hardly be compared with actual crab shells. Growth on crab meal does not conclusively prove that an organism would be capable of growing on the actual waste.

3. The crab meal was sterilized prior to the innoculation with the organism to be tested; this eliminated any competitors. It must be remembered that there are numberous competitors present in the actual marine environment which would greatly affect the viability of any vibrio present.

4. Artificial, rather than natural, seawater was used in a number of the experiments. This artificial seawater did not have the natural competitors which would be present. This represents a problem similar to that encountered in sterilizing the crab meal.

Page 21. It must be noted that the minimum growth temperature for Vibrio parahemoliticus is above the water temperatures for Dutch Harbor noted in the report titled "Interim Report to the Environmental Protection Agency on the Impact of Seafood Cannery Waste on the Benthic Biota and Adjacent Water at Dutch Harbor, Alaska" by the University of Alaska, October 1, 1978. Conversation with Dr. John Liston of the University of Washington, a noted authority on Vibrio parahemoliticus, indicated that 15°C. is the minimum growth temperature for Vibrio parahemoliticus in situ.

Of all samples collected during the study, only one was positive for vibrio. This organism was found in the Cordova area and was classified as Vibrio alginolyticus. It was not a subject of the study and is not a human or fish pathogen. The relevance of the finding of this organism in a single sample is questionable.

There have been no cases of vibrio caused diseases reported for either the Dutch Harbor area or Codova. We hope that the Agency will recognize the limited applicability of this report to the Section 74 Seafood Study.

Comments on Report Titled "Interim Report to Environmental Protection Agency of the Impact of Seafood Cannery Waste on the Benthic Biota and Adjacent Water at Dutch Harbor, Alaska" by Howard M. Feder and David C. Burrell, Insititute of Marine Science, University of Alaska, October 1, 1978

As this is an unfinished interim report, the industry feels it cannot adequately comment on the material presented at this time. The indication of the impact of the waste on the benthic population appears to be the major item yet to be concluded and, without this material, comments would be premature. It is hoped that the agency will consider the additional new material presented with these comments titled "Biological and Water Quality Implications of Current Crab Processing Waste Disposal Practices in Dutch Harbor, Alaska", March 1979, by Dr. Timothy J. Bechtel and "Investigation of Crab Waste Disposal Alternatives in Dutch Harbor, Alaska" by Brown and Caldwell Consulting Engineers, March 1979, when evaluation the impact of seafood waste at the Dutch Harbor site.

Comments on Report Titled "Benthic Macrofauna, Sediment and Water Quality Near Seafood Cannery Outfalls in Yaquina Bay, Oregon, by Marine and Freshwater Ecology Branch, Corvallis Environmental Research Laboratory, Environmental Protection Agency, Marine Science Center, Newport, Oregon, January 29, 1979

The industry has only a few general comments on this study. For the most part, there appear to be no major problems caused by the seafood discharges in this area. The agency consistently uses the term "seafood cannery" for processing plants. Very few of the seafood processing facilities in Yaquina Bay are actually "canneries". Most of them, in fact, freeze the product. This same problem in terminology exists in the Dutch Harbor benthic study. The distinction is more than academic as there are differences in the waste generated by canneries compared to waste generated by freezing facilities. The Agency has recognized these differences in establishing different effluent guideline limitations for canning operations versus freezing operations.

Again it is noted that the indices of species diversification and dominance used in this study were different from those used in the SCS Engineering study.

As a final note, industry again hopes that the agency will note the presence of pelagic species and other marine life in the plant discharge areas which indicates that the discharges are an important part of the marine food web.

Additional Material

We wish to submit the following reports for consideration by the Agency. We believe that these reports have considerable bearing on the Section 74 Seafood Study.

"Ecological Changes in Outer Los Angeles - Long Beach Harbors Following Initiation of Secondary Waste Treatment and Cessation of Fish Cannery Waste Effluent" by Institue for Marine and Coast Studies, Allan Hancock Foundation, Los Angeles, California, April 1979.

"Biological and Water Quality Implications of Current Crab Processing Waste Disposal Practices in Dutch Harbor, Alaska" by Dr. Timothy J. Bechtel, March 1979.

"Investigation of Crab Waste Disposal Alternatives in Dutch Habor, Alaska" by Brown and Caldwell Consulting Engineers, March 1979.

ADDRESS ONLY THE DIRECTOR,
FISH AND WILDLIFE SERVICE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
WASHINGTON, D.C. 20240

In Reply Refer To:
FWS/ES

AUG 31 1979

Mr. Robert B. Schaffer
Director
Effluent Guidelines Division
U.S. Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Schaffer:

In response to your letter of May 23, 1979, as well as a meeting with Mr. Cal Dysinger of your staff on July 24, 1979, we are providing limited comments on your seafood study. We have reserved comments on the report by Ms. Dorthy Soule. We understand that staff from our Laguna Nigel Field Office will provide separate comments on this report. Our comments will be brief and limited to the Alaska and Oregon reports.

In general, we believe the reports received are based on short-term studies under conditions requiring an extremely fast turnaround time. Furthermore, the reports are limited in scope, appear to have significant oversights and omissions, and in most cases no provisions appear to be made for follow-up studies. These reports tend to make rather broad conclusions regarding environmental impacts which we believe are not in keeping with the character of the studies. An additional report by the National Marine Fisheries Service on Finger Bay in Alaska is enclosed for your information.

Specific Comments:

Under this heading brief comments regarding specific reports are provided.

1. An Investigation of Certain Aspects of Crab Processing Waste Disposal Practices: In Situ and In Vitro Responses of Vibrio parahemolitius and Vibrio anguillarium.

   This report by the University of Alaska is very specialized and limited in scope. It is an excellent investigation of the ability of two marine life intestinal pathogens of the genus Vibrio to survive in the marine environment near seafood processing wastes. However, the substance of the report does not justify its use as an evaluation of the potential for diseases of marine life related to the dumping of seafood processing wastes. Such wastes are ideal breeding grounds for large concentrations of fungi, molds, and

other types of decomposers. Many organisms in these groups are well known to be opportunistic parasites which periodically infect marine and freshwater organisms on a large scale. Such groups should be thorougly investigated in any evaluation of seafood dumping sites.

2. Working Papers #EPA 910-8-77-100 and 910-8-78-101: "The Dutch Harbor Studies"

We fully concur with many of the conclusions of report #EPA 910-8-77-100 regarding Dutch Harbor. Seafood wastes are primarily responsible for the adverse conditions observed in Iliuliuk Harbor, inner Iliuliuk Bay, and Dutch Harbor. Investigations by ourselves and others support this conclusion. Referral to other studies of this type suggests that this report does not address the full impact of the discharges of seafood wastes in the bay area. For instance, there was no attempt to analyze for H_2S, a significant environmental by-product of the waste. Certainly the conclusions regarding the elimination of discharges from these areas are appropriate and well supported.

The investigation of the discharges to the west side of the island described in report #EPA 910-8-78-101 appears to be superficial and belie the full impacts which are apparently occurring along the west coast of the island. The fact that decomposition is considerably slower than the rate of addition by the discharges supports this belief. It is also supported by the fact that many of the active discharge pipes were moved during the study period creating adjacent pollution sites of close proximity. The fact that the abandoned sites have significant debris and are totally devoid of life after a period of a year or more would suggest a potential for significant damage near shore by such movement of the pipe. The failure of this report to quantitatively assess the amount of H_2S in these locations or determine the western (seaward) extent of the waste from the discharge pipes also limits the report's value as a tool for assessing impacts of the processing wastes.

3. Benthic Macrofauna, Sediment, and Water Quality Near Seafood Cannery Outfalls in Kenai and Cordova, Alaska.

We believe that the conclusions of the study are somewhat misleading. The report appears to minimize existing problems and fails to address the potential for future problems. Certainly the study at Cordova occurred during a season of minimum productivity and the study was not sufficiently in-depth to justify a solid conclusion that the impacts are of a highly localized nature. Follow-up studies are needed to verify the findings. Extensive

sediment analysis should be incorporated in future studies including nutrient loading, H_2S production, and ammonia production. Trends in the ecosystem near the waste sites and down-current from them need to be ascertained before any firm conclusions can be drawn regarding impacts.

Similar weaknesses are found in the Kenai study. Our experts agree that no significant impacts may be demonstrated at Kenai at this time. However, they raise the question of potential significant impacts at Kenai with increased loading from additional plants. A similar argument can be made for the Cordova situation.

In the review of previous Alaskan studies section, there are several summaries which are misleading and in some cases invalid. For example, we cannot accept the analogy to Iliuliuk Bay presented in the summary of the Brickell and Goering studies. The fact that natural loading of dissolved organic nitrogen and ammonia in an estuary where salmon carcasses accumulated after spawning approximates the ammonia values in Iliuliuk Bay does not mean the two situations are truly comparable. A consideration of the total freshwater drainage area discharging into the estuary or bay versus the loading and other constraints of the two systems would be necessary before comparability could be contemplated.

The summary of the Nakatoni and Beyer mortality studies provides another example, since the studies are summarized without noting the fact that chronic exposure and secondary effects are not addressed.

The community analysis procedure discussed in the methodology could prejudice against any rare or endangered species found in the study area. Furthermore, we disagree with their contention on page 36 that using a 0.5 mm instead of a 1.0 mm screen changes the conditions described. The conditions are the same; the refinement of those conditions is what differs. The decision of whether or not to use more refinement is tied directly to comparability with techniques used in other studies. Without comparability, refinement is of no value.

4. Benthic Macrofauna, Sediment and Water Quality Near Seafood Cannery Outfall in Yaquina Bay, Oregon.

This report appears to be better done than the Alaskan reports, but still suffers from the same basic weaknesses. H_2S was not addressed. No effort was made to evaluate the relationship of carcinogenic benzopyrene effects to the presence of the seafood wastes, nor was there an effort to determine the source or other possible interrelationships of the benzopyrenes to seafood processing wastes.

Follow-up studies would be needed for the conclusions of this report to be concrete. In addition, loading evaluations of the marine system in Yaquina Bay should be conducted.

5. Section 74 Seafood Processing Study.

We agree with the report's observed differences between the Alaskan seafood industry and the industry found in the contiguous United States. Furthermore, we concur that the reluctance of other processors in the vicinity by the Alaskan fish meal plants to screen their wastes has contributed to the limited success of the enterprises. The report's observation that allowing plants to continue grinding waste for discharge to the marine environment does not provide the necessary incentive for effective in-plant water and waste management practices is well taken.

The report only addresses the problem of waste reduction processes. We believe that the potential value and feasibility of waste disposal technology should also be addressed by EPA, but have no indication that it has been seriously addressed in connection with this series of reports. One possible disposal technology that might be explored is the use of the collection system in reverse to spread the waste over a large area of ocean to create a more natural situation for its degradation and eliminate its adverse impact.

We trust these comments will be helpful to you in preparing your final report. Since we realize that these reports are mandated by Congress and provide the potential basis for future decisions, we have emphasized their limitations and oversights and how they might affect any conclusions of negative impacts. If there are any additional questions, please contact my staff for clarification.

Sincerely yours,

Michael J. Spear
Associate Director

Enclosure

STATE OF ALASKA

DEPT. OF ENVIRONMENTAL CONSERVATION

JAY S. HAMMOND, GOVERNOR

RECEIVED
JUN 29 1979

ENFORCEMENT DIVISION
POUCH O – JUNEAU, 99811 REGION 10

June 20, 1979

XAOO790702
XJAK790702

Mr. Denton Sherry
President
Whitney-Fidalgo Seafood, Inc.
Box C 99308
Seattle, Washington 98199

Dear Mr. Sherry:

This letter is in response to your letter to me dated June 6, 1979. We appreciate your taking time to set forth your views on seafood waste disposal regulations in Alaska. Increased dialogue between the Industry and this Department would be beneficial to all concerned parties.

As you are probably aware, we have advocated dropping the distinction between "remote" and "non-remote" sites for the purpose of seafood waste disposal. It is our belief that screening of seafood wastes should not be arbitrarily mandated, but rather should be invoked where receiving water conditions require it. For example, I'm sure that almost everyone would agree that the processors around the community of Kodiak need to be screening their seafood wastes.

Our position on screening has unfortunately been made difficult by some of the seafood processors in the "non-remote" communities not adequately disposing of their wastes. Improper disposal includes such practices as 1) dumping wastes including fish heads and whole carcasses in large piles under docks, 2) inadequate outfalls for the waste that is ground and 3) inadequate attention to reducing floating solids and foam. Efforts by the entire industry to run as clean an operation as possible would go a long way to strengthen the industry's position on adequate disposal practices. Toward that end, we plan to check on industry progress this summer in Petersburg and Ketchikan.

As you point out, the Dutch Harbor crab waste situation is a vexing problem. Most of the processors are to be commended for the measures that they have taken to clean up the waters of Illiuliuk Harbor. This leaves us all with the problem of rapidly accumulating wastes from the discharges to the west side of Amaknak Island. As noted in the recent Bechtel report, prepared at the processors' behest, the piles do last through the winter. A University of Alaska study shows detrimental effects on the benthic environment occurring 0.3 mile away from the outfalls. Accordingly, we can not fully agree with your contention that the crab waste problems are minimal and localized.

Hopefully, the current shallow water discharge study being conducted by the processors will result in answers that will help alleviate some of the existing problems with seafood waste accumulation. It would appear that the processors should not depend exclusively upon this solution. The same large volume of waste is still being discharged in essentially the same small area. The processors should continue to explore alternative disposal options. We are in concurrence with the processors' contentions that physical constraints in the Dutch Harbor area (including weather) will make barging difficult at certain times of the year. Perhaps barging the majority of the wastes while allowing grinding and discharge during foul weather would be a workable solution.

In conclusion, everyone's best efforts to resolve the existing problems should result in viable solutions amenable to all. Please let me know if I can be of further assistance.

Sincerely,

C. Deming Cowles
Deputy Commissioner

cc: Roger De Camp
Lloyd Reed

bcc: Kyle Cherry
Deena Henkins
Mark Brodersen
Ron Hansen

PACIFIC SEAFOOD PROCESSORS ASSOCIATION
1600 South Jackson Street
Seattle, Washington 98144
(206) 323-3540

August 17, 1979

Mr. Calvin Dysinger
Effluent Guidelines Division (WH-552)
U. S. Environmental Protection Agency
Washington, D.C. 20460

Dear Cal:

The University of Alaska final report titled "Impact of Seafood Cannery Waste on the Benthic Biota and Adjacent Water at Dutch Harbor, April 1, 1979", has been reviewed by a number of our members.

This report contains some well documented, valuable information on conditions at specific sites throughout the Dutch Harbor area. This information will be very helpful as a small part in understanding the entire question of the condition at Dutch Harbor. However, this report falls far short of defining the impact of seafood waste on the area as its title implies.

The fact that the report has expanded from 73 pages in its interim form to 211 pages in its final form, without any additional site studies, is a symptom of the problem. From the beginning, we have stated that investigations for the Section 74 Seafood Study should cover a sufficient period of time to determine the changing conditions and effects in an area during the season. While we understand the money and time problems in this type of approach, the same question keeps reoccuring. That is, what is the real impact of the discharge of seafood waste on the environment? A study such as this which lasted only 2 days cannot adequately describe the present situation, let alone the estimation of effects in the future. This is like trying to draw a curve from a single data point which itself is based on an insufficient sampling. The lack of sufficient data to fully define the impact is demonstrated in this report by the numerous suppositions and estimates throughout the text. The terms "expected to", "may", "probable" and "potential danger" are prevalent. The authors themselves recommend that additional studies be conducted to put the situation in proper perspective.

There are other problems with this report which tend to cloud the main issures. Areas which receive considerable attention such as the inner harbor, the outer harbor, Captain's Bay and Scan Bay, while of academic interest, have nothing to do with the impact of the discharge of processing waste. All processing waste is discharged on the north or west side of Amaknak Island in Unalaska Bay. Lengthy discussions of sills, currents and natural anoxic conditions in areas not receiving processing waste do not meet the goal of this study. Even worse, they set the tone of the report and tend to lead the reader toward the unsupported conclusion that seafood processing waste is dangerous to the environment. In further support of our objections, water column sulfide was detected at only one station, but we were led to believe the situation was much more serious. Grab samples from the piles should have a sulfide odor as this is a normal and expected result of decomposition. The report states that negative effects of the waste piles dissipate within a relatively short distance and that processing is not impacting broad areas near the outfalls. Then, rather than relating the small size of the affected areas to the large size of Unalaska Bay and determining why there is no broad impact, the authors jump to the unsupported position that accumulated wastes will eventually cover much of the nearshore bottom and cause serious ecological and sanitary problems unless the discharge of waste solids is prohibited.

In summary, we feel that the report is inconclusive and does not evaluate the impact of the direct discharge of seafood processing waste. It leaves unanswered the question of why years of direct discharge have evidently only slightly affected the environment. We are dissapointed that so much effort has been expended without answering the basic question.

In order to determine the mechanics of direct discharge and its effects on the environment, the Dutch Harbor Processors are presently conducting a research project. Our earliest concerns have been with the fate of the discharged waste over an extended period of time. History itself has disproven the theory that the waste piles grow progressively larger without significant dispersion. The enclosed July 1979 Status Report on the processor's project indicates that there is considerable dispersion under certain conditions over a period of time. This project should provide us with answers to some of the questions raised when Congress mandated the Section 74 Seafood Study. We appreciate the opportunity to comment on the University of Alaska study and are looking forward to seeing the Section 74 Study draft.

Very truly yours,

Roger A. DeCamp
Director, Technical Services

RAD:vcb
Enclosure

NEARSHORE DISCHARGE EXPERIMENT
STATUS REPORT
JULY, 1979

General

The Vita Foods test outfall is located on the west side of Amaknak Island and serves the Barge Vita and one additional floating vessel on a seasonal basis. The outfall discharges ground crab waste through an open-ended pipe, positioned eight feet off the bottom in 18 feet of water (MLLW). Distance to shore is about 110 feet. Discharge through the test outfall began on March 29, 1979.

Results through 1979 Tanner Crab Season

Production and Waste Discharged. Over the period March 29, 1979 through June 11, 1979, Vita Foods processed 4.1 million pounds of raw crab and 188,000 pounds of shrimp. Assuming a waste solids/raw crab ratio of 25 percent,[1] total waste generated is approximately one million pounds. At 50 pounds crab waste solids per cubic foot (Bechtel, 1979), this represents approximately 20,000 cubic feet of crab waste solids. If a recovery rate of 15 percent is applied to the 188,000 pounds of shrimp processed (Tondre, 1979), approximately 160,000 pounds of shrimp waste were discharged.

Waste Pile Observations. The attached table shows the results of diver observations at the test discharge site. Over the tanner crab season, the pile grew in size until late May, when it reached 10,000 cubic feet. June 11 observations show an increase in pile size of over 7,000 cubic feet, while only 3,000 cubic feet of crab waste was discharged since the prior dive. The difference is attributed to the shrimp processed during the same period. Shrimp waste settles poorly, resting as a floc-like blanket on the bottom. Pile measurement is very difficult under these conditions.

The subsequent dive on July 9, 1979, when shrimp was not being processed, showed measured pile volume had declined by nearly 10,000 cubic feet, a greater reduction than might have been expected to occur had the pile consisted of crab waste alone. Neglecting anomalous June 11 results, maximum pile volume was 10,080 cubic feet, approximately 57 percent of the amount of waste solids discharged. Maximum area covered was 4,240 square feet in late May (again neglecting June 11 figures). Diver reports indicate that the waste pile remained cone-shaped throughout the season with maximum depth ranging from seven to nine feet.

---

[1] The principal species processed was C. opilio, which has a waste/solids ratio slightly higher than the 20 percent reported by Bray (1978) for C. bairdi.

Through the entire tanner crab season no onshore accumulations of crab shell were observed. While some lateral pile movement was observed, particularly with lighter shrimp shell, pile contours did not show pronounced net drift, nor was any significant downslope movement indicated. At no time during the season did waste accumulations exceed applicable permit requirements for bottom coverage.

Weather. The spring and summer in Dutch Harbor have been unusually mild with no sustained storms of significance. Over the period March 29 to June 11, winds exceeding 20 knots were recorded on only nine occasions. The wave environment in the vicinity of the test outfall has been similarly mild.

Discussion

The experimental nearshore discharge has now been operational for four months. In the planning stage, the processors assumed that this experiment would continue for a relatively longer period than four months, and that the effects of good and bad weather, winter and summer and new and mature piles would be observed and evaluated. The experiment continues to comply with Environmental Protection Agency conditions that no shore accumulation occur and that pile size does not become excessive. It would be premature to attach major significance to preliminary results (e.g., pile buildup and decay, the lack of beach accumulations, compliance with the existing permit requirements for bottom coverage). If the experiment is to produce meaningful results, either positive or negative, it is important that the duration of the test be sufficiently long to account for unusual discharge conditions. Consequently, it is desirable that the nearshore discharge experiment continue.

Vita Foods Test Outfall Waste Pile Volume Changes: 1979 Tanner Crab Season

Date	Pounds raw crab processed to date	Waste crab solids discharged to date, cu ft	Pile volume, cu ft	Change in volume, cu ft	Area covered, sq ft[a]	Maximum pile depth, ft
3/29	0	0	0	--	0	0
4/5	342,662	1,713	1,003	+1,003	480(3)	8
4/14	763,528	3,818	4,598	+3,595	2,000(3)	9
4/27	1,663,747	8,319	5,656	+1,058	2,960(2)	7
5/11	2,548,311	12,742	8,366	+2,710	3,310(1)	9
5/26	3,548,395	17,742	10,080	+1,714	4,240(1)	7-1/2
6/11[b]	4,188,868[c]	20,944[d]	17,295	+7,215	10,950(1)	8-1/2
7/9	4,188,868	20,944	7,502	-9,793	3,080(4)	8

[a] Area covered to depth, in inches, indicated in parentheses.

[b] End of Tanner Crab processing.

[c] Does not include 188,277 pounds of shrimp processed.

[d] Does not include 160,000 pounds of shrimp waste.

* 7/83 replacement report (this 1 missing pages) is filed w/ this volume.

BIOLOGICAL AND WATER QUALITY IMPLICATIONS OF CURRENT CRAB PROCESSING WASTE DISPOSAL PRACTICES IN DUTCH HARBOR, ALASKA

PACIFIC SEAFOOD PROCESSORS ASSOCIATION
SEATTLE, WASHINGTON

March 1979

Timothy J. Bechtel, Ph. D.
Consulting Biologist

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	iv
CONCLUSIONS	v
INTRODUCTION	1
MATERIALS AND METHODS	4
Field Activities	4
Underwater Photographs	4
Pile Volume Measurements	4
Review of Previous Studies	4
Data Reduction	5
Pile Volume Calculations	5
Discharged Waste Volume Calculations	5
RESULTS AND DISCUSSION	6
Underwater Photographs and Diver Observations	6
Pile Volume Measurements	13
Pile Volume and Discharged Waste Volume Calculations	13
Waste Pile Volume Reduction Rates	25
Recent Trends in Dutch Harbor Crab Waste Production	26
Effects of Crab Wastes on Water Quality	29
Effects of Crab Wastes on Marine Organisms	30
ALTERNATIVE DISPOSAL SYSTEMS	34
Environmental Effects of Deepwater Disposal of Crab Wastes	34
LITERATURE CITED	37

LIST OF FIGURES

Number		Page
1	Location of Crab Processors and Waste Disposal Sites	2
2	Fresh Crab Waste on Pacific Pearl Waste Piling Looking From Edge of Pile Toward Top	7
3	Juvenile Baitfish Feeding on Waste Particles Floating Above the Top of the Pacific Pearl Pile	7
4	Flatfish at Edge of Pacific Pearl Pile	8
5	Attached Organisms on the Universal Discharge Pipe Where It Crosses over Pacific Pearl Pile	8
6	Organisms on Pan-Alaska Discharge Pipe 90 Feet from Outfall	9
7	Mud-Sand Bottom Adjacent to Pan-Alaska Discharge Pipe	9
8	Point at Which Pan-Alaska Discharge Pipe Enters Crab Waste Pile	10
9	Closeup of Pan-Alaska Waste Pile Showing Decomposed Condition of Wastes Remaining from 1978 Tanner Crab Season	10
10	Configurations of Pacific Pearl Waste Pile in October and January (contours in feet)	14
11	Configurations of Universal Waste Pile in October and January (contours in feet)	15
12	Configurations of Vita Waste Pile in October and January (contours in feet)	16
13	Configurations of Pan-Alaska Waste Pile in October and January (contours in feet)	17
14	Configuration of Whitney-Fidalgo Waste Pile in October and January (contours in feet)	18
15	Configurations of Sea-Alaska Waste Pile in October and January (contours in feet)	19

LIST OF TABLES

Number		Page
1	Relationship Between Waste Pile Volume Changes and King Crab Wastes Discharged During 1978 Season	20
2	Pan-Alaska Waste Pile Volume Changes During 1977 Tanner Crab Season	25
3	Recent Dutch Harbor Crab Production Data	28

ACKNOWLEDGEMENTS

This study could not have been accomplished without the excellent cooperation received from the Dutch Harbor crab processors. The assistance of the Steering Committee, consisting of Roger DeCamp, Pacific Seafood Processors Association; Dick Pace, Universal Seafoods, Ltd.; and Ken Moll, Castle & Cooke, Inc., is greatly appreciated. Data requests and information concerning processing activities were expeditiously handled by Rich White and Bill Tondre, Universal Seafoods, Inc.; Terry Bertoson and Doug Weaver, Sea-Alaska Products, Inc.; Jack Showalter, Pan-Alaska Fisheries, Inc.; Lance Van Brocklin and Paul Palmer, Whitney-Fidalgo Seafoods, Inc.; and Arne Abrams, Pacific Pearl Seafoods.

The assistance of Steve Bingham and Tony Harber, Brown and Caldwell Consulting Engineers, was particularly appreciated. Duane Karna, EPA Region X; Bob Nelson, Alaska Department of Fish and Game, Dutch Harbor; and Howard Feder, Institute of Marine Science, University of Alaska, provided valuable insight to the biological characteristics of the study area and effects of crab wastes. Finally, I would like to thank Marty and Paul McCasland, Dutch Harbor Divers, for their persistent diving efforts, particularly during less than desirable weather conditions.

CONCLUSIONS

1. Waste pile compaction and slumping, microbial degradation, downslope movement, and dispersion are four mechanisms affecting the fate of ground crab wastes discharged in nearshore areas around Amaknak Island. At the Pacific Pearl and Universal outfall locations, compaction, microbial degradation, and downslope movement appear to be the dominant factors. The majority of wastes discharged at the shallow Vita outfall are dispersed by wave action with some degradation and downslope movement occurring. Pan-Alaska and Whitney-Fidalgo pile volumes are also reduced by compaction, degradation, and downslope movement, but some dispersion by wave action or wave-induced bottom currents is also indicated. All wastes discharged through outfalls at depths ranging from 20 to 50 feet off the spit separating Dutch Harbor from Iliuliuk Bay were almost completely dispersed by wave and tidal currents under winter conditions. Only a small waste pile was observed at the Sea-Alaska outfall in early January.

2. The waters adjacent to the Dutch Harbor - Iliuliuk Bay spit have a great capacity for waste dispersion. Essentially all of 91,700 cubic feet (4,585,000 pounds) of ground crab wastes discharged through three outfalls during the 1978 king crab season were effectively dispersed east of Amaknak Island over a 112-day period for an average rate of 819 cubic feet or 0.89 percent per day. Seasonal effects on waste dispersion are pronounced in this area since only 5,231 cubic feet or 261,550 pounds of waste in the Sea-Alaska pile were dispersed and degraded over the three summer months of 1978 for an average rate of 58 cubic feet or 0.5 percent per day.

3. Whitney-Fidalgo did not process after their waste pile was measured on October 29. From then until January 3 the pile volume decreased by 12,146 cubic feet for an average rate of 184 cubic feet or 0.43 percent per day. Vita and Pan-Alaska continued to process crab through the January pile measurement dates, but since there was a net reduction in pile volumes, a net reduction rate could be estimated. Between October 29 and January 7 (70 days) the Vita pile was reduced at an average rate of 401 cubic feet or 1.1 percent per day, while the Pan-Alaska pile decreased at 235 cubic feet or 0.43 percent per day over a 67-day period. Based on these estimates, it appears that a shallow water discharge on the west side of Amaknak Island will provide effective dispersion at least during the winter.

4. Review of crab production data from 1975 through 1978 revealed that the amount of live crab purchased and the amount of waste produced have increased steadily. However, the percent of total and solid

waste produced per pound of live crab has been steadily declining because of decreases in meat production and increases in section production. The consequence of these production changes is that 41 percent less solid waste is discharged per pound of live crab processed.

5. Burrowing and attached marine benthic organisms are completely eliminated from areas that become covered with crab wastes deeper than about an inch. The wastes appear to have a smothering effect on these organisms and do not provide a suitable substrate for recolonization after deposition. Mobile bottom and swimming organisms are attracted to the piles, particularly those containing fresh wastes. The soft-tissue component of the waste provides a food source for these animals. There are no data to evaluate whether the species diversity and relative abundance of the fish and macroinvertebrates or any significant nursery areas have been affected by the wastes.

6. The seaward edges of the waste piles on the west side of Amaknak Island were observed to be moving downslope into deeper water. The University of Alaska's benthic study indicated that these wastes were completely degraded to an organic sediment within 0.3 mile of the shoreline. These results also indicated that complete degradation of crab waste can occur within several years. This study concluded that the waste piles caused total mortality of sediment-dwelling organisms but that these negative effects were dissipated over relatively short distances from the accumulated deposits. Degraded wastes provided an adequate substrate for benthic organisms in contrast to the partially degraded wastes further inshore and in the piles.

7. The amount of bottom area covered by the main waste piles varies during the year as the piles increase and decrease in size. The maximum extent of bottom coverage by the main piles totaled at least 126,000 square feet (3 acres) of the nearshore zone on the west side of Amaknak Island. For those wastes moving downslope, an additional 29 acres of bottom area can be assumed to be affected. The total bottom area of Unalaska Bay south of Hog Island is about 3.5 miles square or 2,240 acres. Thus, at present, crab wastes directly affect approximately 1.4 percent of the benthic environment.

8. Water quality data collected in October 1976, October 1977, March 1978, and June 1978 indicated that dissolved oxygen levels were always greater than 8 mg/l. The majority of samples indicated dissolved oxygen concentrations were greater than 10 mg/l in bottom water just offshore from the piles on the west side of Amaknak Island. Detectable levels of sulfide within a few feet of the piles, slightly elevated NH_3 concentrations in the overlying waters, and increased turbidity around the piles were the only water quality effects that could be associated with the crab waste discharges. Large amounts of sulfide are generated by the decomposing wastes, but the waters are highly oxygenated and have good mixing so that

the sulfide is rapidly oxidized or dispersed. Toxic concentrations of hydrogen sulfide may diffuse from the waste piles but the diffusion rate is orders of magnitude slower than the dispersion rate of overlying waters.

9. Observations of marine life around the waste piles indicate that there are not consistent toxic sulfide conditions existing. It appears that the surface of the waste pile remains aerobic, but that the interior portions of the pile are anaerobic. Colonization of the pile by marine organisms has not been observed because the shell particles do not provide a suitable substrate for organisms other than those affecting decay.

10. Evaluation of the screening and barging alternative indicates that deepwater disposal does not provide any substantial water quality and marine biological benefits compared to current waste disposal practices. In fact, there may be some disadvantages with respect to a slower degradation process and a greater amount of bottom area covered with crab wastes.

INTRODUCTION

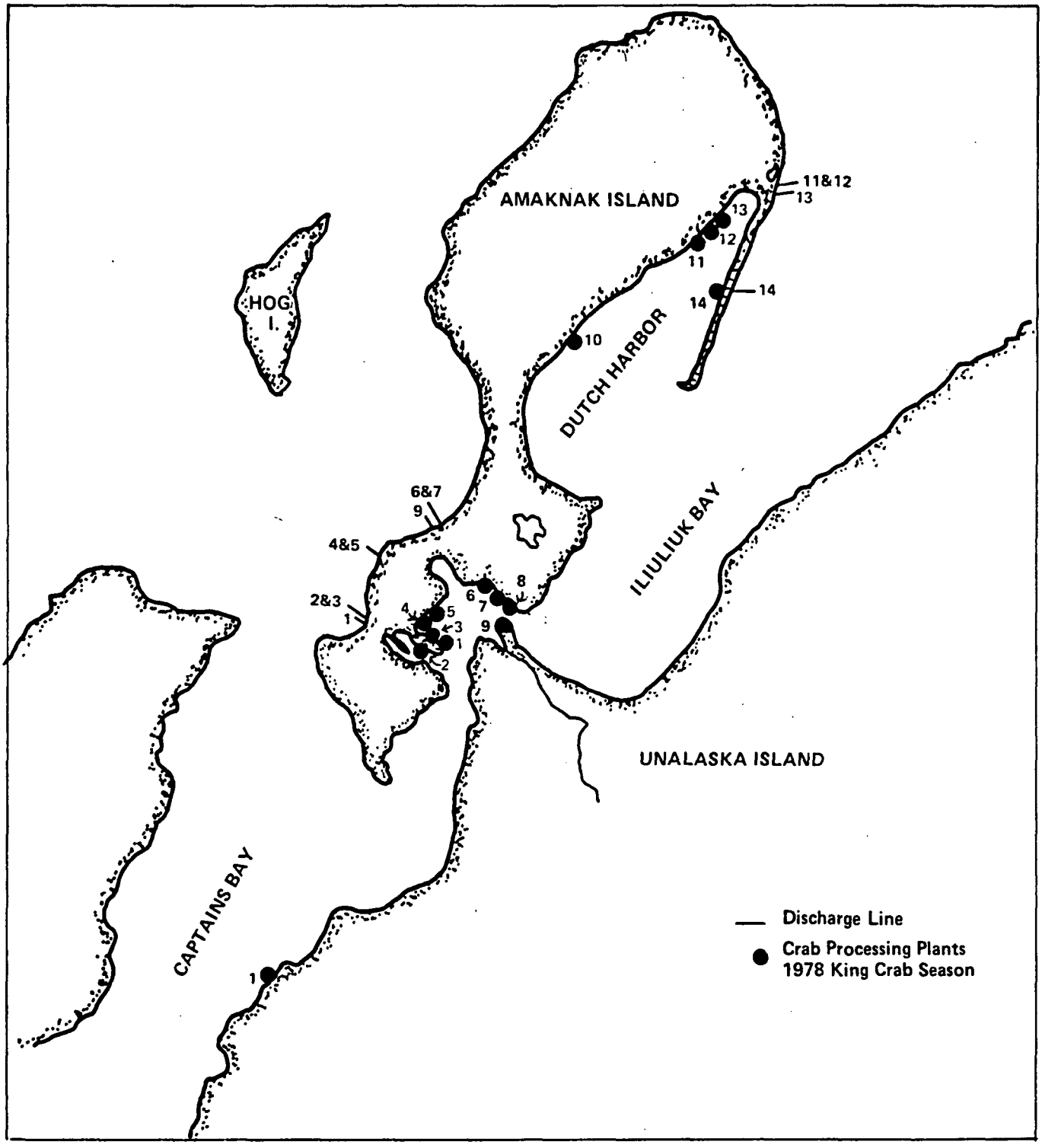
Dutch Harbor, Alaska, is a major center for processing Alaskan red king crab (*Paralithodes camtschatica*), blue king crab (*P. platypus*), and tanner crab (*Chionoecetes bairdi*). During the 1978 king crab season eight companies in Dutch Harbor processed approximately 60 million pounds of crab in three shore plants, two operated by Pacific Pearl Seafoods and one by Pan-Alaska Fisheries, and on twelve vessels from July through December (Figure 1). In addition, approximately 50 million pounds of tanner crab were processed from February through June 1978.

All processors attempt to grind wastes generated during processing to approximately 0.5 inch in diameter. At all but three of the facilities, ground wastes are transported from the confined harbor areas where the processors are located through pipes to discharge points in relatively unconfined nearshore areas. One facility discharges into Captain Bay, one into Dutch Harbor, and one screens ground wastes for disposal by barge at a deepwater disposal site northeast of Amaknak Island. Eight separate pipes discharge the large majority of the wastes into the nearshore waters on the east and west sides of Amaknak Island (Figure 1).

The Environmental Protection Agency has claimed that the nearshore discharge of processing wastes is unacceptable because of accumulations of waste on the bottom in the vicinity of the discharges. Current waste discharge permits issued by EPA require that all processors install screens to separate waste water from waste solids and barge the solids to deepwater disposal sites or otherwise dispose of them.

Although acknowledging that the accumulation of wastes in the nearshore areas has some localized environmental effects, the crab processors have argued that screening and barging as well as other alternatives such as production of by-products from the solids are impractical and uneconomical. In addition, all of the alternatives to the present disposal method suffer environmental and energy conservation disadvantages of their own. Finally, the processors contend that the extent of environmental degradation created by the accumulated waste has not been adequately defined nor has the problem been evaluated from the perspective of the overall effects on the nearshore marine ecosystem of Unalaska and Iliuliuk Bays. The key objectives of this study are to estimate more precisely the long-term environmental impacts of the current nearshore waste discharges and to compare them with the potential marine impacts of alternative disposal methods.

As part of an overall evaluation of current waste disposal practices and alternatives, the specific objectives of this study were to:



1 PACIFIC PEARL (2)
2 GALAXY
3 UNISEA
4 VICEROY
5 VITA
6 WHITNEY
7 MOKA HANA
8 EASTPOINT
9 PAN-ALASKA
10 THERESA LEE
11 SEA ALASKA
12 SEA PRODUCER
13 ROBERT E. RESOFF
14 YARDARM KNOT

Figure 1

LOCATION OF CRAB PROCESSORS AND WASTE DISPOSAL SITES

1. Describe the relationship between the amount of crab waste discharged during the 1978 crab season and any subsequent change in waste pile volumes;

2. Estimate the dissipation rates of the waste piles;

3. Evaluate the marine biological and water quality effects of the crab wastes as currently being discharged;

4. Examine recent crab production data to identify any trends in the amount of total and solid wastes being produced; and

5. Evaluate the marine biological and water quality effects of any alternative disposal systems that might be proposed.

To achieve the objectives of the study, the following tasks were accomplished.

1. Dutch Harbor Divers were contacted to measure waste piles at the combined discharge location of Dutch Harbor Seafoods and Universal Seafoods and at the location of discharges from Pacific Pearl Seafoods, Vita Food Products (owned by Universal), Whitney-Fidalgo Seafoods, Pan-Alaska Fisheries, and Sea-Alaska Products three times during the 1978 king crab season.

2. Production data from each of the participating companies were obtained to calculate the volumes of waste discharged during the intervals between pile measurements. Net waste pile dissipation rates were calculated for those piles having smaller volumes after the end of the processing season than during the season.

3. Underwater photographs were taken of the Pacific Pearl and Pan-Alaska waste piles by John D. Showalter, Director, Quality Control, Pan-Alaska Fisheries, on September 11. He also photographed marine life present in the vicinity of the waste piles as well as that attached to the discharge pipes.

4. Previous crab waste, oceanographic, and water quality studies in the vicinity of Dutch Harbor were reviewed for pertinent information. Reports written by divers after routine discharge pipe inspections or when measuring waste depths 98 feet from the end of the pipe in accordance with discharge permit requirements were also reviewed.

5. Recent production data were obtained from those companies participating in this study and compiled to identify product trends and consequent changes in the amount of wastes discharged.

6. A close working relationship with Stephen H. Bingham and Anthony F. Harber, Brown and Caldwell Consulting Engineers, was maintained as they formulated and evaluated alternative waste disposal concepts.

MATERIALS AND METHODS

FIELD ACTIVITIES

Underwater Photographs. Photographs of the Pacific Pearl and Pan-Alaska waste piles using Ektachrome ASA 400 slide film were taken on September 11, 1978, with a Nikonos III camera and a Vivitar 283 flash with an Ikelite flash housing.

Pile Volume Measurements. At each waste pile the diver measured the depth of the pile at the end of the discharge pipe with a 10-foot graduated metal rod, measured distances to the perimeter of the pile in four directions with a graduated line, and then obtained intermediate waste depths with the rod between the top and perimeter of the pile. Periodic water depth measurements were made by the diver using a Dacor depth gage. Any marine organisms observed during the dive were noted. After each dive a scaled drawing of the pile was made showing waste depth contours.

REVIEW OF PREVIOUS STUDIES

During the last four years several EPA- and industry-sponsored studies were conducted to:

1. Document the accumulation of processed crab wastes in the discharge areas and to assess their localized effects on marine organisms and water quality (Stewart and Tangarone 1977; Karna 1978);

2. Investigate physical oceanographic and water quality conditions to determine the optimal location for discharges and to evaluate alternative outfall/diffuser systems (Colonell and Reeburgh 1978; Brown and Caldwell 1978);

3. Determine the amounts and characteristics of crab wastes and evaluate the economics of alternative utilization and disposal systems (Bray 1978); and

4. Document the effects of crab wastes on benthic infaunal invertebrates and water quality adjacent to waste disposal locations and throughout Unalaska and Iliuliuk Bays (Feder and Burrell 1978).

Pertinent data from these studies are utilized in the discussion section of this report.

DATA REDUCTION

Pile Volume Calculations. Pile volumes were calculated by using an Ott compensating planimeter to measure the total bottom area covered by the pile and the area of each successive waste pile depth contour from the perimeter to the top of the pile. The volume of each contoured section was obtained by multiplying the area of that section by its relative depth. The total pile volume was then determined by summing all the section volumes.

Discharged Waste Volume Calculations. For direct comparison with the waste pile volumes, the volume of waste discharged through each outfall between successive pile measurements was required. The production data supplied by each processor, i.e., pounds of live crab purchased and pounds of products produced, were used to calculate the total amount of waste produced. Using figures developed by Bray (1978), the total waste figures were reduced by 20 percent to account for fluids lost during butchering and cooking to obtain an estimate of the pounds of solid waste, i.e., shell, gills, and viscera, discharged. To convert the solid waste mass discharged to a volume of material on the bottom, a factor of 50 pounds of ground crab shell per cubic foot of waste was applied. This figure was presented by Bray (1978) and can be deduced considering the following factors. Brown and Caldwell (1978) found the density of crab shell to range from 1.15 to 1.20 while the density of crab meat was between 1.03 and 1.06. The density of seawater characteristic of Dutch Harbor is approximately 1.027 or 64 pounds per cubic foot. Using a density of 1.15, a cubic foot of crab shell would weigh 73.6 pounds if dry and tightly compacted.

Based on diver observations and photographs, the ground shell is not tightly compacted upon discharge, but rather forms an easily disturbed pile with a great amount of interstitial water. Consequently, less waste would be expected to occupy a cubic foot and allows the use of a lower weight-to-volume conversion factor than would be expected if the material were deposited on land. Based on this information, the 50 pounds per cubic foot conversion factor appears reasonable. In addition, processors at Kodiak Island use a rule of thumb of 50 pounds per cubic foot for king and tanner crab processing wastes delivered to a crab meal plant.

RESULTS AND DISCUSSION

UNDERWATER PHOTOGRAPHS AND DIVER OBSERVATIONS

Several photographs of the Pacific Pearl and Pan-Alaska waste disposal areas are presented here to depict conditions existing in the vicinity of the waste piles. All photographs taken on these dives are available for review at the offices of the Pacific Seafood Processors Association.

Pacific Pearl processed 1.8 million pounds of king crab during the summer and was discharging wastes when the photographs were taken, so that the wastes observed were fresh. On the other hand, Pan-Alaska had not operated since the tanner crab season ended in June, so that wastes observed had been decomposing for approximately three months.

Figures 2 through 5 are photographs of the Pacific Pearl pile. Figure 2 was taken at the edge of the waste pile looking toward the top. The waste is fresh and readily distinguishable as ground crab shells. Figure 3 is of juvenile baitfish feeding on waste particles floating above the top of the pile. These particles are most likely the soft crab tissues which are almost neutrally buoyant (Brown and Caldwell 1978). Figure 4 shows a flatfish at the edge of the pile. The discharge pipe can be seen in the upper left-hand corner. Note that the rocks adjacent to the pile and the visible section of the pipe are devoid of attached organisms. The Universal discharge line crosses over the Pacific Pearl pile. Figure 5 provides an indication of the density of attached organisms on the Universal line. The Pacific Pearl wastes below the line are visible in the lower right-hand corner. Significant numbers of lighter waste particles are prevalent in the water column. It appears that attached organisms can remain on the pipe even if it is close to the waste pile as long as the organisms are not covered by the waste.

Conditions characteristic of the Pan-Alaska discharge line and waste pile a few days before processing began are presented in Figures 6 through 9. Figure 6 shows attached organisms as well as mobile starfish and crabs on the pipe 90 feet from the outfall. Empty clam shells were prevalent in this area. The shoreward edge of the waste pile at this time was 45 feet further down the pipe. Figure 7 shows the mud-sand bottom characteristic of the area adjacent to the discharge line 5 feet from the shoreward edge of the pile. The pipe can be seen in the upper right-hand corner. Many small tanner crabs were present in this area. Figure 8 was taken at the shoreward edge of the pile where the discharge line enters the pile. Note that the pipe at this point is devoid of attached organisms, indicating that wastes previously covered it. Figure 9 is a closeup of the waste pile. In contrast to the Pacific Pearl waste pile (Figure 2),

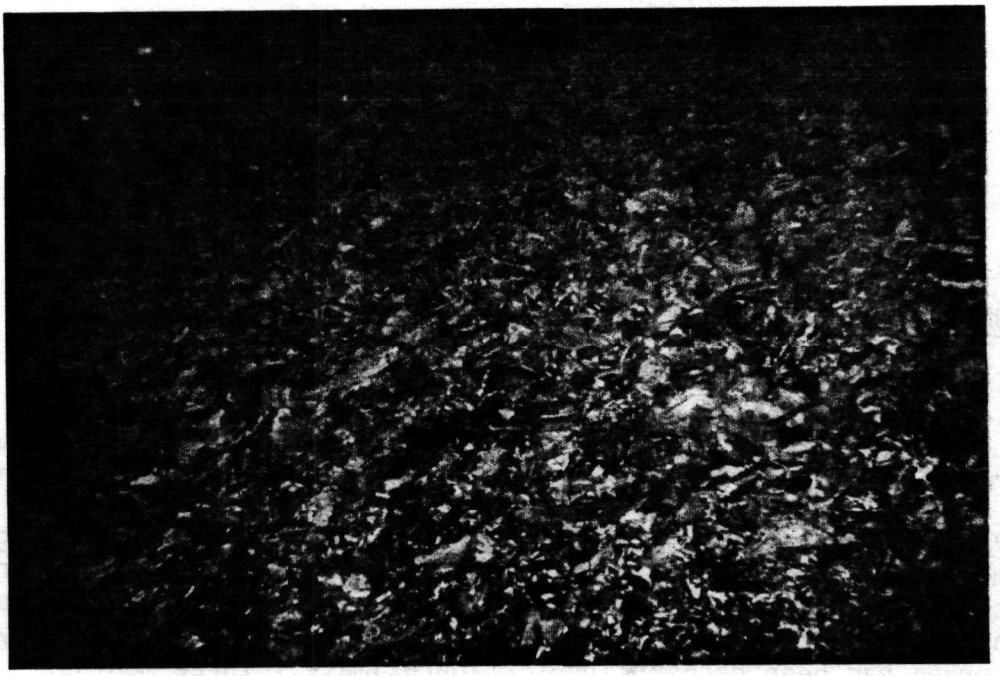


Figure 2. FRESH CRAB WASTE ON PACIFIC PEARL WASTE PILE LOOKING FROM EDGE OF PILE TOWARD TOP

Figure 3. JUVENILE BAITFISH FEEDING ON WASTE PARTICLES FLOATING ABOVE THE TOP OF THE PACIFIC PEARL PILE

Figure 4. FLATFISH AT EDGE OF PACIFIC PEARL PILE

Figure 5. ATTACHED ORGANISMS ON THE UNIVERSAL DISCHARGE PIPE WHERE IT CROSSES OVER PACIFIC PEARL PILE

Figure 6. ORGANISMS ON PAN-ALASKA DISCHARGE PIPE 90 FEET FROM OUTFALL

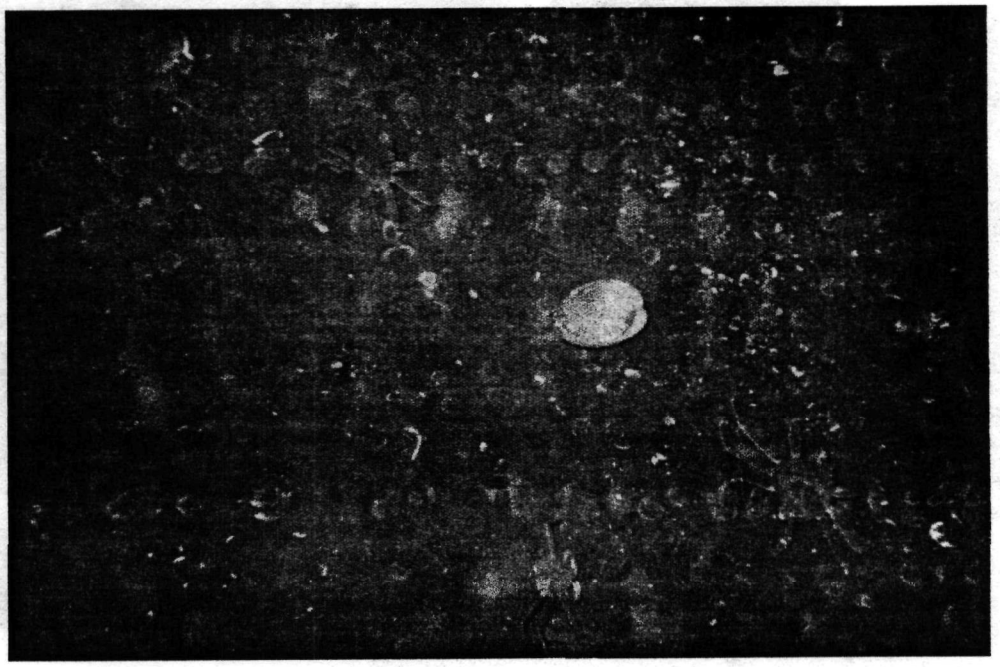


Figure 7. MUD-SAND BOTTOM ADJACENT TO PAN-ALASKA DISCHARGE PIPE

depth (about 50 feet) characteristic of the discharge areas, but was away from the influence of any waste discharges.

The EPA control area pictures most likely do accurately represent the type of attached and mobile benthic community structure to be expected in areas having a substrate similar to the control area. In this particular case, it is a medium-sized cobble bottom. What the EPA control area pictures do not reflect are the communities characteristic of other types of substrates occurring in the discharge areas. For example, the Pan-Alaska and Whitney-Fidalgo outfalls discharge onto mud-sand bottoms containing some rocks (see Figure 7). The shallow Vita pipe discharges into an area with a rocky bottom that has several large rocky reefs, some of which extend above the water surface. The deeper Vita discharge area used in 1977 has a cobble and sand bottom. Pacific Pearl discharges over a rock ledge onto a sloping rocky bank (see Figure 4). The Universal discharge area is also predominantly rock, containing small- to medium-sized cobble and some large rocks. Sand and gravel become more prevalent near the seaward edge of the pile. The bottom area in the vicinity of the Sea-Alaska, M/V Robert E. Resoff, and M/V Yardarm Knot outfalls is covered predominantly by rocks and kelp beds with some sand.

Portions of the Pacific Pearl, Universal, and the abandoned deep Vita discharge areas are the only areas that are comparable with the EPA control area with respect to similar substrate and depth. That all the discharge areas resembled the EPA control area before crab wastes were discharged should not be implied. The predominant substrate in the discharge areas and seaward of the waste piles is mud-sand and not the type that would support the attached control area community. Figure 6 provides some indication of the differences in community structure that can be observed on mud-sand and hard substrates. However, until a more accurate inventory of the amount of bottom area comprising the different substrate types and associated biota both in and away from waste-affected areas is obtained, the magnitude of benthic community destruction or disruption in the nearshore areas cannot be determined.

The fish and mobile benthic animals observed in the vicinity of the waste piles appear to be characteristic of Aleutian Island nearshore areas (Isakson, *et al.*, 1971; Simenstad, *et al*, 1977). What is not known is whether the species diversity and relative abundance of the fish and macroinvertebrate communities or any significant nursery areas have been affected by waste discharges. At present it is not known whether the wastes have caused mobile organisms to leave the discharge areas or have had an attractive effect for feeding purposes. A quantitative comparative study in waste-dominated and unaffected areas similar to that supporting the above-mentioned references would be required to make such a determination. It would also be informative to investigate the bioenhancement potential of the crab wastes. The wastes may provide a source of nutrients through mineralization during the decay process. Nutrients diffuse into overlying waters and are reincorporated into the marine food web.

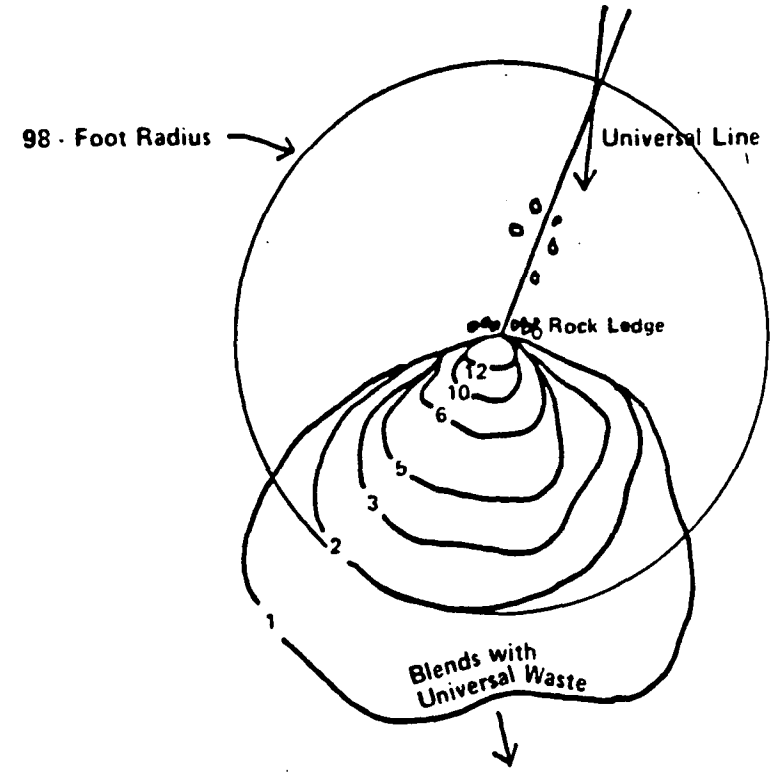


Figure 10a
10/28/78

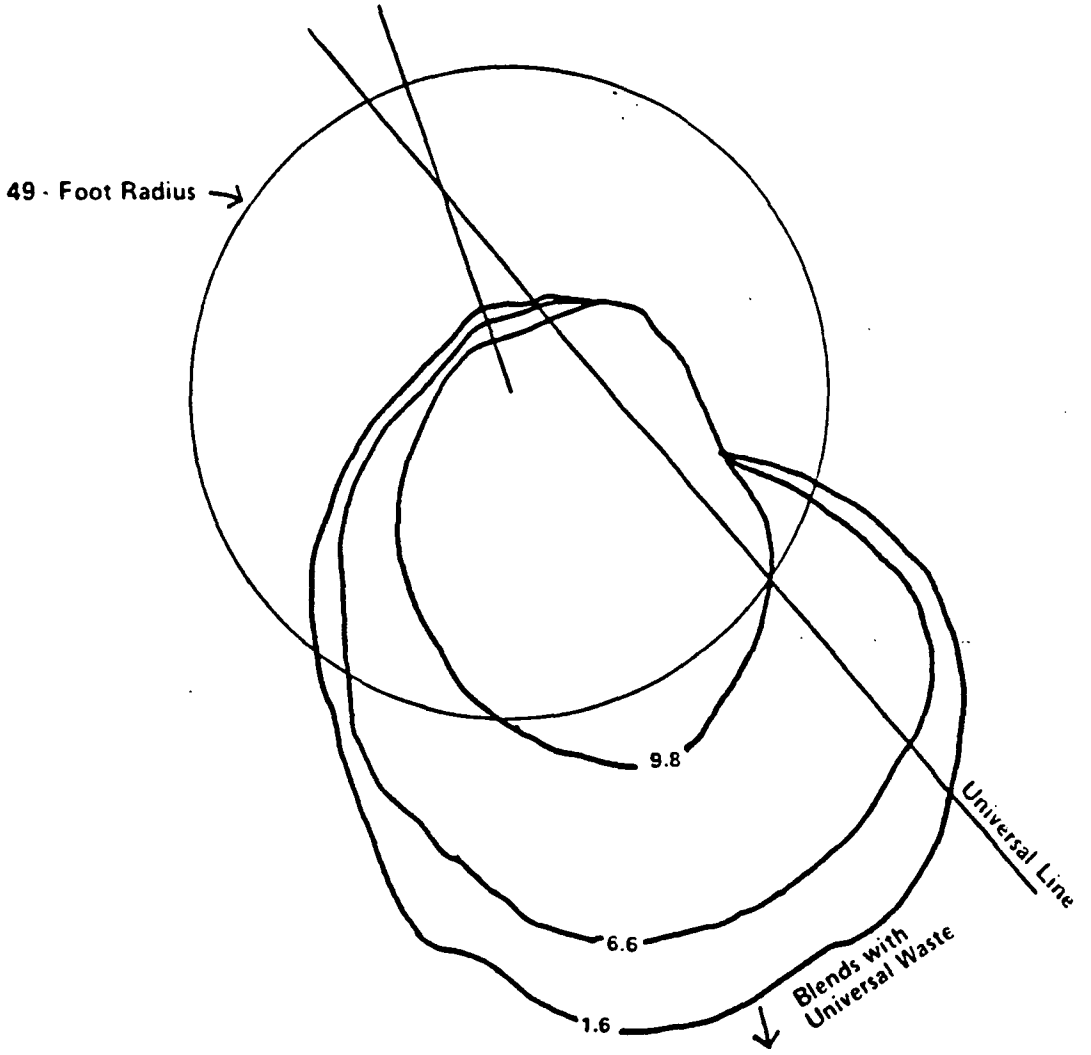


Figure 10b
1/5/79

Figure 10. CONFIGURATIONS OF PACIFIC PEARL WASTE PILE IN OCTOBER AND JANUARY (contours in feet)

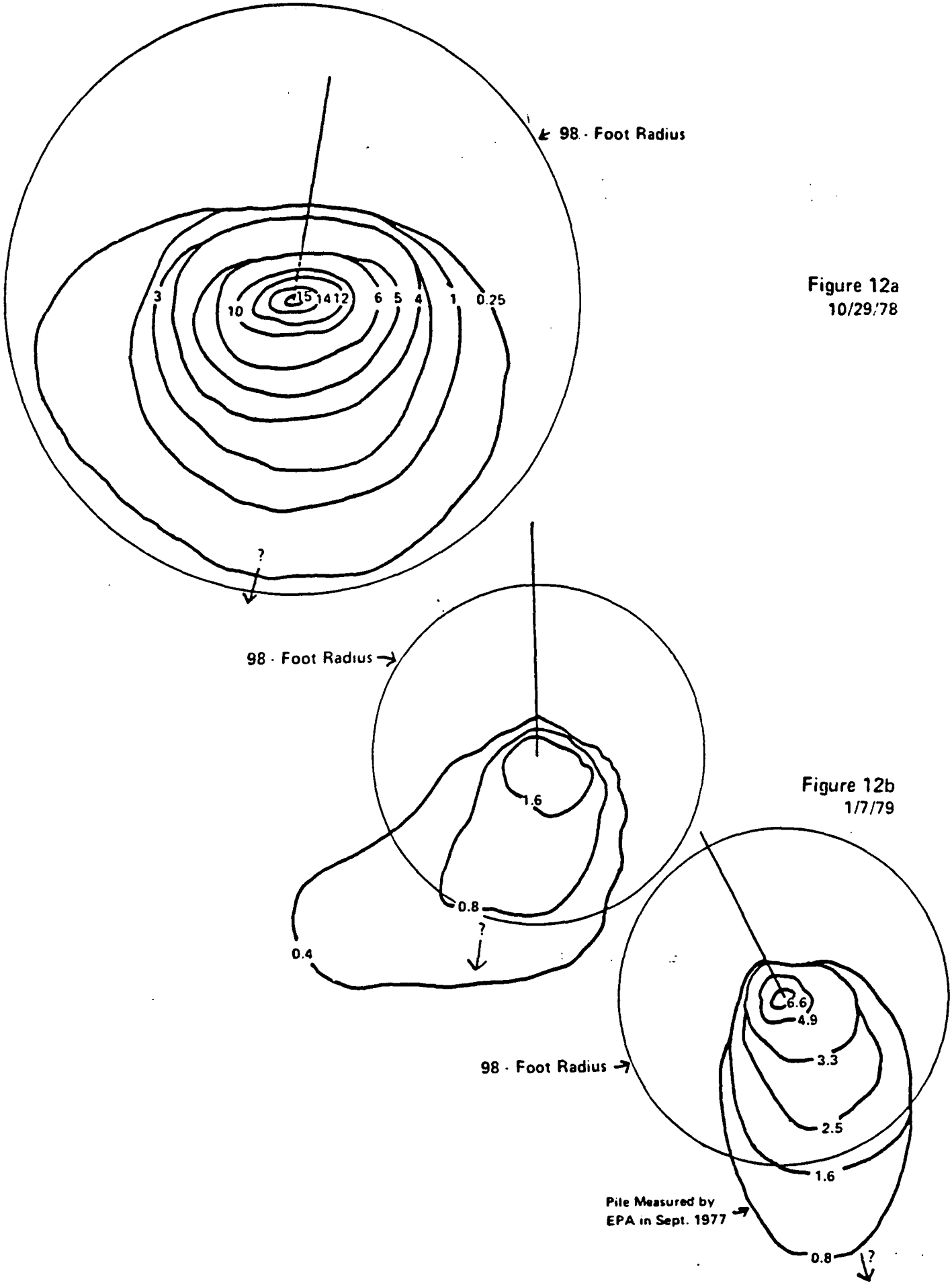


Figure 12a
10/29/78

Figure 12b
1/7/79

Figure 12. CONFIGURATION OF VITA WASTE PILE IN OCTOBER AND JANUARY (contours in feet)

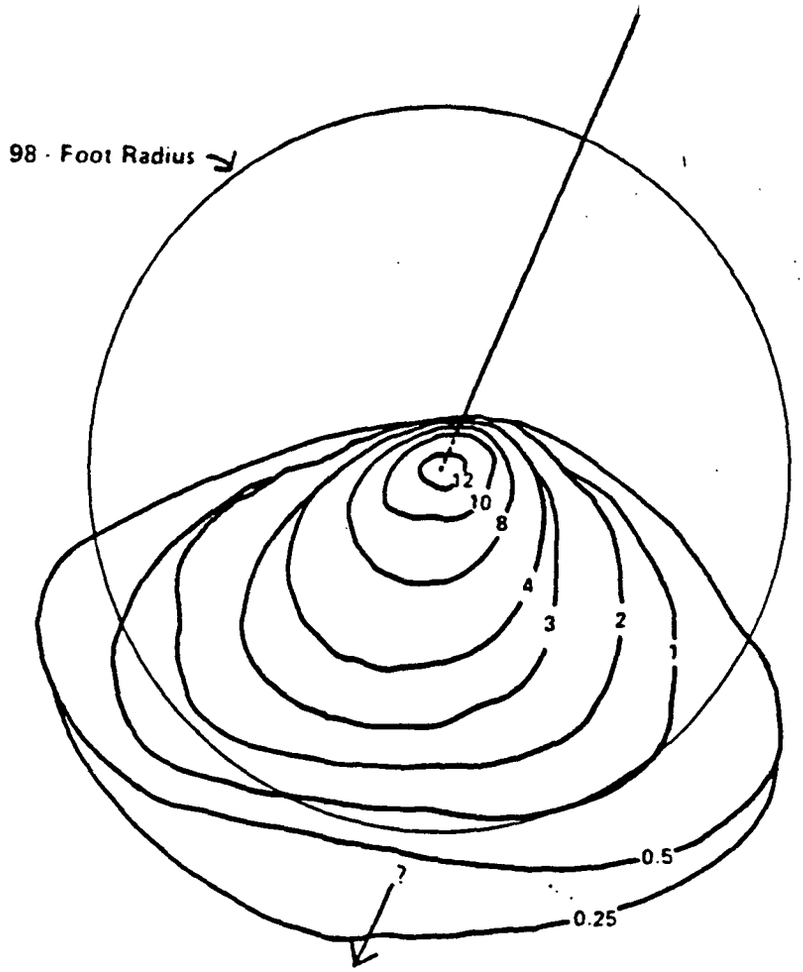


Figure 14a
10/29/78

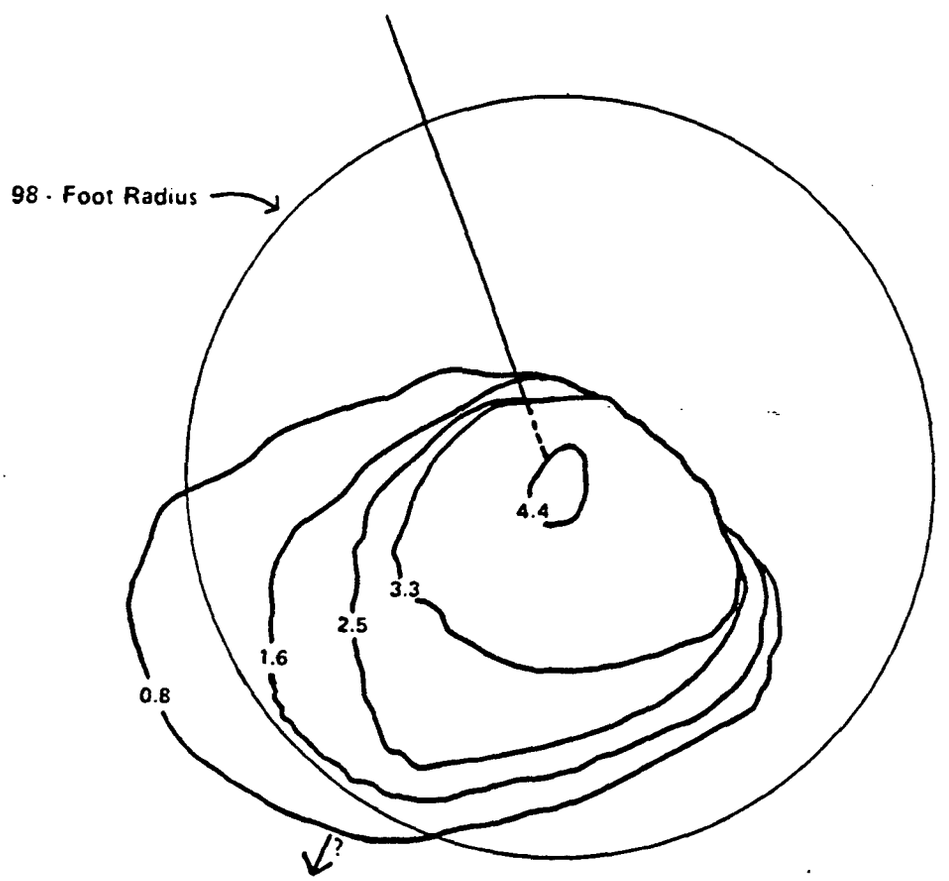


Figure 14b
1 / 3/79

Figure 14. CONFIGURATION OF WHITNEY-FIDALGO WASTE PILE IN OCTOBER AND JANUARY (contours in feet)

Table 1. RELATIONSHIP BETWEEN WASTE PILE VOLUME CHANGES AND KING CRAB WASTES DISCHARGED DURING 1978 SEASON

Discharger	Date Pile Measured	Pile Volume (ft^3)	Change in Pile Volume Between Measurements (ft^3)	Waste Discharged Between Measurements (ft^3)	Bottom Area Covered (ft^2)	Maximum Pile Depth (ft)
				6,653[a]		
Pacific Pearl	9/13	29,678			18,587	10
	10/28	41,416	+11,738	12,729	17,603	12
	1/5	54,527	+13,111	8,849	18,140	10
Universal	9/16	35,566			>32,000[b]	15
	10/30	66,831	+31,265	46,298	>32,000	20
	1/8	75,585	+8,754	11,447	>32,000	12
Vita	9/15	21,446			7,854	8.2
	10/29	36,364	+14,918	58,091	15,588	15
	1/7	13,200	-23,164	4,922	>21,062[b]	1.6
Pan-Alaska	9/14	49,305			>31,416[b]	10
	10/28	54,553	+5,248	10,185	>29,447	15
	1/3	49,810	-4,743	10,992	>32,008	5.7
Whitney-Fidalgo	9/14	25,986			>7,854[b]	10
	10/29	43,246	+17,260	28,738	>22,497	12
	1/3	31,100	-12,146	-0-	>15,224	4.4
Sea-Alaska	June '78[c]	11,769			4,418	8
	9/15	6,538	-5,231		1,963	10
	10/29	9,569	+3,031	63,237	10,148	11
	1/5	291	-9,278	3,247	81	1.6

[a] Waste discharged between 7/23 and 9/12.
[b] Total bottom area covered could not be determined because wastes were dispersing downslope into deep water.
[c] Measurements made at end of tanner crab season.

Of the 28,738 cubic feet of waste discharged prior to October 29 by Whitney-Fidalgo, 17,260 cubic feet or 60 percent accumulated in the pile. The wastes along the seaward edge of the pile were observed to be dispersing toward deeper water so that the total bottom area covered could not be defined. In contrast to Pan-Alaska, Whitney-Fidalgo did not discharge any waste after October 29.

The Whitney pile decreased in volume by 12,146 cubic feet between October 29 and January 3 and exhibited a rather dramatic change in shape (see Figure 14). The pile decreased from a maximum depth of 12 to 4.4 feet and spread to the north. It can be hypothesized that wave-generated bottom currents flowed downslope counter to the wave trains breaking along this section of coastline and moved the wastes in a northerly direction.

At the Sea-Alaska outfall, a dive was made in June 1978 by Dutch Harbor Divers to measure the waste pile at the end of tanner crab season. During the summer of 1978 there was a net loss of 5,231 cubic feet of wastes (Table 1). During the height of the 1978 king crab season the amount of waste discharged was 20 times greater than that which accumulated in the vicinity of the outfall. The maximum bottom area covered was 10,148 square feet. Although Sea-Alaska was the largest producer of waste during the 1978 king crab season, waste accumulations five weeks after processing ended were negligible (Figure 15).

The M/V Robert E. Resoff was added to the Sea-Alaska complex in 1978 to increase production, and a separate discharge line was installed parallel to the older line. The new line is closer to shore and discharges in 40 feet of water in contrast to 50 feet for the older line. A dive on the Resoff line was made on January 5, 1979. There was no waste pile and only scattered pockets of shell, all less than an inch deep, within several hundred feet of the outfall. The Resoff had discharged 8,998 cubic feet of waste between the beginning of the season and November 20.

Whitney-Fidalgo brought the processing vessel M/V Yardarm Knot into Dutch Harbor in 1978 and installed an outfall across the spit from the Yardarm Knot's moorage 400 feet offshore in 20 feet of water (Figure 1). Between September 18 and October 24, 9,982 cubic feet of wastes were discharged, but no wastes were observed around the outfall at the end of the season.

A more complete history of waste pile dynamics during a processing season was compiled by Pan-Alaska during the 1977 tanner crab season. Beginning April 22, Gene Anderson, an oceanographer from the University of Washington, made biweekly dives to measure the pile and, as part of his reports, provided some detailed descriptions of his observations. Excerpts from his dive reports are included here verbatim because they provided a great deal of insight as to how the waste pile changed over time, aided in interpreting the pile volume data, and indicated some effects on marine life. Table 2 summarizes the pile changes as derived by planimetry from Anderson's pile drawings.

> April 22: "Today I made my second dive at the effluent line and placed four marker posts at 100 feet from the pile in each of four

June 23: "The effluent pile seems to have rounded off and slumped down a little during the few days we were not processing. The top of the pile is much flatter with a large, rounded-out crater and less steeply sloping sides. The depth of the shell at Station 1 has decreased from 10 inches back to 7 inches and is an indication that the pile has settled downward somewhat. Station 2 has grown to 2 inches of shell, and station 3 has grown to 1 inch. Station 4 has also grown slightly to a depth of 1.75 inches.

"The marine life which is represented primarily by clams seems to be showing a much more adverse reaction to the shell debris. There are now many small empty shells at the surface which I had not noticed before, and the large clams are still crawling around over the sediment surface. Most of them are still alive but react fairly slowly when touched and a few didn't close at all.

July 11: "The effluent pile has now rounded off to a big slush pile of muddy crab debris. A large portion of the pile has been reduced by a combination of factors. Much has apparently washed away as exemplified by the complete lack of rubber bands which are light and easily carried away. Some has obviously sunk and compacted downward since there are no large crab shells or large pieces of debris apparent at the pile surface. Also, a small amount has most likely been eaten by various marine organisms which is indicated by numerous shrimp, eels, a few flounder, small crabs, and large sculpins on or near the pile. There are also very distinct wave ripple marks over the whole pile, giving it an aged look.

"The overall size of the pile has been reduced approximately one-third since processing stopped (June 21), and the area surrounding the pile which was lightly dusted with debris is practically barren again. The shell depth at station 1 is now down to just 3 inches to 5 inches depending on whether the measurement is made in a trough or at a peak of a ripple. Stations 2 and 3 are back to 0.5 inch, and station 4 has 0.75 inch of debris.

"The clam community seems to have completely vacated this area since I was unable to find one live clam or any trails. There were a few empty shells scattered around but most have been there for awhile. There were a couple of dead small crabs and one very large dead buffalo sculpin on the top of the pile."

January 7 the Vita pile was reduced at an average rate of 401 cubic feet or 1.1 percent per day, while the Pan-Alaska pile decreased 235 cubic feet or 0.43 percent per day. These reduction rates include the wastes discharged between the October and January pile measurement dates. Since the Pacific Pearl and Universal waste piles increased in volume throughout the season, any volume reduction estimates are precluded.

Because the Whitney-Fidalgo and Pan-Alaska waste piles occupy the same general area, are at similar depths (40 feet), and are subjected to similar reduction mechanisms, it is not surprising that the percentage reduction rates for these piles are the same (0.43 percent per day). In comparison, the Vita discharge in only 20 feet of water has nearly a threefold greater percentage reduction rate (1.1 percent per day), indicating the better dispersive nature of the shallower nearshore waters.

On the east side of Amaknak Island waste dispersion equaled or exceeded 100 percent of the wastes discharged during the season plus pre-season accumulated wastes.

Crab was last produced by Sea-Alaska on November 24. A pile containing 9,569 cubic feet on October 29 plus 3,247 cubic feet discharged between October 29 and November 24 was dispersed to the extent that only 291 cubic feet remained in the pile on January 5. If it is assumed that all dispersion occurred after November 24, the dispersion rate is 298 cubic feet per day. However, 63,237 cubic feet of wastes were discharged between September 15 and October 29, while only 3,031 cubic feet accumulated in the pile, indicating that dispersion may be occurring on a more continuous basis in this area. This dispersion of 60,206 cubic feet of waste in 44 days results in an average dispersion of 1,368 cubic feet per day. The total waste dispersed during the king crab season was 72,731 cubic feet in 112 days for an average rate of 649 cubic feet or 0.89 percent per day. This can be compared to the 1978 summer dispersion rate of approximately 58 cubic feet or 0.5 percent per day.

The M/V Yardarm Knot discharged 9,982 cubic feet of waste during 36 days of production. No accumulated wastes remained at the end of the season. Similarly, the M/V Robert E. Resoff outfall had no accumulated wastes around it on January 5 after discharging 8,998 cubic feet between September 15 and November 20. Considering all three outfalls crossing the spit, a total of 91,711 cubic feet of crab wastes were effectively dispersed east of Amaknak Island during the 1978 king crab season. The average dispersion rate over a 112-day period was 819 cubic feet or 0.89 percent per day.

RECENT TRENDS IN DUTCH HARBOR CRAB WASTE PRODUCTION

At a January 12, 1979, meeting attended by representatives of the crab processors and EPA personnel, the point was discussed that waste discharged to nearshore waters had been reduced over recent years because of changes in market demand, i.e., there were now less pounds of meat and more pounds of sections being produced so that less solid waste was being generated per pound of crab processed.

Table 3. RECENT DUTCH HARBOR CRAB PRODUCTION DATA

	Live Crab Purchased (lb)	Meat Produced (lb)	Meat as % of Live Crab	Sections Produced (lb)	Sections as % of Live Crab	Total Products Produced (lb)	Total Products as % of Live Crab	Total Waste Produced (lb)	Total Waste as % of Live Crab	Solid Waste Produced (lb)	Solid Waste as % of Live Crab
King Crab											
1975	21,933,928	3,613,813	16.5	3,910,200	17.8	7,524,013	34.3	14,409,915	65.7	10,023,129	45.7
1976	26,747,360	3,208,101	12.0	9,310,780	34.8	12,518,881	46.8	14,228,479	53.2	8,879,007	33.2
1977	30,376,947	2,728,952	9.0	13,550,142	44.6	16,279,094	53.6	14,097,853	46.4	8,022,464	26.4
1978	57,429,767	3,693,017	6.4	27,559,987	48.0	31,253,004	54.4	26,176,763	45.6	14,690,810	25.6
Tanner Crab											
1976	9,174,292	365,160	4.0	3,330,676	36.3	3,695,836	40.3	5,478,456	59.7	3,643,598	39.7
1977	27,423,678	450,354	1.6	15,570,649	56.8	16,021,003	58.4	11,402,675	41.6	5,917,939	21.6
1978	48,351,285	50,000	0.1	28,907,541	59.8	28,957,541	59.9	19,393,744	40.1	9,723,487	20.1

An increased level of sulfide appears to be the major water quality abnormality associated with the current ground crab waste disposal practices. Sulfide will be generated anaerobically during decomposition of the crab wastes, particularly the tissue protein portion of the waste, and will continue to be generated as long as degradable organic matter remains. Sulfide can exist in three forms in the dissolved state depending on the pH of the water. Within the pH range most likely to occur in the vicinity of Dutch Harbor, the percent of sulfide ion that is in the form of undissociated hydrogen sulfide (H_2S) will range from about 40 to 5 percent or, conversely, 60 to 95 percent will be in the ion form HS^-. The toxicity of sulfide is derived primarily from H_2S rather than the sulfide ion (NAS 1973).

Sampling conducted by EPA (Karna 1978) and the University of Alaska (Feder and Burrell 1978) as well as diver observations indicated that sulfide concentrations were detected only within a few feet of the piles. Water current measurements, density data, and dissolved oxygen concentrations indicated that the waters have reasonably good mixing and are highly oxygenated in the areas where crab wastes are currently being discharged, thereby lessening the probability that high concentrations of sulfide will exist outside the immediate vicinity of the piles.

The most pertinent data on solid waste generation of sulfide can be found in Pratt *et al.* (1973). Although this study dealt with compacted household garbage of which the majority of organic solid material was paper, their observations on sulfide dynamics appear to be applicable to the Dutch Harbor situation. These investigators found that the diffusion rate of H_2S from wastes was on the order of 10^{-5} cm^2/sec, while rates of dispersion of overlying waters varied from 1 to 10 cm^2/sec. Accordingly, there was a reduced likelihood of toxic H_2S levels in overlying water other than in the boundary layer in contact with a waste deposit. Although not directly comparable with dispersion rates, bottom current velocities measured along the west side of Amaknak Island were on the order of 1 to 11 cm/sec (Brown and Caldwell 1978). These velocities indicate a significantly greater overlying water dispersion rate than sulfide diffusion rate from the waste piles.

EFFECTS OF CRAB WASTES ON MARINE ORGANISMS

Crab wastes could cause mortality of marine organisms by creating toxic conditions through sulfide production and by smothering attached and burrowing organisms. Detrimental effects could also involve eliminating food sources and spawning or nursery areas. On the other hand, the return of ground crab wastes to the nearshore marine environment could have beneficial effects by providing a food source (soft tissues) and enriching the sediments after degradation outside the immediate disposal area.

pile. The benthic sampling program by the University of Alaska in the deeper waters of Unalaska Bay helped to define the fate of the crab wastes moving downslope from the areas occupied by the piles. It should be noted that the interim report included only field notes made when the benthic samples were collected. These results thus constitute a qualitative analysis. A more detailed analysis and discussion of species composition by station will be included in their final report. Consequently, there may be some conditions described later which will differ from the general impression originally obtained by Feder and Burrell (1978), but it is unlikely that the overall trend observed and discussed below will be significantly altered.

A grab sample of bottom material from the Universal outfall area yielded new shell material overlying many centimeters of old black waste. The sample had a nauseating H_2S odor and no living organisms were observed.

Moving offshore to approximately 0.2 mile, samples were taken in line with the outfalls and at three stations to the north of the Pan-Alaska and Whitney-Fidalgo outfalls. A variety of bottom types were found including sand, black sediment, sandy silt, and fine gravel to cobbles. A few organisms were found in most samples. Some of the samples had a strong sulfide smell and some had "fishy" organic smells. At Station 3I north of the outfall no sulfide was noted, but a crushed shell and sand mixture was found, indicating some northward dispersion of ground shell.

At stations located further offshore (0.3 to 0.7 mile), sediments were silty-sand or silt, some of which were black and had strong organic smells but no sulfide odors. Organisms were found in all samples.

Additional stations sampled throughout Unalaska Bay indicated a variety of organisms and substrates, some having organic odors, but all appeared to be uninfluenced by processing wastes.

The University of Alaska's results indicate that the wastes moving downslope into the deeper waters off the west side of Amaknak Island are decomposed to an organic sludge still maintaining the "fishy" organic odor characteristic of its source, but apparently not harmful to organisms by the time it has moved offshore 0.3 mile or more. It appears that this material provides an adequate substrate for burrowing organisms in contrast to the partially degraded wastes further inshore and in the piles. In addition, these sediments are aerobic throughout the year (see water quality section of this report and Feder and Burrell, 1978). The lack of sulfide odors and identifiable crab shell material in samples from 0.3 mile or more offshore indicates that complete degradation presently occurs within 0.3 mile of the discharge areas. Since most outfalls had been in operation about two or three years, it appears that complete degradation of crab waste can occur within this time frame. A definitive statement as to whether the bottom areas beyond 0.3 mile are being enriched or inhibited by the waste-derived sediment will have to be deferred until the quantitative data are available.

ALTERNATIVE DISPOSAL SYSTEMS

ENVIRONMENTAL EFFECTS OF DEEPWATER DISPOSAL OF CRAB WASTES

One of the alternatives to current crab waste disposal practices in Dutch Harbor is to screen the processing wastewater stream to separate the solid and liquid portions of the effluent and then barge the solid wastes to a deepwater disposal site. This alternative is one that has been often suggested by EPA. The proposed disposal site is in relatively open water off the northeast coast of Amaknak Island in about 300 feet of water. The effects of such an operation on water quality and marine biota in the disposal area are addressed here. Physical aspects of a barging operation are discussed by Brown and Caldwell (1979).

As the barging alternative is understood, there would be no grinding of wastes as is now practiced. Whole carapaces, tails, viscera, gills, and leg shells, if meat is extracted, would be dumped from a hopper barge instantaneously while being towed over the disposal site. Any residual liquids associated with the waste would disperse in the surface waters immediately upon dumping. The viscera, gills, and other soft-tissue fragments would tend to disperse or sink slowly in the surface waters since the density of these materials is only slightly greater than that of cold seawater. Eventual sinking could be expected, but time and location of sinking would depend on water column density stratification, prevailing winds, currents, and wave action. Some of these soft tissues could also be expected to be consumed by seabirds and fish. The more dense shell material would be expected to sink almost straight down and settle on the bottom. Brown and Caldwell (1979) estimated that the extent of bottom area covered by each barge load would be about 31,400 square feet (a 200-foot-diameter circle) at an average depth of 1.5 inches. Except for some turbidity generated during the dumping process, it is not anticipated that this type of operation would cause any adverse water quality or biological effects in the water column.

As is the case with the current discharge of ground wastes in nearshore waters, the water quality and biological effects of the dumped wastes will be manifest on the bottom. Deepwater disposal removes a major dispersive force identified as being responsible for waste dispersion in shallow waters, i.e., wave action and wave-generated bottom currents. At 300 feet, little dispersion can be expected. Furthermore, since the disposal area is relatively flat, little waste movement of any kind can be expected after initial settling.

The amount of bottom in the disposal area that would be covered with wastes annually was estimated by Brown and Caldwell (1979) to be 134 acres assuming that no new waste load overlapped previously dumped

sediment and bottom water quality conditions in the inner harbors. However, one could expect to see floatables and the liquid effluent dispersing from the barge during loading operations. This would probably be more of an aesthetic problem than a long-term detriment to overall water quality.

Although a good deal of conjecture and supposition has been presented in the preceding discussion, it appears that deepwater disposal does not provide any substantial water quality and marine biological benefits compared to current waste disposal practices. In fact, there may be some disadvantages with respect to a slower degradation process and a greater amount of bottom area covered with crab wastes.

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Stewart, R. K., and D. R. Tangarone. 1977. *Water Quality Investigation Related to Seafood Processing Wastewater Discharges at Dutch Harbor, Alaska--October 1975, October 1976.* Working Paper No. EPA 910-8-77-100. Environmental Protection Agency, Surveillance and Analysis Division, Seattle, Washington.

APPENDIX B

SCS ENGINEERS

STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS, INC.

BENTHIC MACROFAUNA, SEDIMENT AND WATER QUALITY NEAR SEAFOOD CANNERY OUTFALLS IN KENAI AND CORDOVA, ALASKA

Final Report

February 15, 1979

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TABLE OF CONTENTS

	Page
List of Figures	iv
List of Tables	v
Acknowledgements	vii
Abstract	viii
Introduction	1
Review of Previous Alaskan Studies	2
Purpose of Present Study	6
Materials and Methods	8
General Description of Study Areas	8
Hydrological Determinations	15
Water Quality	15
Sediment Samples	16
Underwater Photography	18
Biological Indices	18
Limitations to Sampling	20
Results and Discussion	21
Kenai	21
Description of Seafood Processing Operations	21
Aesthetic Conditions	21
Bottom Accumulations	25
Hydrological Conditions	25
Water Quality	29
Sediment Particle Size	32
Sediment Chemistry	32
Macrobenthos	35
Cordova	43
Description of Seafood Processing Operations	43
Aesthetic Conditions	46
Bottom Accumulations	47
Hydrological Conditions	51
Water Quality	54
Sediment Particle Size	56
Sediment Chemistry	58
Macrobenthos	60
Conclusions	84
Kenai	84
Aesthetics	84
Water Quality and Sediment Conditions	85
Biological Conditions	86
Effects of Cannery Discharges	86

Page

Cordova..... 87
Aesthetics..... 87
Bottom Accumulations..... 87
Water Quality and Sediment Conditions..... 89
Biological Conditions..... 90
Effects of Cannery Discharges..... 90

Comparison of Alaskan Sites..... 91

Literature Cited..... 92

Appendix..... 94

LIST OF FIGURES

Number		Page
1.	Map of Alaska, showing locations of Kenai and Cordova, Alaska	9
2.	Kenai River, Alaska, and location of two study zones	11
2a.	Inset A - Kenai River sampling stations off Kenai Packers Cannery	12
2b.	Inset B - Kenai River sampling station Off Columbia-Wards Fisheries	13
3.	Location of sampling sites at Cordova, Alaska	14
4.	Evidence of seafood waste accumulations near Kenai Packers Cannery outfall	24
5.	Variations in tidal height at Kenai Packers Cannery, Kenai, Alaska	28
6.	Species group clusters of Cordova samples (1 mm and 0.5 mm screenings)	80
7.	Station group clusters of Cordova samples (1 mm and 0.5 mm screenings)	81

LIST OF TABLES

Number		Page
1.	Estimated Seafood Waste Production Kenai Packers	22
2.	Estimated Seafood Waste Production Columbia-Wards Fisheries	22
3.	Tidal Data for Kenai, Alaska July 23-July 26, 1978	26
4.	Tidal Current Data for Kenai, Alaska July 23-July 26, 1978	27
5.	Water Quality and Depth for Kenai River Sampling Stations	30
6.	Size Distribution (Percent Weight) of Kenai River Sediment Samples	33
7.	Sediment Chemistry Data for Kenai River Sampling Stations	34
8.	Station List of Macrobenthos of Kenai River Sediments (1 mm Screenings)	37
9.	Station List of Macrobenthos of Kenai River Sediments (0.5 mm Screenings)	38
0.	Station List of Macrobenthos of Kenai River Sediments (1 and 0.5 mm Screenings)	39
1.	Density (N), and Species Richness (S) Values of Kenai River Benthic Samples (combined 1 and 0.5 mm Screenings Data)	40
2.	Estimated Seafood Waste Production St. Elias Ocean Products	44
3.	Estimated Seafood Waste Production North Pacific Processors, Inc	44
4.	Estimated Seafood Waste Production New England Fish Company	45
5.	Tidal Data for Cordova, Alaska July 29-August 1, 1978	52
6.	Tidal Current Data for Mid-Channel and Control Stations in Orca Inlet, Cordova, Alaska, July 26-August 1, 1978	53

TABLES (continued)

Number		Page
17.	Water Quality and Depth for Cordova Sampling Stations	55
18.	Size Distribution (Percent Weight) of Cordova Sediment Samples	57
19.	Sediment Chemistry Data for Cordova Sampling Stations	59
20.	Station List of Macrobenthos of Cordova Sediments (1 mm Screenings)	61
21.	Station List of Macrobenthos of Cordova Sediments (1 mm Screening)	65
22.	Station List of Macrobenthos of Cordova Sediments (1 mm and 0.5 mm Screenings)	69
23.	Density (N), Species Richness (S), and Diversity (H') Values of Cordova Benthic Samples (1 mm Screenings)	75
24.	Density (N), Species Richness (S), and Diversity (H') Values of Cordova Benthic Samples (0.5 mm Screenings)	76
25.	Density (N), Species Richness (S), and Diversity (H') Values of Combined Cordova Benthic Samples (1 mm and 0.5 mm Screenings)	77

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Abstract

Hydrological conditions, sediment and water quality, and macrobenthos, were examined at two Alaskan coastal sites in an effort to identify the ecological impacts which result from seafood processing operations. Monitoring studies were performed at Kenai and Cordova, Alaska, two sites not previously studied.

At Kenai, the impacts of cannery discharges on the marine environment were negligible. Little, if any, impact to water and sediment quality were observed. A poorly developed macrobenthos community was identified. However, this community structure appeared to result from natural rather than man-induced conditions. Tidal induced scouring and burial by bottom sediments, and daily salinity changes appeared to be the major factors which limited habitat utilization by macrobenthic organisms. Strong river and tidal currents flush the cannery discharge areas on a daily basis and problems of persistent seafood processing waste accumulations were not observed.

At Cordova, poor flushing action in the vicinity of active cannery outfalls had resulted in considerable accumulations of nonground processing waste debris at two of the three active discharge areas. Localized impacts to sediment and water quality, and surface water aesthetics in the vicinity of the disposal areas were also recorded. The macrobenthic community was generally stable and very diverse. The effects of cannery effluents on the macrobenthos were only observed at one of the active cannery outfalls. At this one outfall, considerable reduction in species richness and diversity occurred.

INTRODUCTION

On December 27, 1977, the Clean Water Act of 1977 was adopted to amend several provisions of the Federal Water Pollution Control Act Amendments of 1972. Section 74 of the new Act requires the U.S. Environmental Protection Agency (EPA) to conduct a study "to determine the effects of seafood processes which dispose of untreated natural wastes into marine waters, to examine technologies to facilitate the use of nutrients in these wastes or to reduce their discharge into the marine environment (1)". One aspect of the EPA study was to assess the geographical, hydrological, and biological characteristics of marine waters receiving untreated seafood processing waste discharges. The following report discusses this aspect for two seafood processing sites in Kenai and Cordova, Alaska.

Alaska is the location of numerous seafood processing facilities which utilize raw seafood catch in the preparation of finished products. Generally, a large portion of the raw material processed at these facilities is not utilized in the finished product. The percentage of unused or waste material varies with the species processed. In salmon processing, this waste material constitutes from 33 to 45 percent of the raw product (by weight), and from 36 to 88 percent in crab processing (2).

Although the unused raw product contains large amounts of protein and nutrients, Alaskan processing facilities usually

discharge this material directly to receiving waters after little or no treatment. In recent years, attention has been directed at assessing the ecological effects (either beneficial or adverse) which result from these waste discharges. Both the seafood industry and the EPA have funded research in Alaska to study the effects of seafood processing at various sites. The following paragraphs discuss the results of these efforts.

REVIEW OF PREVIOUS ALASKAN STUDIES

In 1970, a preliminary ecological survey of Bristol Bay and Kodiak Island, Alaska, was performed by the Fisheries Research Institute of the University of Washington, Seattle, Washington (3). This study was in response to concerns expressed by the Northwest Canning Industry about the impact of seafood processing wastes on the receiving waters in the vicinity of salmon canneries. These investigations indicated no serious or significant detrimental effect on the ecology of marine organisms, although the wastes did cause some small depressions of dissolved oxygen at the surface and bottom in small, highly localized areas near the points of discharge (3, 4). These studies further noted that the depressions were not only highly confined, but were also very transient because of the twice-daily scouring and flushing effect of the tides. During the surveys at these two sites, sufficient amounts of oxygen for the healthy maintenance and growth of organisms were reported to be

present at all times. Similar results at seven processing sites in British Columbia were reported from studies performed for the British Columbia Fisheries Association (5).

A brief water quality survey conducted by the University of Alaska in Dutch Harbor, Alaska, in 1968 (cited in 6) observed higher than normal concentrations of ammonia, and lowered dissolved oxygen resulting from the decomposition of accumulated seafood wastes on the bottom.

Brickell and Goering (7) reported large concentrations of ammonium and considerable oxygen depletion in the receiving waters of Iliuliuk Bay, Dutch Harbor, Alaska, as a result of canning activity. They concluded that the decomposition of seafood material, in a restricted body of water like the bay, could significantly influence the nitrogen concentration and availability in this environment, and some of the higher concentrations might affect marine organisms. They reported concentrations in the bay as high as 23.8 μg-atom NH_4^+-N/ℓ, while lower concentrations, although still higher than ambient levels, were observed over tens of square miles of ocean in the area. Open ocean ambient concentrations of ammonium were reported at 1 μg-atom NH_4^+-N/ℓ.

In addition to their work at Iliuliuk Bay, Brickell and Goering examined two other systems; a freshwater stream where salmon spawning occurred, and the receiving estuary where salmon carcasses accumulated following spawning. Their purpose in studying these systems was to evaluate a naturally occurring situation which showed accumulations of organic material in the

marine environment similar to the situation observed in the vicinity of seafood procesing sites. They found that combined dissolved organic nitrogen and ammonium values in the natural systems approximated ammonium values in Iliuliuk Bay. These results suggested that high concentrations of ammonium and organic nitrogen from salmon decomposition may not be restricted to waters receiving wastes from seafood processing (7). Their results also indicated that dissolved organic nitrogen was the initial breakdown product of salmon decomposition.

Surveys in 1975 and 1976 by U.S. EPA (6) in Iliuliuk Harbor, Inner Iliuliuk Bay, and Dutch Harbor, Alaska, encountered low dissolved oxygen concentrations near the bottom, increased nutrient concentrations within the bays, and decomposing sludge deposits of seafood wastes. They attributed these conditions to large amounts of waste discharges which were not adequately dispersed due to poor current movement and circulation patterns.

Investigations of seven disposal locations used by seafood processors at Dutch Harbor, Alaska, during October 1976 and September 1977, found that, although some shellfish wastes were dispersed by tides, wave surges, and longshore currents, as well as being fed upon by aquatic organisms, the reduction of the waste material by these means and by decomposition was not as great as the rate of waste accumulation from the discharges (9). This research also recorded adverse impacts of the waste sludge beds on the benthic environment. The shellfish debris physically smothered all immobile organisms within a 30 m radius

of the discharge point (8). Benthic communities on the periphery of the disposal site showed significantly fewer organisms than were present in control areas.

In 1971, EPA Region X reported on the pollution problem from shellfish processor discharges in Kodiak Harbor, St. Paul Harbor, and Gibson Cove, Alaska (9). These three embayments receive seafood processing wastes from 15 processing plants in or near the city of Kodiak. This area represents the greatest concentration of seafood processing plants in the state. In this study, Provant, et al. (9), observed oxygen concentrations of less than 6 mg/ℓ (with some surface-level concentrations as low as 1.3 mg/ℓ), and seafood solids accumulation on the bottom forming large sludge-like deposits. They estimated a bottom area of roughly 21 hectares (52 acres) to be severely impacted. Normal benthic marine life was not observed in this impacted area. Benthic samples obtained near processor outfalls did not contain any macroscopic forms, while samples collected further out from the outfalls contained only ooze-dwelling polychaetes and amphipods. The authors commented that the occurrence of these benthic organisms attested to the severely polluted bottom conditions. Sulfide concentrations in the water were reported to be at levels which might affect the ecological balance of the waters, or cause acute or chronic problems for marine organisms.

In 1971, the National Canners Association (presently National Food Processors Association) and Petersburg Fisheries funded a study to evaluate the impacts of seafood disposal by

canneries in Petersburg, Alaska (10). The findings of this study indicated that cannery wastes did not appreciably affect dissolved oxygen concentrations; populations of intertidal fauna were abundant through the study area; scavenging fish and birds fed heavily on wastes from the discharge plume; and other water quality determinations demonstrated rapid dilution and dispersion of wastes.

Laboratory studies by Nakatani and Beyer (11), assessing the effects of salmon cannery waste on juvenile salmon, demonstrated that prolonged periods of exposure were required for these wastes to cause mortalities in selected juvenile salmonids. Initial mortalities, even at 20,000 ppm of salmon processing wastes (70 percent of peak discharge concentrations reported by Nakatani and Beyer (10) for Petersburg, Alaska), did not occur until after 20 hr of exposure, well beyond the time of a total tide cycle (11). Additional screening bioassays of the salmon waste indicated that the factor causing mortalities in the juvenile salmon was in solution rather than associated with particulate waste (11).

PURPOSE OF PRESENT STUDY

As indicated in the above discussion, the discharge of seafood processing wastes has been shown to cause varying impacts under different hydrological conditions. The present study is intended to identify the important site-specific

factors which may determine the nature of the ecological impacts which result from seafood processing operations.

This study examined the marine environment near seafood cannery outfalls in Kenai and Cordova, Alaska, two Alaskan sites not previously studied. These sites differ with respect to hydrological conditions, seafood processed, and length of processing season.

The major areas of investigation in this study were:

- Aesthetic conditions, e.g. visible conditions in the water and along the shore
- Waste accumulations on the ocean bottom
- Hydrological conditions (tides and currents)
- Water and sediment quality
- Macrobenthos

MATERIALS AND METHODS

GENERAL DESCRIPTION OF STUDY AREAS

Field studies were conducted from July 23 to August 2, 1978, at Kenai and Cordova, Alaska. Kenai as sampled during the period July 23 to 27, and Cordova July 29 to August 2. Discussions with Alaskan Fish and Game and Alaskan cannery personnel in May and June, 1978, indicated that peak salmon runs and processing periods for Kenai and Cordova would probably occur during mid to late July for Kenai, and late July to early August for Cordova. Field sampling periods were selected to coincide as closely as possible with those projected peak processing times. The M/V Tres Cher, chartered out of Tacoma, Washington, was used to transport personnel and equipment to and from the sampling stations and study sites. When conditions permitted, some water quality sampling of shallow water stations was performed from a small skiff.

Kenai is located approximately 113 km (70 mi) south-southwest of Anchorage, Alaska, on the western side of the Kenai Peninsula (60° 33' N latitude, 151° 14' W Longitude) (Figure 1). Four canneries are located along the Kenai River and all discharge their processing wastes directly to the river. The two largest processors are Kenai Packers (KP), located nearest the mouth of the river, and Columbia-Wards Fisheries (CWF), located furthest upstream. The respective locations of these

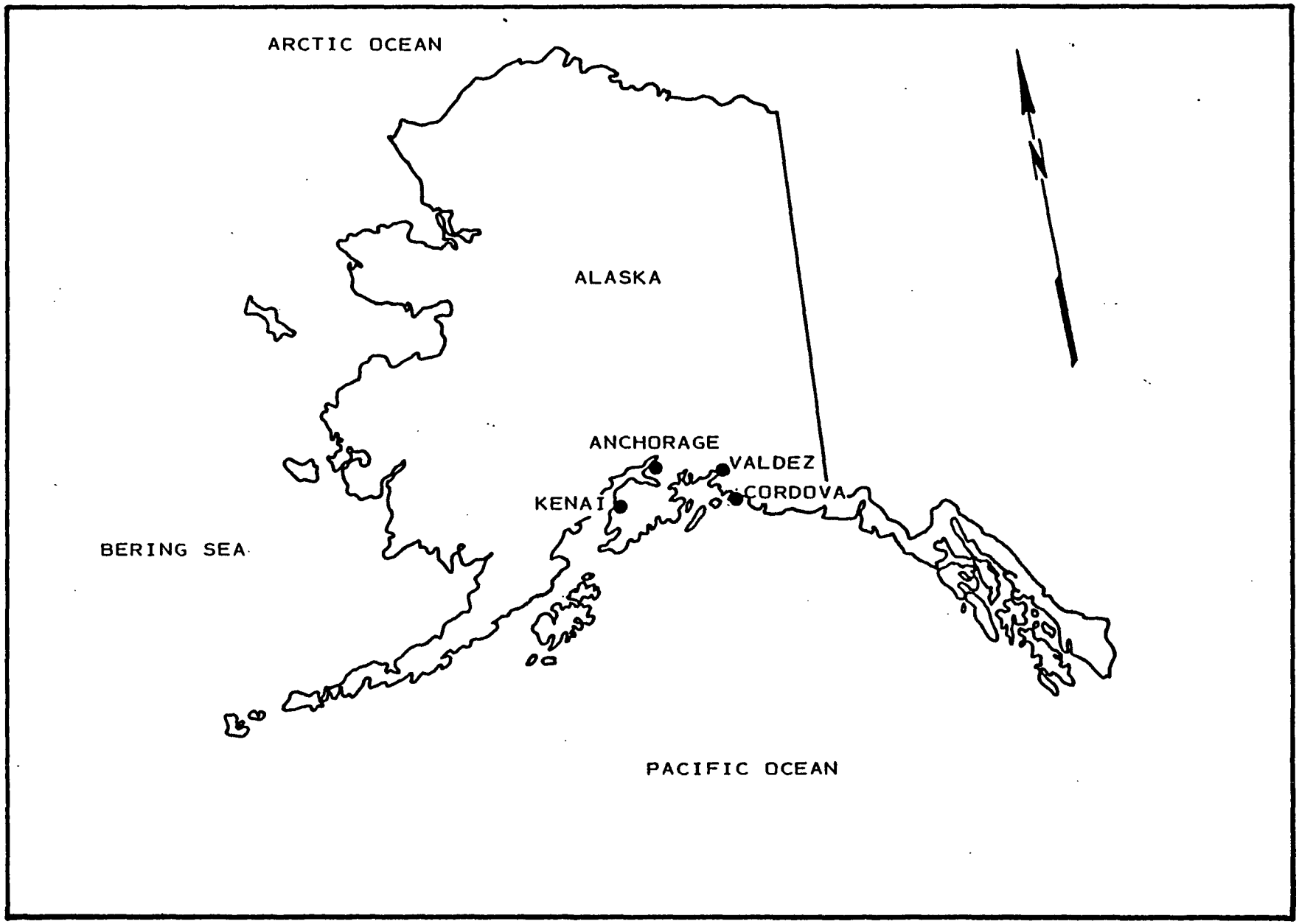


Figure 1. Map of Alaska, showing locations of Kenai and Cordova, Alaska.

two canneries and of the general areas surveyed are shown in Figure 2. Locations of sampling stations are shown in Insets A and B for KP and CWF, respectively. In Inset A of Figure 2, Stations A and X are shown located furthest downstream from the KP cannery. Station B', located at the outfall pipe, receives wastes from the egghouse and mechanical butchering operations. Station C' is shown located near the outfall for the hand butchering operation. Station E is the furthest upstream station, and Stations L, M, and N served as controls.

In Inset B of Figure 2, Station S is shown located near the end of the CWF outfall. Officials at CWF were unsure of its exact location because they were not present when the line was relaid in the spring. However, they estimated that its location was the area designated by Station S. Station R is located downstream from Station S.

Large tidal fluctuations, strong river and tidal currents, and shallow waters and hidden shoals prevented more extensive sampling off CWF. Consequently, the heaviest concentration of samples was collected off KP.

Cordova is located approximately 257 km (160 mi) southeast of Anchorage, and roughly 80 km (50 mi) south-southeast of Valdez, Alaska (60° 33' latitude; 145° 66' W longitude) (Figure 1). Four canneries are located in Cordova; St. Elias Ocean Products (St. E), North Pacific Processors (NPP), Morpac, Inc., and New England Fish Company (NEFCO). The locations of sampling stations for the Cordova survey are shown in Figure 3. Stations N, O, and P served as control stations.

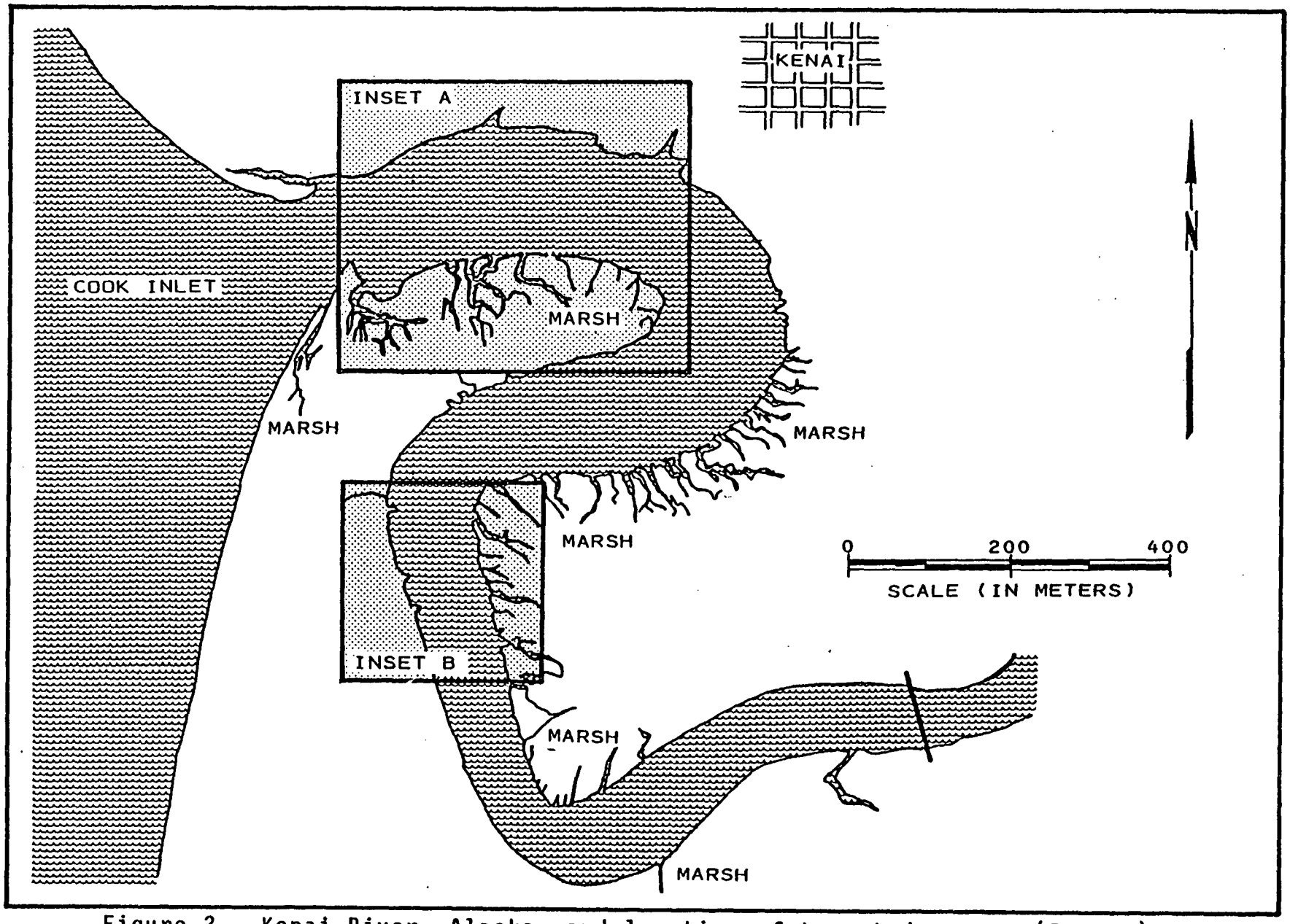


Figure 2. Kenai River, Alaska, and location of two study zones (Insets).

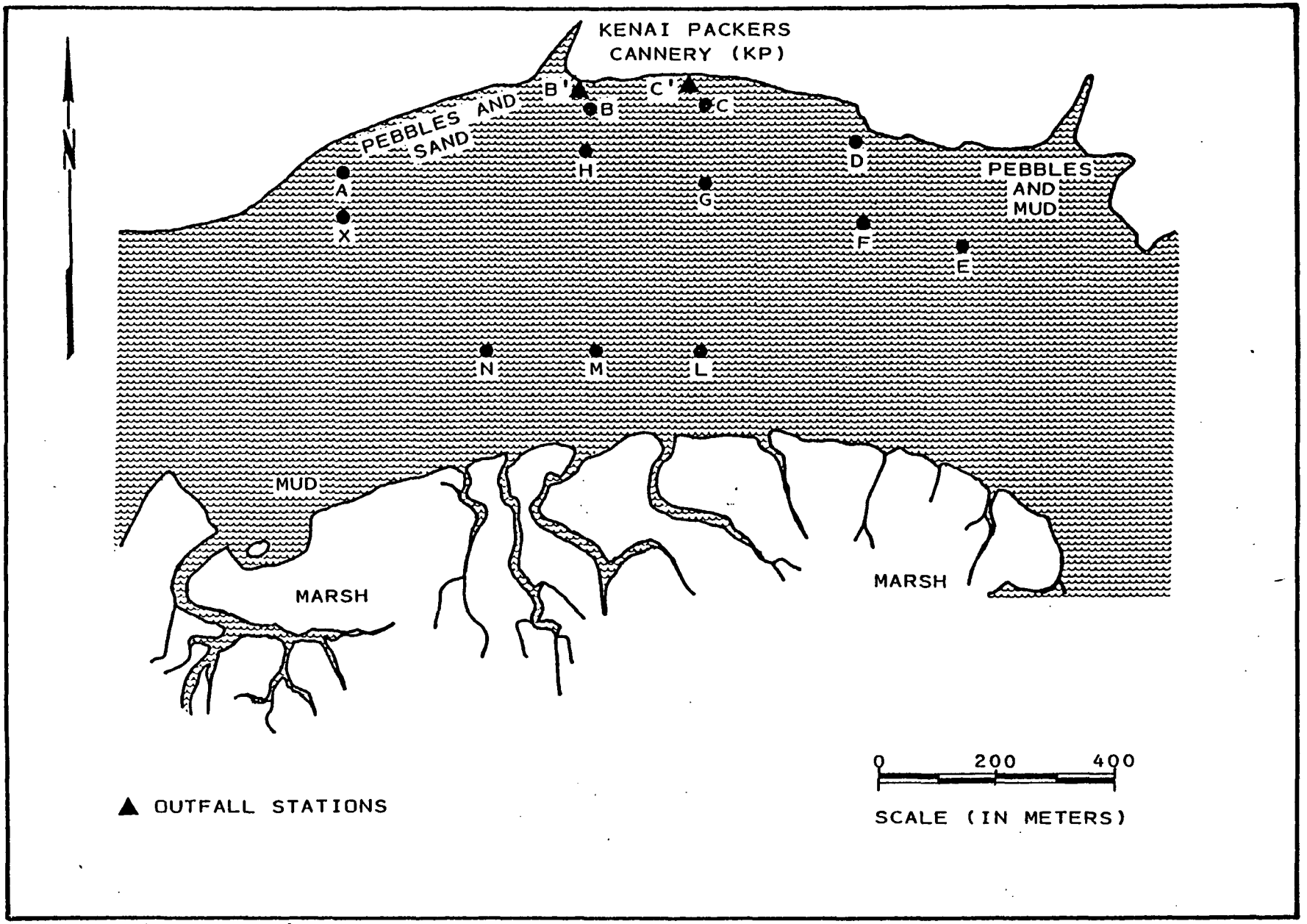


Figure 2 (Continued), Inset A. Kenai River sampling stations off Kenai Packers Cannery.

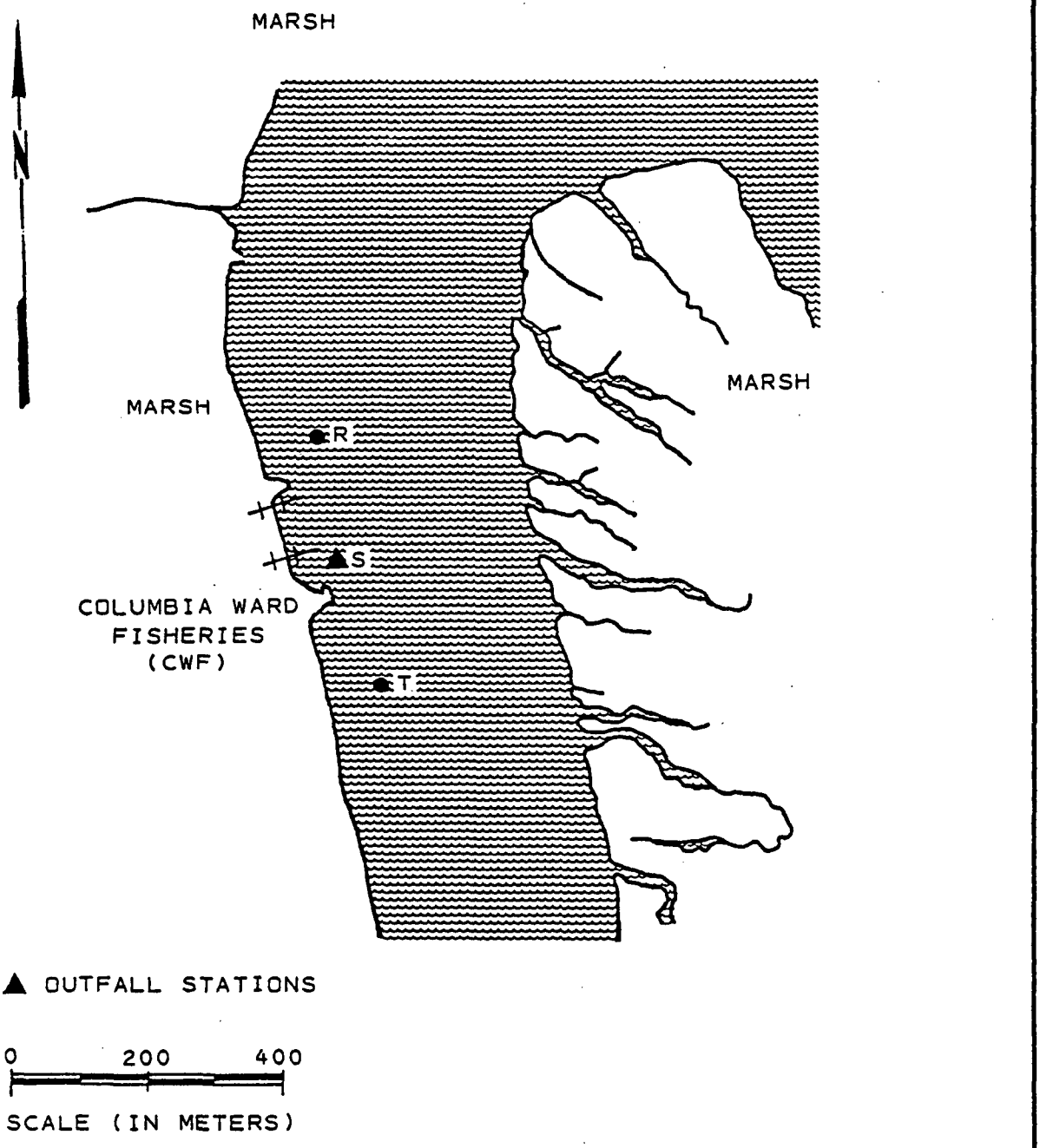


Figure 2 (Continued), Inset B. Kenai River sampling stations off Columbia Ward Fisheries.

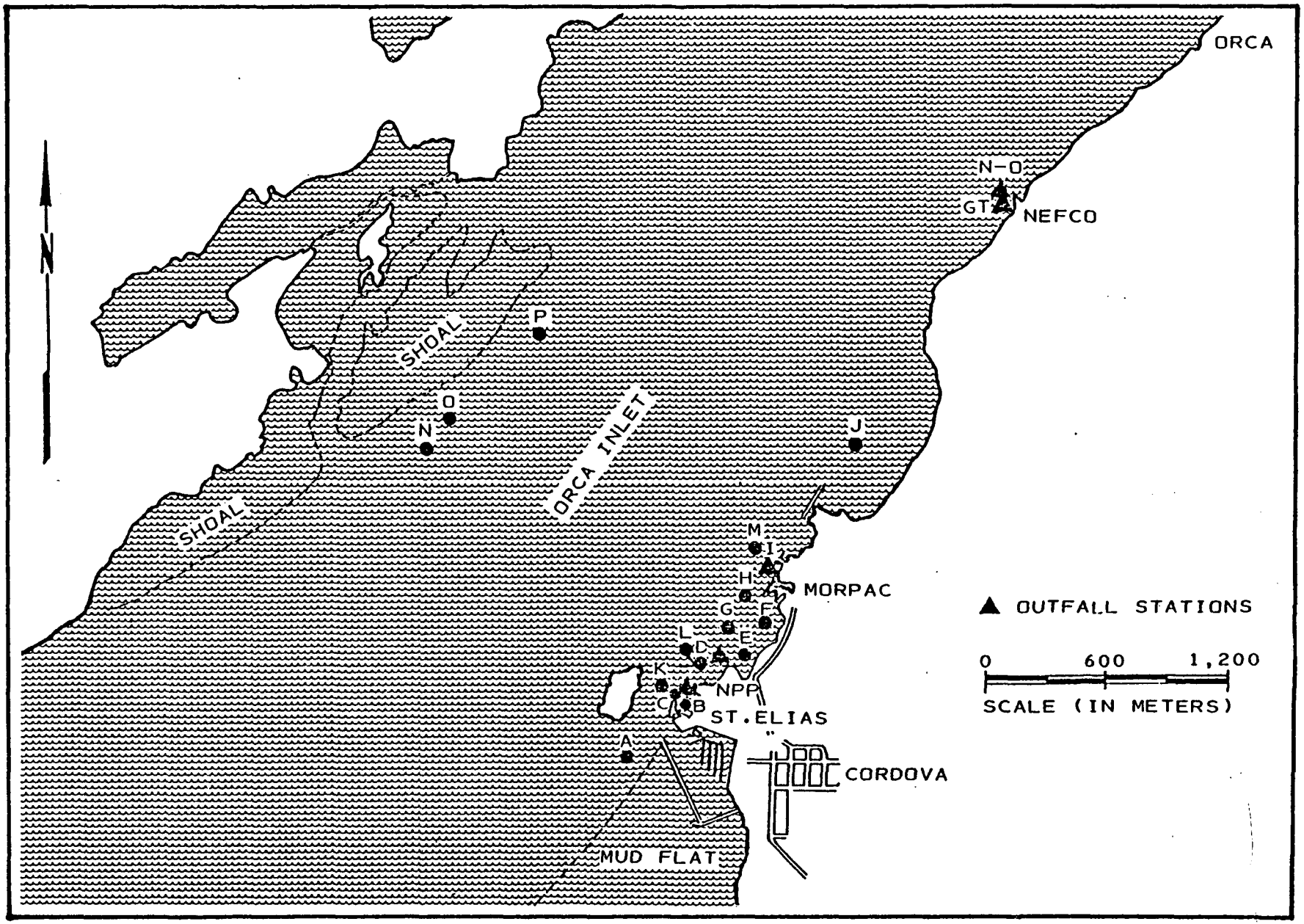


Figure 3. Location of Sampling Sites at Cordova, Alaska.

HYDROLOGICAL DETERMINATIONS

Daily tidal range and tidal currents for the two sites were calculated using National Oceanic and Atmospheric Administration (NOAA) Tide Tables 1978 (12) and Tidal Current Tables 1978 (13). These tables list high and low water predictions for the Kenai City Wharf (located less than 1 km upstream of KP), tidal currents for the KP Wharf, tidal height for Cordova Harbor, and mid-channel tidal current predictions off Cordova. Field current measurements were not made because of equipment malfunctions.

WATER QUALITY

Water quality was determined by measurement of the following parameters: dissolved oxygen, temperature, salinity, transparency, pH, ammonia, organic (Kjeldahl) nitrogen, orthophosphate, total phosphorus, and hydrogen sulfide.

Water samples for salinity, dissolved oxygen, pH, and nutrients were collected with a 3 ℓ, opaque, Van Doren water sampler at bottom, mid- and surface water depths. Duplicate samples were obtained for each depth.

Nutrient and hydrogen sulfide analyses were made by Dames and Moore Engineering, Fairbanks, Alaska, after the methods described in Standard Methods (14) and U.S. EPA Methods for Chemical Analysis of Water and Wastes (15).

Dissolved oxygen was measured by a Modified Winkler procedure (16); temperature with a stem thermometer (0.1°C); salinity with an American Optical refractometer (0.2‰), Model No. 10419; transparency with a white Secchi disc (15 cm diameter); and pH with an Orion field pH meter, Model No. 339A.

SEDIMENT SAMPLES

Four sediment samples were collected at each station using a 0.1 m^2 Van Veen benthic bottom sampler. At Kenai, benthic samples from stations exposed during low tide were obtained using a rectangular plastic sampler measuring 0.1 m^2. For the latter method, the sample area was randomly selected and the sampler pushed into the sediment. The material within the sample area was removed to a maximum depth of 16 cm (6 in).

Two of the four sediment samples were used intact for benthic faunal analysis. These benthic samples were transferred to 5-gal plastic buckets, fixed immediately with a 10 percent buffered formalin solution, sealed, and shipped to the University of Alaska, Sorting Center, Seward, Alaska, for sorting and identification of benthic organisms. At the Sorting Center, the samples were deformalized using diluted ammonia and then washed on a 1 mm screen. The material retained was represerved in 10 percent buffered formalin. The material which passed through the 1 mm screen was retained and washed again on a 0.5 mm screen.

The 1 mm screen material was placed on a dark green and white tray in water. The material was examined on first the dark, and then the light side of the tray. The organisms removed were again preserved for later identification.

The material retained on the 0.5 mm screen was drained. A pie shaped slice was removed for sorting and identification. Total 0.5 mm sample weight and weight of each fraction were determined. The numerical values for the organisms identified in the sample fraction were corrected to the total weight of the sample.

Three 500 ml plastic screw-cap jars were filled from each of the remaining two sediment samples for sediment chemistry analysis. Total organic carbon (TOC), total volatile solids (TVS), total Kjeldahl nitrogen (TKN), and total sulfide (TS) determinations on two of the three sub-samples were conducted by the Analytical Research Laboratory at University of Southern California, Los Angeles, California. Procedures described in Standard Methods (14) were used for TKN, TVS, and TS. TOC determinations were made on 5 g of wet sediment using a LECO TC-12 Automatic Carbon Analyzer. Particle size distribution studies on the third sub-sample were determined by SCS Engineers, Long Beach, after methods described in American Standards for Testing and Materials (17).

UNDERWATER PHOTOGRAPHY

Underwater video films were taken at Cordova for indications of seafood processing waste accumulations and responses by marine organisms to these wastes. Bottom conditions at each cannery outfall, at mid-channel stations, and control sites were recorded. Similar filming at Kenai was not performed because of highly turbid river waters and strong currents.

BIOLOGICAL INDICES

Faunal density at each station was calculated as the total number of individuals of all species (N). Species richness was estimated as the number of species (S) collected at each station Species diversity was calculated according to the Shannon-Wiener formula:

$$H' = \Sigma P_i \ln P_i \quad (18)$$

where $P_i = n_i/N$; P_i = proportion of total number of individuals occurring in species i.

Normal numerical classification of the benthic data was also performed. The normal classification grouped the stations according to species similarities, and the species acording to

station similarities. The Czekanowski coefficient (19, 10) was used in the normal classification, and was calculated as follows:

$$C_Z = 2W/(A + B)$$

where:

A is the sum of the species scores for sample a;

B is the sum of species scores for sample b;

W is the sum of the smaller scores of each species in the two samples being compared.

All species counts were log transformed using log (X + 1) (20). After the formation of a matrix of coefficients, a dendrogram was produced using group-average sorting (21).

Species represented by five or less individuals in all benthic samples from a given location were not included in the statistical analyses of benthic macrofaunal data. While it has been argued that the elimination of rare species may remove those species which are highly selective in their habitat type, it has been shown by Field (19) and Day, et al. (22) that rare species have virtually no effect on community structure analysis when using the Czekanowski coefficient of similarity. After the

initial data reduction, replicate samples from each station were pooled for quantitiative faunal analysis.

LIMITATIONS TO SAMPLING

At Kenai, strong tidal currents confined all sampling to the slack water period. The slack following the maximum flood usually afforded the most time for sample collections (1-2 hr). As tidal currents increased, severe problems with the wire angle of water bottle and benthic grab lines were encountered, thus preventing collection of meaningful samples. Tidal currents at Cordova were not a hindrance to sample collection.

Limitations imposed by field conditions, available field sampling time, and in-lab sample processing time, prohibited any additional sampling or resampling of stations or sites.

RESULTS AND DISCUSSION

KENAI

Description of Seafood Processing Operations

Salmon and herring processing at Kenai occurs from mid-May through mid-August. Processing of canned and frozen salmon products occurs from late June through mid-August at both KP and CWF. Herring processing at both canneries is limited to mid-May.

Estimated seafood waste production quantities for these two Kenai canneries are shown by seafood type in Tables 1 and 2. As indicated in these tables, over 1,200 and 1,500 Tons of processing wastes were produced and discharged to the Kenai River by KP and CWF, respectively, in 1977. Waste production figures for the 1978 season were not available; however, it is anticipated that 1978 waste production figures will exceed those of 1977 because of record salmon catches for the 1978 season.

Field monitoring studies at Kenai were performed approximately one week after the peak cannery processing period, although considerable processing activity was ongoing during the field sampling.

Aesthetic Conditions

At KP, discoloration of surface waters and accumulations of nonground fish parts (heads, fins, viscera, and roe) were observed at one discharge point (Station B') during periods of

TABLE 1

ESTIMATED SEAFOOD WASTE PRODUCTION
KENAI PACKERS *

Type of Waste	Waste Quantity (Tons/year) 1977	1976	1975
Salmon	1,290	994	666
Tanner Crab	-	-	-
Dungeness Crab	-	-	-
Halibut	-	-	-
Herring	-	104	109

TABLE 2

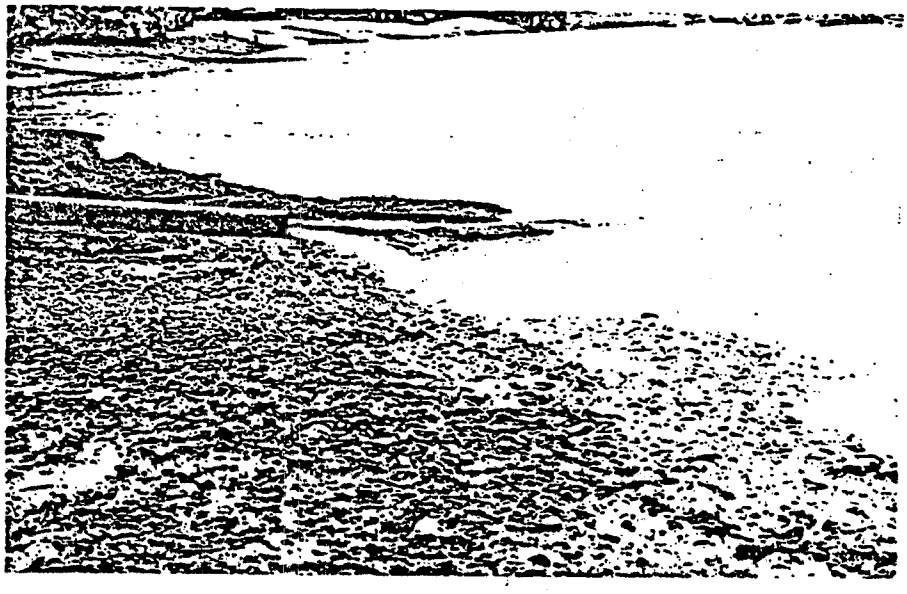
ESTIMATED SEAFOOD WASTE PRODUCTION
COLUMBIA-WARDS FISHERIES *

Type of Waste	Waste Quantity (Tons/year) 1977	1976	1975
Salmon	1,550	1,560	717
Tanner Crab	-	-	-
Dungeness Crab	-	-	-
Halibut	-	-	0.6
Herring	-	101	-

*Ref. 23

slack low water. At this discharge point, wastes were being discharged above the low-tide level, resulting in pinkish surface discolorations and whole-fish waste accumulations on shore near the discharge (Figure 4). According to KP Cannery officials, whole, ~~non~~un-ground wastes were being discharged because the grinder was inoperative. These effects were limited to an area of riverbank and adjacent littoral region 15 m downstream from the discharge at low tide. Beyond 15 m, currents sufficiently diluted the surface discolorations. The combined action of currents and tidal fluctuations removed the accumulated fish wastes to the extent that the shore was clean by ~~the~~ low tide ~~of~~ the following morning. Sediment samples and general observations of river margins further downstream (Stations A and X) did not indicate the presence of any fish parts. The extent, if any, of upstream transport of these wastes during flood tides was not investigated.

No surface effluent plume or fish wastes were observed at or near Station C' (hand butchering outfall). However, a waste stream was apparent through portions of the dock-face, resulting in the discoloration of the waters immediately adjacent to the dock-face near the egghouse at slack waters of low-tide, and in the accumulation of waste materials on the exposed riverbank portions at the base of the wharf. The origin of this waste stream was not apparent, since the entire understructure of the wharf is concealed by exterior siding. According to cannery personnel, however, a waste collection line does run under the



4a. Seafood processing waste stream discharged above low water level.

4b. Accumulations of whole fish parts on Kenai River bank immediately downstream of cannery outfall.

Figure 4. Evidence of seafood waste accumulations near Kenai Packers Cannery outfall.

wharf from the mechanical-butchering area connecting into the egghouse discharge line and leaks in this line may have been the source of the dock-face waste stream. As in the case of the waste accumulations at Station B', changes in tidal height and currents removed these accumulations and diluted surface discolorations on a daily basis.

At CWF, the grinder system was in operation during the field sampling, and no surface discolorations, or floating debris, were observed near the CWF sampling stations.

Decreases in water transparency as the result of cannery discharges were not assessed because of naturally high concentrations of suspended material, primarily glacial fines, in the Kenai River.

Bottom Accumulations

Underwater photography was not performed at Kenai because water transparency was severely limited by high concentrations of suspended glacial fines.

Hydrological Conditions

Tidal height data for Kenai is presented in Table 3. As indicated in this table maximum diurnal tidal ranges of 8.1 m were encountered at Kenai. The extent of diurnal variation in tidal height at KP Wharf are shown in Figure 5. Figure 5a indicates tidal height on July 25 near maximum flood tide and Figure 5b during ebb tide. Tidal current data for the Kenai River at the KP Wharf is listed in Table 4.

TABLE 3 . TIDAL DATA FOR KENAI, ALASKA
JULY 23-JULY 26, 1978*

Date	LW	HW	LW	HW	Maximum Diurnal Range
	meters (feet)				
July 23	-0.3 (-1.0)	6.9 (22.8)	-1.2 (-3.9)	6.8 (22.4)	8.1 (26.7)
July 24	-0.2 (-0.5)	6.5 (21.3)	-0.6 (-2.1)	6.6 (21.5)	7.2 (23.6)
July 25	0.1 (0.3)	5.9 (19.4)	0.0 (0.0)	6.2 (20.3)	6.2 (20.4)
July 26	0.4 (1.3)	5.3 (17.5)	0.7 (2.3)	5.8 (19.0)	5.4 (17.7)

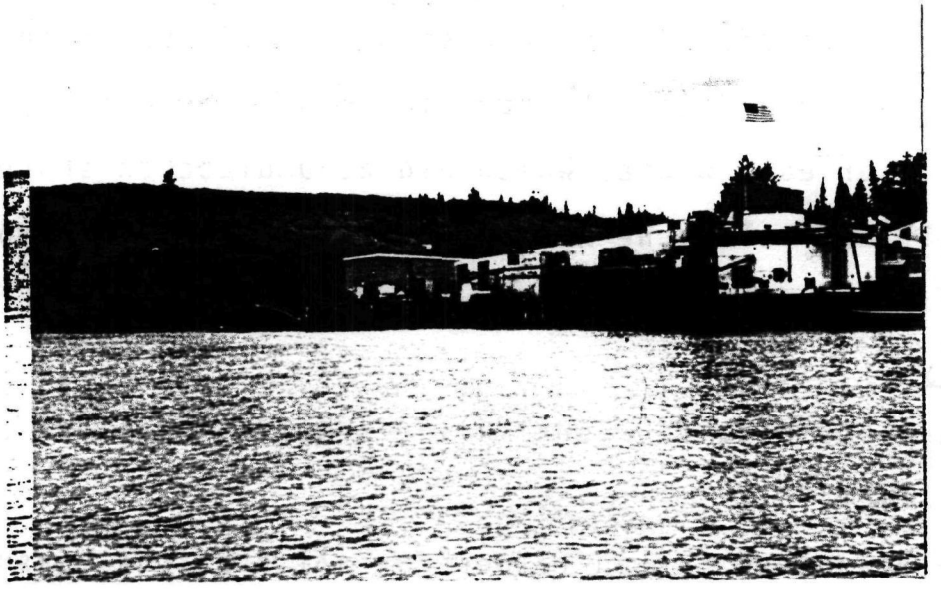
*Ref. 13

Legend: LW = Low Water
HW = High Water

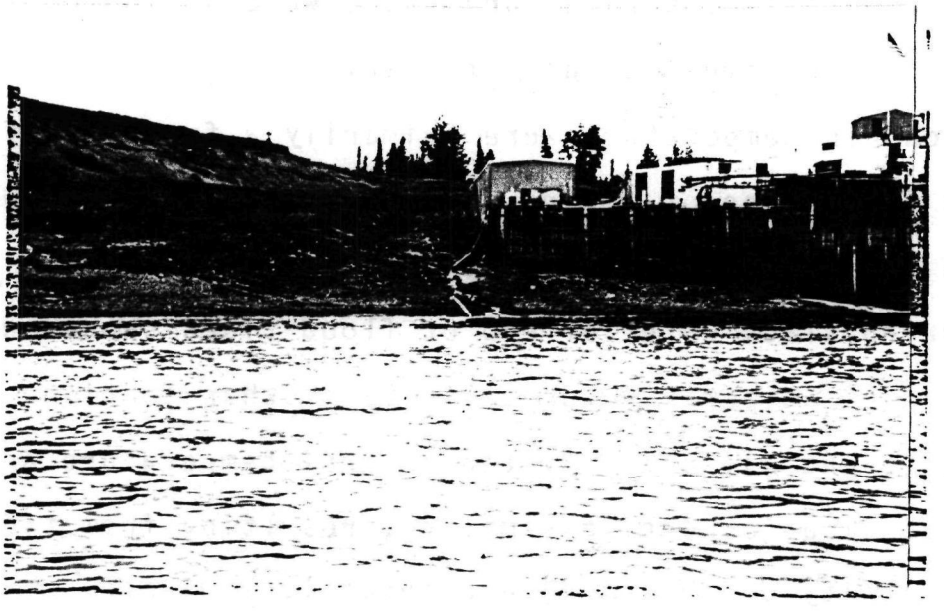
TABLE 4. TIDAL CURRENT DATA FOR KENAI, ALASKA
JULY 23-JULY 26, 1978*

Date	Maximum Tidal Current			
	Flood	Ebb	Flood	Ebb
	In km/hr (knots)			
July 23	1.9 (1.0)	4.1 (2.2)	2.0 (1.1)	3.3 (1.8)
July 24	1.7 (0.9)	3.5 (1.9)	3.2 (1.7)	1.7 (0.9)
July 25	1.5 (0.8)	2.8 (1.5)	1.5 (0.8)	2.6 (1.4)
July 26	1.1 (0.6)	2.2 (1.2)	1.3 (0.7)	2.4 (1.3)

*Ref. 14



5a. Tidal height off Kenai Packers near maximum flood tide.



5b. Tidal height off Kenai Packers during ebb tide.

Figure 5. Variations in tidal height at Kenai Packers Cannery, Kenai, Alaska.

The combined action of tidal currents and large daily variations in tidal height appeared to sufficiently flush the Kenai River of seafood processing wastes. As discussed in an earlier section, no persistent accumulations of processing wastes were observed. Wastes which did accumulate on shore near one KP outfall and below the KP wharf at low tide were removed by the low tide of the next tidal cycle.

Water Quality

Water quality data for Kenai River sampling stations are presented in Table 5.

Surface dissolved oxygen values for all stations measured at or near saturation. The lowest oxygen measurement (8.5 mg/ℓ) was from bottom water at Station C. Values of 9.0 mg/ℓ or greater were typically observed, and there were no indications of depressed oxygen values at any station.

Variations in temperature were primarily a function of tidal cycle, the degree of mixing, density differences between brackish and fresh water, and sampling date. Some samples collected during slack water of ebb or flood tides showed no stratification of temperature or salinity. Other stations (e.g., E, F, X, and R), demonstrated inverse temperature and salinity stratification during sampling, resulting from tidal flow, water density differences, and incomplete mixing. Evidence of tidal cycle influence was shown at Stations G and H. Although these stations were sampled on the same date, sampling occurred during different portions of the tidal cycle.

TABLE 5. WATER QUALITY AND DEPTH FOR KENAI RIVER SAMPLING STATIONS.

Parameter		Station A	B	B'	C	C'	D	E	F	G	H	X	R	S	T
Date (1978)		7/26	7/24	7/26	7/23	7/26	7/26	7/25	7/25	7/23	7/23	7/26	7/26	7/26	7/26
Time		1600	0600	1630	0650	1700	1500	0720	0750	1500	1430	0830	0900	0800	0720
Depth (m)		0.3	8.5	0.3	9.9	0.3	0.3	6.3	8.8	7.0	12	7.8	6.5	6.5	5.5
Dissolved Oxygen (mg/ℓ)	S	10.8	9.0	10.9	9.3	10.6	10.9	9.5	9.9	10.0	9.1	9.7	10.2	10.0	10.5
	M	--	9.0	--	9.0	--	--	9.1	9.0	10.1	8.9	9.0	9.5	10.2	10.5
	B	--	--	--	8.5	--	--	8.9	9.2	10.7	9.1	9.0	9.5	9.6	10.5
Temperature (°C)	S	12.4	12.4	12.3	12.0	13.0	12.4	12.0	11.6	11.1	12.7	11.6	12.0	12.0	11.9
	M	--	12.3	--	12.0	--	--	12.4	12.1	11.2	12.7	12.2	12.1	12.0	11.9
	B	--	12.3	--	12.0	--	--	12.4	12.2	11.2	12.7	12.2	12.2	12.1	11.9
Salinity (‰)	S	0.0	25	0.0	22.0	0.0	0.0	19.0	11.0	0.0	21.0	22.0	3.0	0.0	1.0
	M	--	26	--	24.0	--	--	22.0	21.0	0.0	24.0	24.0	12.0	0.0	0.0
	B	--	26	--	23.5	--	--	25.0	25.0	0.0	24.0	26.0	20.0	9.0	0.0
pH	S	6.6	7.3	6.6	8.1	6.6	6.5	7.6	7.4	6.4	6.8	7.9	6.7	6.5	6.7
	M	--	7.3	--	8.0	--	--	7.6	7.5	6.9	7.4	7.6	7.5	6.6	6.8
	B	--	7.4	--	8.1	--	--	7.7	7.6	7.3	7.7	7.7	7.6	7.4	6.6
Seechi Depth		--	0.23	--	0.20	--	--	--	--	0.20	--	--	--	--	--
Ammonia (mg/ℓ)	S	ND	ND	ND	0.04	0.04	ND	0.03	ND	<0.02	0.02	ND	ND	ND	ND
	M	--	ND	--	<0.02	--	--	ND	ND	ND	ND	ND	ND	ND	ND
	B	--	ND	--	0.02	--	--	ND	ND	<0.02	ND	0.02	ND	ND	ND
Organic Nitrogen (mg/ℓ)	S	0.03	0.10	0.03	0.08	0.04	0.03	0.04	0.03	0.02	0.03	0.04	0.02	0.03	0.02
	M	--	0.07	--	0.05	--	--	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.03
	B	--	0.05	--	0.06	--	--	0.03	0.05	0.03	0.02	0.03	0.02	0.02	0.02
Orthophosphate (mg/ℓ)	S	ND	0.03	ND	0.02	ND	ND	0.02	0.02	ND	0.03	0.02	ND	ND	ND
	M	--	0.03	--	0.03	--	--	0.03	0.03	ND	0.02	0.03	ND	ND	ND
	B	--	0.03	--	0.03	--	--	0.03	0.03	ND	0.02	0.03	ND	ND	ND
Total Phosphorus (mg/ℓ)	S	0.03	0.03	0.02	0.03	0.02	0.03	0.02	0.03	0.03	0.03	0.04	ND	ND	ND
	M	--	0.03	--	0.03	--	--	0.03	0.03	0.03	0.03	0.04	0.02	ND	ND
	B	--	0.03	--	0.04	--	--	0.03	0.03	0.02	0.02	0.05	ND	0.02	ND
Sulfide (mg/ℓ)	S	ND	ND	ND	ND	<0.004	ND	ND	ND	ND	ND	ND	ND	ND	ND
	M	--	ND	--	ND	--	--	ND	ND	ND	ND	0.004	ND	ND	ND
	B	--	ND	--	ND	--	--	ND	0.005	ND	ND	ND	ND	ND	ND

Salinity showed the most dramatic daily fluctuations of the parameters examined. Salinity values ranges from fresh water conditions (0.0‰) during ebb tides to brackish water concentrations (<26‰) during flood tides. This daily fluctuation was solely a function of tidal exchange, and any contribution from cannery discharges would have been negligible. The greatest range in daily fluctuations occurred at KP because of its closer proximity to saline ocean waters. Fluctuations of 12‰ were observed in the river off CWF.

Variations in pH between stations appeared to parallel salinity changes. Lower pH values (6.4-6.7) were observed during ebb tides, while higher pH values corresponded to flood tides.

The low secchi depth values resulted from the high concentrations of suspended glacial fines in the water. This suspended matter greatly reduced water transparency.

Nutrient concentrations were extremely low in the river water and in many instances were below or only slightly above minimum detection limits. Variations in nutrient concentrations between stations were not apparent with the possible exception of higher Kjeldahl nitrogen concentrations at Stations B and C. At the range of concentrations observed, these differences may not be important.

Sulfide values were generally below detection limits or at concentrations which were insignificant.

Sediment Particle Size

Sixteen stations were sampled for particle size distribution of Kenai River sediments. Particle size distributions for these stations are shown in Table 6. Substantial variation existed between stations, largely as a function of the river configuration, current, and sediment deposition patterns. In the narrower portions of the river off CWF (Stations R, S, and T), currents scour the bottom and carry away the finer sized material. Gravel and sand were characteristic of the sediment at these stations. As the channel curves downstream from CWF (Figure 2), the riverbank is eroded and some of the eroded material is carried downstream with the current. This material is deposited, in part, further downstream at Stations L, M, and N. Formation of eddies and bars as the river channel widens toward the mouth will also cause deposition of material along these features. Although these features are transient in nature, they may account for the high sand content observed at Stations E, F, and H. The riverbank, including the portion housing the KP cannery, is another point of erosion, and patchy, exposed areas of clay and sand were commonly observed along this stretch at low tide. Higher percentages of silt and clay were found in material collected along this portion of the river (Stations A, B', C', and D).

Sediment Chemistry

Results of sediment chemistry analyses for 16 stations in the Kenai River are shown in Table 7. Sediment chemistry was

TABLE 6. SIZE DISTRIBUTION (PERCENT WEIGHT) OF KENAI RIVER SEDIMENT SAMPLES.

Size Class	Station																
	A	B	B'	C	C'	D	E	F	G	H	L	M	N	X	R	S	T
Gravel*	5	-	0	50	9	28	6	7	96	8	2	0	4	30	35	93	42
Sand†	49	-	46	44	29	22	90	89	4	85	92	96	84	66	63	7	51
Silt#	29	-	32	4	34	28	4	4	0	2	2	1	7	4	2	0	5
Clay**	17	-	22	2	28	22	0	0	0	5	4	3	5	0	0	0	2

Legend

*Gravel - >2 mm
†Sand - 50 microns to 2 mm
#Silt - 2-50 microns
**Clay - >2 microns

TABLE 7. SEDIMENT CHEMISTRY DATA FOR KENAI RIVER SAMPLING STATIONS.

	Station															
	A	B	B'	C	C'	D	E	F	H	L	M	N	X	R	S*	T
Volatile Solids (%)	1.57	2.22	1.35	0.78	0.80	2.73	1.49	1.20	1.16	1.22	0.93	1.16	1.32	1.55	1.68	1.44
Total Organic Carbon (%)	0.245	0.282	0.34	0.07	0.33	0.32	0.097	0.096	0.07	0.064	0.060	0.091	0.092	0.105	0.110	0.06
Total Sulfide (mg/kg) (dry)	43.4	39.7	290	28.5	72.8	75.5	24.3	58.6	33.5	44.9	43.2	34.5	23.5	28.5	125.0	65.3
Total Kjeldahl Nitrogen (mg/kg) (dry)	107	98	100	46.6	123	68.6	26.3	390	74.6	92	45.3	46.2	30.1	26.3	30.6	46.9

*No replicate.

not performed on Station G sediment because of limited sample material. TVS content in the river sediment was low, with the highest values occurring at Stations B (2.22 percent) and D (2.73 percent). TVS content in outfall station sediments was among the lowest in value. Although TOC concentrations were highest at the two KP outfall stations (B' and C'), high TOC values were also measured at stations downstream (Station A), and upstream (Stations B and D) of the outfalls. At this time, it is not clear whether the higher TOC concentrations at Stations A, B', B, C', and D are the result of cannery discharges or naturally high TOC concentrations in the sediment at these stations. Stations C, L, M, and N had the lowest TOC values. TOC concentrations at Stations R and S were nearly twice the concentration at Station T. Although all three of the CWF stations had sediment that was predominantly sand and gravel, the higher TOC values at Station S and downstream at Station R, suggested the possible influence of cannery discharges on sediment TOC values at these stations. Total sulfide was highest at outfall Stations B' and S.

Macrobenthos

Sediment samples for benthic macrofaunal analysis were collected from all stations except B, C, and S. Adequate-size samples for benthic analysis could not be obtained at these stations despite repeated grab attempts. A list of the

organisms found at each station in the 1 mm, 0.5 mm, and combined screenings are given in Tables 8, 9, and 10, respectively. Density and species richness values for the combined screening data are shown in Table 11.

The 1 mm screening data in Table 8 indicated that oligochetes and, to a lesser degree, gammarid amphipods were the only macrobenthic organisms occurring in significant numbers. The 0.5 mm screening data (Table 9), however, revealed the presence of two additional animal groups, nematodes and platyhelminths, with nematodes clearly the dominant species of the four groups. The appearance of nematodes and platyhelminths in the 0.5 mm screenings also demonstrated the importance of performing the 0.5 mm screening on benthic samples. The station occurrence, richness, and density of species had clearly changed from the conditions described by the 1.0 mm data. Without the 0.5 mm data, an inaccurate description of the benthic community in the Kenai River would have been made.

The combined macrobenthic data presented in Table 10 showed that nematodes and oligochaetes were the dominant macrobenthic species, with nematodes being the principal dominant. Nematode and oligochaete abundance was greatest in sediment with a high percentage of sand (e.g., Stations E, F, M, X, and R). Although these organisms were able to utilize a sand habitat, a sand habitat can also restrict colonization by some benthic organisms. Sediment with high sand content may exclude those

TABLE 8 STATION LIST OF MACROBENTHOS OF KENAI RIVER SEDIMENTS (1 mm SCREENINGS) *

	STATION													
	A	B'	C'	D	E	F	G	H	L	M	N	X	R	T
Gammaridae	0	0	0	0	0	0	0	0	0	0	0	1	2	14
Oligochaeta	0	0	0	4†	8	13	127†	173†	0	4	7	41	328	276

* Unless otherwise noted, abundance values represent mean of replicate samples.
† No replicate.

TABLE 9. STATION LIST OF MACROBENTHOS OF KENAI RIVER SEDIMENTS (0.5 mm SCREENINGS).*

	STATION													
	A	B'	C	D	E	F	G	H	L	M	N	X	R	T
Gammaridae	0	0	0	0	0	0	0	0	0	0	0	21	0	0
Oligochaeta	17	0	0	75+	1,863	0	110+	288+	0	0	1,000	489	1,352	561
Nematoda	0	43	11	2+	1,775	2,250	268+	403+	625	2,750	179	595	7,960	149
Platyhelminthes	0	0	0	0	0	0	0	0	0	250	0	0	0	82

* Unless otherwise noted, abundance values represent mean of replicate samples.

+ No replicate.

TABLE 10. STATION LIST OF MACROBENTHOS OF KENAI RIVER SEDIMENTS (1 AND 0.5 mm SCREENINGS) *

	STATION													
	A	B'	C'	D	E	F	G	H	L	M	N	X	R	T
Gammaridae	0	0	0	0	0	0	0	0	0	0	0	22	2	14
Oligochaeta	17	0	0	79+	1,863	13	237+	461+	0	4	1,007	530	1,680	837
Nematoda	0	43	11	2+	1,775	2,250	268+	403+	625	2,750	174	595	7,930	149
Platyhelminthes	0	0	0	0	0	0	0	0	0	250	0	0	0	82

* Unless otherwise noted, abundance values represent mean of replicate samples.

+ No replicate.

TABLE 11. DENSITY (N), AND SPECIES RICHNESS (S) VALUES OF KENAI RIVER BENTHIC SAMPLES (COMBINED 1 AND 0.5 mm SCREENING DATA).

Station	N	S
A	17	1
B'	43	1
C'	11	1
D	81	2
E	3,638	2
F	2,263	2
G	505	2
H	864	2
L	625	1
M	3,004	3
N	1,181	2
X	1,147	3
R	9,612	3
T	1,082	4

benthic forms which require a less coarse sediment for tube building, or some organisms which are surface detrital and deposit feeders. The limitations imposed by a sandy habitat may explain the low species richness observed at these stations.

Species density, and species richness were greatest at Stations R and T, respectively. Daily salinity changes at these stations are less than at the other sampling stations, and this factor may make the sediment environment at Stations R and T more suitable to benthic organisms. Species density was greatest at Station R. Although this station is located downstream of CWF, without benthic samples from Station S and between Stations R and S, it cannot be concluded that the greater density was associated with CWF waste processing discharges.

Depauperate macrobenthic conditions were reported for Stations A, B', C', and D. At this time, it is not clear whether these conditions were the result of cannery discharges or were due to sediment type. Sediment clay content was highest at these stations, and this factor may have restricted habitat utilization by burrowing benthic forms. Some parameter not tested in this study may also have been responsible.

Community structure analyses of the Kenai River macrobenthos data were not performed because of the low number of species.

As a whole, the Kenai River benthic community is poorly developed. Attempts to associate cannery discharges to the observed benthic conditions were inconclusive. Limitations on habitat utilization imposed by sediment type, tidal induced scouring and burial by bottom sediments, and daily salinity changes are probably the major factors responsible for low species richness and the generally poorly developed benthic community.

Description of Seafood Processing Operations

Seafood processing at Cordova differs somewhat from Kenai. In addition to processing several salmon species, Tanner and Dungeness crab, halibut, and herring are also processed. Unlike Kenai, the seafood processing season at Cordova can run year-round. The actual length of the Cordova season is dependent upon the seafood catch. The salmon processing season typically runs from early July through mid-August. Dungeness crab processing runs from June through October, and Tanner crab from mid-November through June.

Estimated 1977 seafood waste production quantities are shown by seafood type in Tables 12, 13, and 14, for St. E, NPP, and NEFCO, respectively. Although written requests for waste production data were sent in September, 1978, to the home offices of all processing plants associated with the marine monitoring program (E. C. Jordan, personal communication), a response was not received from Morpac, Inc. For the years shown in Tables 12 and 13, crab processing wastes ranged from 19 to 50 percent of the total waste produced. Waste production figures for the 1978 season were not available.

At Cordova, 1978 seasonal fish catches and processing levels were far below pre-season estimates. Consequently, operations at three of the canneries (St. E., NPP, and Morpac) were at less than half their normal seasonal levels when the

TABLE 12

ESTIMATED SEAFOOD WASTE PRODUCTION
ST. ELIAS OCEAN PRODUCTS *

Type of Waste	Waste Quantity (Tons/year) 1977	1976	1975
Salmon	951	749	425
Tanner Crab	108	710	390
Dungeness Crab	45.5	14.0	48.2
Halibut	-	-	-
Herring	-	-	-

TABLE 13

ESTIMATED SEAFOOD WASTE PRODUCTION
NORTH PACIFIC PROCESSORS, INC. *

Type of Waste	Waste Quantity (Tons/year) 1977	1976	1975
Salmon	1,260	1,040	890
Tanner Crab	337	240	797
Dungeness Crab	0.4	-	2.1
Halibut	1.0	1.0	-
Herring	-	-	-

*Ref. 23

TABLE 14

ESTIMATED SEAFOOD WASTE PRODUCTION
NEW ENGLAND FISH COMPANY*

Type of Waste	Waste Quantity (Tons/year) 1977	1976	1975
Salmon	1,150	843	--
Tanner Crab	--	--	--
Dungeness Crab	--	--	--
Halibut	--	--	--
Herring	18.3	--	--

*Ref. 23

field sampling was conducted. The majority of the processing at this time was of Dungeness crab. One cannery, NEFCO, never opened because of the poor season. However, some field samples were collected from two stations at the NEFCO Cannery in an effort to assess conditions at an outfall area in which no waste discharges had occurred for nearly a year.

Aesthetic Conditions

Some surface discolorations and floating debris were observed near the St. E. dock and in the vicinity of the NPP outfall. At the St. E. dock, the major aesthetic problem was from floating debris associated with the dumping of whole crab shells and some crab appendages off the center of the dock. According to cannery officials, this practice occurred because the cannery grinder system was inoperative and alternative methods for disposal of processing wastes were not available. The majority of this waste sank to the bottom shortly after dumping and comparatively small amounts remained on the surface.

At NPP, a surface plume was observed in the vicinity of the cannery outfall following each discharge. The effluent caused a whitish-yellow discoloration of the surface water. Considerable feeding by sea gulls on larger particulate matter in the surface plume occurred. Because of the intermittent nature of the discharges, the plume was not continuous. However, patches of floating debris from previous discharges were recorded over 45 m from the discharge point.

No aesthetic problems were observed at Morpac, NEFCO, or the non-outfall stations.

Bottom Accumulations

Underwater photography of the St. E. discharge line and outfall area revealed that the line was broken off approximately 2 m from the cannery dock. Prior to this observation, the plant manager had estimated the outfall to be located in the inlet, approximately 45 to 60 m off the cannery dock. According to the manager, the line had once extended at least 75 m from the northwest corner of the dock toward Station C; however, at least half of the line had broken off when a fully loaded tender boat set on the line during a low-tide in late spring. No evidence of the broken section was recorded in the films. Sediment deposition in the bottom of the 2 m portion indicated that this discharge line had not been recently used. Twenty to thirty large starfish were attached to the line, and several were also attached to nearby pilings.

Video films taken of the inlet bottom, to a distance of 15 m directly off the end of the broken outfall, showed a few scattered fish heads in various states of decomposition, and empty crab shells. Numerous flatfish (halibut and starry flounder) were also observed feeding off the bottom in this immediate area. Judging by the sediment buildup in the pipe, it appeared that no discharges had recently occurred, and the area in front of the pipe was relatively clean.

Bottom conditions below the center of the dock-face and to a distance of 15 m off the dock were also filmed. Directly below the dock approximately 80 percent of the bottom was

covered with whole empty crab shells and some crab appendages. In some areas the shells were piled on top of one another to a height of 25-30 cm. At a distance of 3 m, the piles thinned out. At 5 m the coverage was estimated at 50 percent and no piles or layering of shells were observed. Flatfish were abundant and actively swimming and feeding in the area of the larger piles. A large ray was observed on top of one of the piles and a few live adult Dungeness crabs were also noted in this area. At 10 and 15 m from the dock the bottom was comparatively clean with approximately 5 percent coverage by empty crab shells. The percent coverage of crab shells under the dock was very low, 1 percent or less. From the film record it appeared that the greatest accumulation of crab wastes occurred directly below the center of the dock, and extended in a semi-circle out from the dock for a distance of 5 m. The center of this impacted area was approximately 16 m from the St. E. outfall.

At NPP, the discharge pipe consists of an approximate 30 m long 10 cm steel pipe which runs off the northwest corner of the cannery and into the inlet. The line was in use and several discharges occurred during the filming period.

The pipe is supported roughly 25 cm off the bottom, and discharges from the pipe have cut a trough 3 m wide and over 6 m long in front of the outfall. The depth of the trough could not be determined because of debris in the trough. The trough contained considerable fish and crab processing wastes of

various sizes. Numerous fish tails and heads were observed although crab exoskeletal wastes were estimated at 90 percent of the waste material. The crab wastes averaged 5 cm in size. At one point, the diver pushed his arm into the waste pile up to his shoulder and did not touch a hard bottom. Considerably greater fish activity was observed around this waste pile than at Station E. At any one time during the filming, the diver reported minimally 40-50 flatfish measuring 0.3 m or larger in length. Discharges which occurred during the filming did not contain particles the size of those represented in the trough. The discharges were murky and appeared to consist of only fine particulate matter.

At Morpac, the discharge pipe terminates at the end of the cannery dock, where the pipe makes a right angle turn down into the water and ends approximately 1.5 m above the bottom (Station I). Discharges from the pipe are, therefore, ~~directed~~ vertical ~~down~~ rather than horizontal~~ly~~. This discharge pattern has created a depression in the bottom directly below the outfall which is approximately 0.6 m deep. Surface sediment in this depression, and for a circular area of 12-16 m in diameter around the depression, consisted of a layer of primarily silt and finely ground fish and crab parts. The layer appeared to be 15 to 30 cm deep, and in some instances the diver could not discern the type of waste because the particle size was so small. The waste material appeared to be more finely ground than at the NPP outfall and it did not appear as fresh as the

waste debris at NPP or at the crab pile near station St. E. According to cannery officials, processing had occurred during this season, but at reduced levels. It could not be determined whether the observed waste layer represented accumulations from this year, previous years, or both. Very few flatfish were seen in this outfall area. Some starfish and sea anemones were attached to a piece of pipe rising out of the bottom.

Two disposal areas are used at the NEFCO Cannery. Processing wastes are discharged off the end of a gurry trough (Station GT), or through a 120 m long flexible plastic discharge pipe. This discharge pipe is laid in the inlet off the cannery (Station N-0) when the cannery is in operation.

Films of the bottom at Station GT showed no evidence of processing waste accumulations from previous years. The sediment appeared to be primarily sand and silt with numerous burrows in the sediment. No organisms were identified with these burrows during the filming. Very few flatfish were observed in this area.

At Station N-0, the bottom was also clean with a few scattered empty clam shells. No crab or fish debris from previous years was apparent. Within a few meters of Station N-0, an area covered by a 15 cm layer of wood chips, clam shells, and silt was noted, but the dimensions of the layer were not recorded. The origin of the wood chips and the reason for their appearance at this station is not presently known. Several large brown algae (4-6 m in length), flatfish, and active crabs were recorded in this area.

Bottom conditions at Station M and at a station mid-way between Stations K and L were very similar. No crab shells or fish parts were observed, although the incidence of empty mollusc shells and shell fragments was high; in some areas viewed, bottom coverage was estimated at over 50 percent at both points. A few flatfish measuring 30 cm or less in length were viewed, as well as other unidentified small fish, and several epibenthic invertebrates. The invertebrates included hermit crabs, decorator crabs, and sea anemones.

Films of Stations N, O, and P showed these stations to have similar bottom conditions. The bottom appeared to be predominantly sand with irregular troughs and ridges caused by bottom currents. Detrital material had collected along the ridges and was noticeably darker in color than the surrounding sand. The bottom was virtually barren except for a few whole mollusc shells which measured less than 1 cm in width. Very few flatfish were observed, and these were small (<15 cm in length).

Hydrological Conditions

Tidal height data for Cordova is listed in Table 15. Maximum tidal fluctuation at Cordova measured 3.7 m, or less than half of the tidal range values observed at Kenai.

Tidal current data for the mid-channel and control stations is listed in Table 16. Distinct ridge and swale patterns on the sediment surface and the generally barren sediment surface, as revealed by the underwater films, gave further evidence of strong tidal current action at these stations.

TABLE 15. TIDAL DATA FOR CORDOVA, ALASKA
JULY 29-AUGUST 1, 1978*

Date	LW	HW	LW	HW	Maximum Diurnal Range
	meters (feet)				
July 29	0.5 (1.8)	2.6 (8.4)	1.3 (4.3)	3.4 (11.1)	2.9 (9.3)
July 30	0.4 (1.3)	2.7 (8.9)	1.3 (4.2)	3.5 (11.4)	3.1 (10.1)
July 31	0.2 (0.7)	2.9 (9.4)	1.2 (3.9)	3.6 (11.7)	3.4 (11.0)
August 1	0.0 (0.0)	3.1 (10.0)	1.0 (3.4)	3.7 (12.1)	3.7 (12.1)

*Ref. 13

Legend: LW = Low Water
HW = High Water

TABLE 16. TIDAL CURRENT DATA FOR MID-CHANNEL AND CONTROL STATIONS IN ORCA INLET, CORDOVA, ALASKA, JULY 26-AUGUST 1, 1978.

Date	Maximum Tidal Current			
	Ebb	Flood	Ebb	Flood
	In km/hr (knots)			
July 29	2.8 (1.5)	1.3 (0.7)	1.9 (1.0)	1.5 (0.8)
July 30	3.0 (1.6)	1.5 (0.8)	2.0 (1.1)	1.5 (0.8)
July 31	3.3 (1.8)	1.9 (1.0)	2.4 (1.3)	1.7 (0.9)
August 1	3.7 (2.0)	2.0 (1.1)	2.8 (1.5)	1.9 (1.0)

*Ref. 14

Although current measurements were not made at the cannery outfall or dumping areas, the extent of waste accumultion at St. E. and at NPP suggested that currents and tidal flushing were insufficient to adequately disperse the wastes at these two sites. At the Morpac outfall (Station I), the wastes appeared to be more evenly distributed along the bottom, but their persistance indicated insufficient flushing action to fully clean this outfall area of debris. The absence of waste debris at both NEFCO outfalls suggested that the NEFCO discharge areas received good flushing action and that problems with persistent waste accumultions did not occurr.

Water Quality

Water quality data for Cordova stations are presented in Table 17.

Dissolved oxygen concentrations were generally 10 mg/ℓ or higher, and at no stations were there indications of depressed oxygen concentrations. Temperature values indicated a pattern of surface heating and stratification by late afternoon, followed by breakdown of this stratification during the night, and a return to near isothermal conditions by morning. Shallower water stations B, E, and F developed higher bottom water temperatures resulting from surface to bottom mixing over these shallower depth ranges. At one deeper station, the NPP outfall, bottom temperature was higher (13.5° C) than would have been expected from water column mixing alone. The higher value reported for bottom water at this station was probably the result of cannery discharge of warmer water effluent.

TABLE 17. WATER QUALITY AND DEPTH FOR CORDOVA SAMPLING STATIONS.

Parameter		Stations A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	NPP	St. Elias	NEFCO GT	NEFCO N-O
Date (1978)		7/30	7/30	7/29	7/29	7/30	7/30	7/30	7/30	7/30	7/30	7/29	7/29	7/29	8/1	8/1	8/1	7/31	7/31	8/2	8/2
Time		0950	1550	1835	1755	1610	1630	1035	1125	1200	1300	1720	1635	1600	950	1100	1200	1345	1500	1150	1220
Depth (m)		6.5	1.1	12.5	8.8	0.8	1.0	7.5	6.8	7.5	10.5	8.5	8.0	18.0	9	8	8	3.5	3	-	-
Dissolved Oxygen (mg/ℓ)	S	10.7	10.3	10.8	10.9	10.8	10.8	10.8	10.6	10.9	10.7	10.9	11.1	10.9	10.3	10.2	11.1	10.4	10.7	10.0	10.1
	M	10.7	-	10.7	10.9	-	-	10.6	10.7	10.6	10.0	10.7	11.4	11.1	9.9	10.0	-	10.5	-	-	-
	B	10.2	11.1	10.1	10.2	10.7	10.9	10.0	10.1	10.0	9.9	10.5	10.6	10.0	10.3	10.0	-	10.5	10.3	-	-
Temperature (°C)	S	11.9	13.8	13.0	13.5	13.4	13.3	12.0	12.1	12.1	11.8	13.4	13.5	13.1	11.7	12.5	12.8	13.0	13.6	12.9	12.3
	M	11.5	-	12.4	12.2	-	-	11.6	11.6	11.4	11.1	12.4	12.0	11.7	11.4	11.5	-	-	-	-	-
	B	11.5	13.6	11.7	11.9	13.3	13.3	11.4	11.6	11.4	11.1	11.6	11.9	11.8	11.5	11.7	-	13.5	13.6	-	-
Salinity (‰)	S	25.0	26.0	28.0	29.0	28.0	27.0	26.0	28.0	27.0	26.0	30.0	28.0	28.0	28.0	27.0	28.0	28.0	26.0	27.0	26.0
	M	25.0	-	30.0	30.0	-	-	28.0	28.0	30.0	30.0	30.0	28.0	28.0	28.0	28.0	-	25.0	-	-	-
	B	27.0	28.0	28.0	29.0	27.0	28.0	28.0	28.0	29.0	30.0	30.0	28.0	28.0	28.0	28.0	-	24.0	27.0	-	-
pH	S	8.1	8.1	8.2	8.2	8.1	8.2	8.1	8.1	7.9	7.7	8.2	8.1	7.9	8.2	8.2	8.2	7.9	8.1	8.2	8.0
	M	7.8	-	8.1	8.2	-	-	8.2	7.8	8.2	8.2	8.1	8.1	7.7	8.2	8.2	-	8.1	-	-	-
	B	7.7	8.1	8.2	8.2	8.1	8.2	8.2	7.7	8.2	8.1	8.1	8.0	7.8	8.2	8.1	-	8.1	8.2	-	-
Seechi Depth (m)		1.89	-	2.00	2.09	-	-	2.15	1.70	1.6	2.0	2.24	2.25	2.43	2.0	1.95	-	1.62	-	-	-
Ammonia (mg/ℓ)	S	ND†	0.06	ND	< 0.02	0.12	0.11	ND	ND	0.04	ND	ND	ND	ND	ND	ND	ND	0.11	0.06	-	-
	M	ND	-	0.02	ND	-	-	ND	ND	0.02	ND	< 0.02	0.02	ND	ND	ND	-	0.08	-	-	-
	B	0.03	0.02	ND	< 0.02	0.03	0.09	< 0.02	0.05	0.04	0.04	ND	ND	ND	ND	ND	-	0.12	0.46	-	-
Organic Nitrogen (mg/ℓ)	S	0.04	0.06	0.03	0.03	0.15	0.13	0.04	0.05	0.05	0.04	0.02	0.03	0.03	0.02	0.04	0.02	0.13	0.17	-	-
	M	0.04	-	0.02	0.02	-	-	0.03	0.06	0.04	0.03	0.02	0.05	0.02	0.02	0.03	-	0.14	-	-	-
	B	0.06	0.09	0.03	0.04	0.06	0.12	0.03	0.08	0.05	0.04	0.02	0.03	0.03	0.04	0.04	-	0.23	0.53	-	-
Orthophosphate (mg/ℓ)	S	0.02	0.05	0.02	0.02	0.03	0.02	0.02	0.02	0.02	ND	0.02	0.02	0.02	0.03	ND	< 0.02	0.04	0.04	-	-
	M	ND	-	0.02	0.02	-	-	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.02	-	0.04	-	-	-
	B	0.03	0.03	0.02	0.02	0.04	0.03	0.03	0.04	0.03	0.03	0.02	0.02	0.03	ND	0.02	-	0.05	0.08	-	-
Total Phosphorus (mg/ℓ)	S	0.03	0.05	0.03	0.03	0.05	0.05	0.02	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	ND	0.04	0.09	-	-
	M	0.02	-	0.04	0.03	-	-	0.03	0.03	0.03	0.02	0.04	0.05	0.03	0.03	0.03	-	0.05	-	-	-
	B	0.03	0.05	0.03	0.03	0.06	0.05	0.04	0.05	0.04	0.03	0.02	0.03	0.04	0.03	0.04	-	0.05	0.10	-	-
Sulfide (mg/ℓ)	S	ND*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
	M	ND	-	ND	ND	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	-	-	-
	B	ND	ND	ND	ND	ND	ND	ND	ND	0.005	ND	ND	ND	ND	ND	ND	-	0.011	0.014	-	-

*Bottom visible from surface.
†ND = Not detectable.

With the exception of Stations NPP and A, salinity values ranged between 27‰to 30‰. The lowest values observed (24‰) were from bottom water samples at NPP and in surface and midwater samples at Station A. The lower value at Station NPP appeared to have been the result of fresh water dilution from cannery wastewater discharges at this depth. Low surface and mid-water values at Station A probably resulted from terrestrial freshwater drainage into the mudflat area near Station A.

Little variation in pH was observed between stations. Ammonia nitrogen values were highest in the vicinity of Stations NPP and St. E. Waste disposal activities and decomposing crab wastes on the bottom near the St. E. outfall station probably contributed to the high ammonia value recorded at Station St. E. Elevated ammonia values were also observed at Stations B, E, and F. Poor flushing action in these shallow embayments may have accounted for these higher readings.

Orthophosphate values were also slightly higher at Stations NPP and St. E., while total phosphorus values did not differ appreciably between stations with the exception of Station St. E. Total phosphorus values at this outfall station were two to three times greater than other station values. Sulfide and organic nitrogen values were also noticeably higher at stations NPP and St. E.

Sediment Particle Size

Particle size distributions for Cordova marine sediments are shown in Table 18. Stations B, E, and F were not sampled

TABLE 18. SIZE DISTRIBUTION (PERCENT WEIGHT) OF CORDOVA SEDIMENT SAMPLES

Size Class	Station A	C	D	G	H	I	J	K	L	M	N	O	P	NPP	St. Elias	NEFCO GT	NEFCO N-O
Gravel*	0	0	4	0	0	0	5	0	0	0	0	0	0	0	1	0	4
Sand†	55	57	60	60	54	13	66	82	60	90	95	94	95	41	17	70	68
Silt#	35	33	11	31	37	41	6	7	6	1	3	2	1	8	41	24	17
Clay**	10	10	5	9	9	14	9	6	4	4	2	4	4	14	16	6	11
Other			20 (C)			32 (F&C)	14 (C)	5 (M)	30 (M)	5 (M)				37 (F&C)	25 (C)		

(C) = Crustacean Exoskeletal Fragments

(M) = Mollusc Shell Fragments

(F) = Fish Skeletal Fragments

Legend

*Gravel - >2 mm
†Sand - 50 microns to 2 mm
#Silt - 2-50 microns
**Clay - <2 microns

because their shallow depth or submerged obstacles made these stations inaccessible to the research vessel. Sediment samples typically had a sand content of 50 percent or more. Few stations had gravel, although several stations, particularly those at outfalls, had comparatively high percentages of fish skeletal, crab shell, or crab exoskeletal fragments which were retained on the No. 10 sieve (72 mm). Crab exoskeletal and fish skeletal fragments were found at all operating outfalls, and crab exoskeletal fragments were also found at Station D. Stations M, K, and L had empty mollusc shells and shell fragments. The highest silt concentrations were recorded at two outfall stations, I, and St. E. Stations A, C, D, G, H, NPP, NEFCO GT, and NEFCO N-O, had similar sediment characteristics, with the exception of varying amounts of shell or skeletal fragments at some of these stations. Stations J, K, L, M, N, O, and P, were primarily sand.

Sediment Chemistry

The results of sediment chemistry analyzes for Cordova are shown in Table 19. In comparison to Kenai River sediments, TVS content of Cordova sediments was several fold higher. The highest values were recorded at Stations H (23.0 percent) and at NPP (24.5 percent). TOC was highest at NPP (0.264 percent), and L (0.289 percent).

Total sulfide was considerably higher at outfall stations I, and St. E. The total sulfide value at Sation NPP was surprisingly low in view of the high total sulfide values

TABLE 19. SEDIMENT CHEMISTRY DATA FOR CORDOVA SAMPLING STATIONS

	A	C	D	G	H	I	J	K
Volatile Solids (%)	9.01	10.0	16.8	5.90	23	9.20	15.80	13.4
Total Organic Carbon (%)	0.065	0.014	0.137	0.149	0.044	0.062	0.129	0.022
Total Sulfide (mg/kg) (dry)	72.8	54.8	219	275	94.7	399	54.4	61.3
Total Kjeldahl Nitrogen (mg/kg) (dry)	731	462	311	302	346	2620	612	1017

	L	M	N	O	P	NPP	St. Elias	NEFCO GT	NEFCO N-C
Volatile Solids (%)	16.5	7.40	7.18	4.70	7.0	24.5	11.1	12.4	9.09
Total Organic Carbon (%)	0.289	.007	0.004	0.10	0.003	0.264	0.160	0.053	0.075
Total Sulfide (mg/kg) (dry)	121	29.6	26.3	13.3	15.6	72.7	380	138	125
Total Kjeldahl Nitrogen (mg/kg) (dry)	1904	302	628	480	253	4510	1353	518	304

observed at the other outfall stations. TKN concentrations were high at outfall Stations I (2,620 mg/kg), NPP (4,510 mg/kg), and St. E (1,353 mg/kg). TKN concentrations at the NEFCO outfall stations were considerably lower than the operating outfalls (518 mg/kg, NEFCO GT; 304 mg/kg, NEFCO N-O). Mid-channel Stations K and L, however, also showed high TKN concentrations possibly from mollusc decomposition in the sediment at these stations.

Macrobenthos

Listings of the macrobenthos organisms collected on the 1 mm and 0.5 mm screens, and on the combined screens are given in Tables 20, 21, and 22, respectively. The number appearing to the left of each species represents the species code used for numerical analysis of the data. Shallow water stations B, E, and F, were not accessible by the research vessel and thus were not sampled. At Station NPP, the depth and extent of fish and crab wastes prevented collection of satisfactory benthic samples.

A total of 78 species in the 1 mm screenings, and 41 in the 0.5 mm screenings were recovered. An additional 17 species were identified from the 0.5 mm material which were not identified in the 1 mm material. Thus, a total of 95 species were recovered in all the Cordova sediment samples.

Density, species richness, and species diversity values for the 1 mm, 0.5 mm, and combined data are shown for each Cordova station in Tables 23, 24, and 25 respectively. The 1 mm data in

TABLE 20. STATION LIST OF MACROBENTHOS OF CORDOVA SEDIMENTS (1 mm SCREENINGS)

Species Code		-STATION- A	C	D	G	H	I	J	K
1.	Ampharete arctica	1		1	28	2	1	3	2
3.	Aoroides sp. 1			1				3	
4.	Armandia brevis	29	4	76	5	28	1	49	5
5.	Anaitides mucosa	3	1			4		1	1
6.	Axinopsida serricata	307	34	30	52	59	10	30	4
7.	Bathymedon sp. 1								
8.	Boccardia sp. 1	1							
9.	Capitella capitata	48	2	55	12	11	2		
10.	Cistenides brevicoma	13	1	28		15	4	9	2
11.	Cirratulus cirratus	2		4				6	1
12.	Clinocardium nuttallii	18	1	2	3	21		1	1
13.	Corophium sp. 1							2	1
14.	Cryptobranchia alka			1				6	
15.	Cylichna occulata	16			8	3			
16.	Diastylis alaskensis	31		1	3	33		20	2
17.	Eteone longa	4		27	4	5	3	1	2
18.	Euhaustorius washingtonianus								
19.	Gastropteron pacificum	1		1	4				
20.	Glycinde picta	18	1	3	8	8		6	1
21.	Haploscoloplos elongata	68	1	12	20	29		3	6
22.	Harmothoe imbricata			13		1		18	3
23.	Harpiniopsis sp. 1								
24.	Hemipodus borealis			1					
25.	Hesionidae			1				2	
26.	Hiatella arctica		1			1		2	
27.	Lacuna sp. 1								
28.	Lamprops sp. 1	1				1		1	1
29.	Lumbrineris luti	29		3	2	11		5	
30.	Lumbrineris sp. 1								
31.	Macoma inquinata	26	5	80	11	19	15	12	3
32.	Macoma moesta alaskana	116	5	14	51	42	1	5	2
33.	Magelona sp. 1	2							
34.	Melita dentata			4				5	2
35.	Mitrella gouldi	6				2		1	
36.	Monoculodes sp. 1							3	3
37.	Musculus niger	1		1			1		
41.	Mya sp. 1							2	1
38.	Mysella tumida	59	3	100	7	78	1	6	
39.	Mysella sp. 1			33					
40.	Mysta barbata	4				6			

TABLE 20 (CONTINUED)

		L	M	N	O	P	NEFCO GT	NEFCO N-O	St.E.
1.	Ampharete arctica	7						3	
3.	Aoroides sp. 1								
4.	Armandia brevis	22					6	53	
5.	Anaitides mucosa	3						7	
6.	Axinopsida serricata	12					20	256	1
7.	Bathymedon sp. 1		1	11	7				
8.	Boccardia sp. 1	1					9	152	
9.	Capitella capitata	4						12	252
10.	Cistenides brevicoma	41					2	38	
11.	Cirratulus cirratus	4							
12.	Clinocardium nuttallii	1						1	
13.	Corophium sp. 1	2						3	
14.	Cryptobranchia alka								
15.	Cylichna occulata	1							
16.	Diastylis alaskensis	2							
17.	Eteone longa	2				1		45	8
18.	Euhaustorius washingtonianus		5	24	19	25			
19.	Gastropteron pacificum	1							
20.	Glycinde picta	2	1					9	
21.	Haploscoloplos elongata	20	8	15	5	15	18	42	
22.	Harmothoe imbricata	8						11	
23.	Harpiniopsis sp. 1		20						
24.	Hemipodus borealis	2						3	
25.	Hesionidae	1							
26.	Hiatella arctica							3	
27.	Lacuna sp. 1							11	
28.	Lamprops sp. 1	1	2	2		1			
29.	Lumbrineris luti	10					2	14	
30.	Lumbrineris sp. 1							12	
31.	Macoma inquinata	6			1	1	5	78	2
32.	Macoma moesta alaskana	15	5	3	2	1	1	5	
33.	Magelona sp. 1	3	20	7	6	9			
34.	Melita dentata	9						1	
35.	Mitrella gouldi								
36.	Monoculodes sp. 1	2	1	1	1	1			
37.	Musculus niger	1							
41.	Mya sp. 1	1					1	1	
38.	Mysella tumida	5				18	1	12	
39.	Mysella sp. 1								
40.	Mysta barbata	1							

TABLE 20(CONTINUED)

		A	C	D	G	H	I	J	K
42.	Nassarius mendicus	7		6	2	1		8	1
2.	Neosabellides sp. 1	161			33	325	44		
43.	Nephtys cornuta	13		2	3	11		2	2
44.	Nephtys caeca			1	1				
45.	Nephtys ciliata							1	1
46.	Nephtys sp. 1					2	1		2
47.	Nereis sp. 1			1				1	
48.	Odostomia sp. 1			11	2	1		6	1
49.	Oenopota sp.					1		3	1
50.	Olivella biplicata				1			9	
51.	Olivella baetica	1		1	1	1	1		13
52.	Ophiuroidea	2		1	6	21		1	1
53.	Orchomene sp.1			3		1			
54.	Oweniidae	1				3			4
55.	Pagarus ochotensis			1				28	
56.	Paraphoxus sp. 1			1				3	
57.	Phloe minuta	37		2	10	14		5	
58.	Phoxocephalidae								
59.	Pleusymtes sp. 1	1				5		1	1
60.	Polycirrus sp. 1								
61.	Polydora socialis			1				3	
62.	Pontocrates arenarius								
63.	Prionospio malmgreni	269		70	64	51	6	150	22
64.	Protomedeia sp. 1				1	2		2	4
65.	Protothaca staminea	1	2	11	2	4		18	
66.	Psephidia lordi	6	8	5	10	8	1	3	
67.	Pycnogonida sp. 1			1				2	1
68.	Saxidomus giganteus	1	2	14	2			7	2
69.	Scolelepsis cirratulus								
70.	Scoloplos armiger								
71.	Solariella obscura								
72.	Spio filicornis	5		6	4	4	1	1	2
73.	Spiophanes bombyx			1					
74.	Streptosyllus sp. 1								
75.	Paraonis gracilis								
76.	Turbonilla sp. 1	3				18		2	
77.	Westwoodilla sp. 1								
78.	Yoldia amygdalea	1		1		4		1	
	Total Species Number	40	15	45	30	39	15	49	33

TABLE 20 (CONTINUED)

		L	M	N	O	P	NEFCO GT	NEFCO N-O	St.E.
42.	Nassarius mendicus	23						13	
2.	Neosabellides sp. 1					1	3	32	
43.	Nephtys cornuta	2			1	2	4	29	
44.	Nephtys caeca		2	1	1				
45.	Nephtys ciliata	2							
46.	Nephtys sp. 1	2				2	3	4	
47.	Nereis sp. 1	1						4	
48.	Odostomia sp. 1					1			
49.	Oenopota sp.								
50.	Olivella biplicata								
51.	Olivella baetica	35	10			1	1		
52.	Ophiuroidea		1					3	
53.	Orchomene sp.1	5							
54.	Oweniidae	15						1	
55.	Pagarus ochotensis								
56.	Paraphoxus sp. 1	3	8	15	6	8			
57.	Phloe minuta	2					1	21	
58.	Phoxocephalidae		2	28	12	29			
59.	Pleusymtes sp. 1	1							
60.	Polycirrus sp. 1	6							
61.	Polydora socialis						2		
62.	Pontocrates arenarius		2	2	1	2			
63.	Prionospio malmgreni	56					5	17	
64.	Protomedeia sp. 1	1						2	
65.	Protothaca staminea							4	
66.	Psephidia lordi	1				42		4	
67.	Pycnogonida sp. 1								
68.	Saxidomus giganteus	1				1		9	
69.	Scolelepsis cirratulus				3	1			
70.	Scoloplos armiger				8				
71.	Solariella obscura		2	2	3				
72.	Spio filicornis	21	10	3	4	6		2	
73.	Spiophanes bombyx	1	2	2	1	1			
74.	Streptosyllus sp. 1				4				
75.	Paraonis gracilis		8	1	4	14			
76.	Turbonilla sp. 1							3	
77.	Westwoodilla sp. 1		19	10	10	40			
78.	Yoldia amygdalea	1							
	Total Species Number	48	19	15	19	22	16	35	4

TABLE 21. STATION LIST OF MACROBENTHOS OF CORDOVA SEDIMENTS (0.5 mm SCREENINGS)

Species Code		A	C	D	G	H	I	J	K
1.	Amphipoda					62		7	20
2.	Ampharete arctica	11		92	3				1
3.	Armandia brevis	4	10	92	40	66		43	5
4.	Axinopsida serricata	15		7	4	34	28	16	
5.	Aricidea sp. 1					15		4	5
6.	Aceola	36			5	4			
7.	Bathymedon sp. 1					15		35	
8.	Capitella capitata	80	3	143	65	48			
9.	Cistenides brevicoma				1	4		34	4
10.	Clinocardium sp. 1	232			24	96			
11.	Cirratulidae	4						13	1
12.	Diastylis sp. 1				2	29		13	
13.	Eteone longa	7	4	5	10	11			1
14.	Euhaustorius washingtonianus								1
15.	Euhaustorius sp. 1								
16.	Harpacticoida	113			18	34		118	
17.	Haploscoloplos elongata	22		28	45	119		53	40
18.	Lamprops sp. 1				1	8		14	1
19.	Lumbrineris luti	4			21	82			1
20.	Lumbrineris sp. 1	51		12		84		9	2
21.	Magelona sp. 1	22			6			7	5
22.	Munna sp. ?	33			10	15		16	
23.	Mytilidae	11			5	4	57	49	
24.	Macoma sp. 1							69	
25.	Macoma moesta alaskana	40		12	26	81		24	1
26.	Monoculodes sp. 1	4						47	30
27.	Mysella tumida	4		108	33	70		156	4
28.	Nephtys cornuta	25			7	48		4	
29.	Neosabellides sp. 1	40			145	405	69	7	
30.	Nematoda	4048	682	963	658	2481	1365	653	209
31.	Ostracoda	22			5			47	
32.	Oligochaeta					26			
33.	Ophiuroidea				11				1
34.	Phloe minuta	145		7	33	225		81	3
35.	Prionospio malmgreni	258		154	163	325		267	73
36.	Rhychospio sp. 1	18		19	9	81		28	1

TABLE 21 (CONTINUED)

Species Code		L	M	N	O	P	NEFCO GT	NEFCO N-O	St.E.
1.	Amphipoda	16	17	2					
2.	Ampharete arctica	3							
3.	Armandia brevis	22			1		44	86	
4.	Axinopsida serricata	41		1				159	
5.	Aricidea sp. 1		19		1				
6.	Aceola					3			
7.	Bathymedon sp. 1	14		7		8		40	
8.	Capitella capitata	3						42	
9.	Cistenides brevicoma	3							
10.	Clinocardium sp. 1						64	4	
11.	Cirratulidae	8			1		64	43	
12.	Diastylis sp. 1								
13.	Eteone longa	7						38	38
14.	Euhaustorius washingtonianus			27	22	14			30
15.	Euhaustorius sp. 1		7						
16.	Harpacticoida	3	9	1	6	92		20	
17.	Haploscoloplos elongata	64	2	2	1	5	44	58	
18.	Lamprops sp. 1		2	3	3	8			
19.	Lumbrineris luti		1					40	
20.	Lumbrineris sp. 1	4		1				43	
21.	Magelona sp. 1	6	11	13	3	5			
22.	Munna sp. 1								
23.	Mytilidae					1		25	
24.	Macoma sp. 1								
25.	Macoma moesta alaskana	15	1		2	3		7	
26.	Monoculodes sp. 1			1				25	
27.	Mysella tumida	69	2	4		1		106	
28.	Nephtys cornuta	6	1			3		20	
29.	Neosabellides sp. 1	3						272	
30.	Nematoda	385	24	6	5	30	1766	1512	4836
31.	Ostracoda	28	2	2	3			67	
32.	Oligochaeta	134							
33.	Ophiuroidea								
34.	Phloe minuta		2					169	
35.	Prionospio malmgreni	108	3		1	10	64	60	
36.	Rhychospio sp. 1			1				31	

TABLE 21 (CONTINUED)

		A	C	D	G	H	I	J	K
37.	Spio filicornis				1				6
38.	Spiophanes bombyx				5				
39.	Sphaerosyllis brandhorsti	4				15		16	
40.	Syllidae					15			
41.	Paraonis gracilis	44		13	10	11			6
	Total Species Number	27	4	13	29	30	4	27	23

TABLE 21 (CONTINUED)

		L	M	N	O	P	NEFCO GT	NEFCO N-O	St.E.
37.	Spio filicornis				2	1			
38.	Spiophanes bombyx		2	1	1	7			
39.	Sphaerosyllis brandhorsti		1					18	
40.	Syllidae	4	37	19	33	32		20	
41.	Paraonis gracilis			17	16	56			
	Total Species Number	22	18	17	16	18	5	24	3

TABLE 22. STATION LIST OF MACROBENTHOS OF CORDOVA SEDIMENTS (1 mm and 0.5 mm SCREENINGS)

Species Code		-STATION- A	C	D	G	H	I	J	K
1.	Aceola	36			5	4			
2.	Ampharete arctica	12		1	31	2	1	3	3
3.	Amphipoda					62			1
4.	Anaitides mucosa	3	1			4		1	1
5.	Aoroides sp. 1			1				3	
6.	Aricidea sp. 1					15		4	5
7.	Armandia brevis	33	14	168	45	44	1	92	10
8.	Axinopsida serricata	322	34	37	56	93	38	46	4
9.	Bathymedon sp. 1					15		35	
10.	Boccardia sp. 1	1							
11.	Capitella capitata	128	5	198	77	59	2		
12.	Cirratulus cirratus	2		4				6	1
13.	Cirratulidae	4					13	1	
14.	Cistenides brevicoma	13	1	28	1	19	4	43	6
15.	Clinocardium nuttallii	18	1	2	3	21		1	1
16.	Clinocardium sp. 1	232			34	96			
17.	Corophium sp. 1							2	1
18.	Cryptobranchia alka			1				6	
19.	Cylichna occulata	16			8	3			
20.	Diastylis alaskensis	31		1	3	33		20	2
21.	Diastylis sp. 1				2	29		13	
22.	Eteone longa	11	4	32	14	16	3	1	3
23.	Euhaustorius washingtonianus								1
24.	Euhaustorius sp. 1								
25.	Gastropteron pacificum	1		1	4				
26.	Glycinde picta	18	1	3	8	8		6	1
27.	Haploscoloplos elongata	90	1	40	65	148		56	41
28.	Harmothoe imbricata			13	1			18	3
29.	Harpacticoida	113			18	34		118	
30.	Harpiniopsis sp. 1								
31.	Hemipodus borealis			1					2
32.	Hesionidae			1				2	
33.	Hiatella arctica		1			1		2	
34.	Lacuna sp. 1								
35.	Lamprops sp. 1	1			1	9		19	2
36.	Lumbrineris luti	33		3	23	93		5	1
37.	Lumbrineris sp. 1	51		12		84		9	2
38.	Macoma inquinata	26	5	80	11	19	15	12	3

TABLE 22 (CONTINUED)

Species Code		-STATION- L	M	N	O	P	NEFCO GT	NEFCO N-O	St.E.
1.	Aceola					3			
2.	Ampharete arctica	10						3	
3.	Amphipoda	3		2					
4.	Anaitides mucosa	3						7	
5.	Aoroides sp. 1								
6.	Aricidea sp. 1		19		1				
7.	Armandia brevis	44			1		50	139	
8.	Axinopsida serricata	53		1			20	415	1
9.	Bathymedon sp. 1	14	1	18	7	3		40	
10.	Boccardia sp. 1	1					9	152	
11.	Capitella capitata	7						54	252
12.	Cirratulus cirratus	4							
13.	Cirratulidae	8			1		64	43	
14.	Cistenides brevicoma	44					2	38	
15.	Clinocardium nuttallii	1						1	
16.	Clinocardium sp. 1							4	
17.	Corophium sp. 1	2						3	
18.	Cryptobranchia alka								
19.	Cylichna occulata	1							
20.	Diastylis alaskensis	2							
21.	Diastylis sp. 1								
22.	Eteone longa	9				1		83	38
23.	Euhaustorius washingtonianus		5	51	41	39			30
24.	Euhaustorius sp. 1		7						
25.	Gastropteron pacificum	1							
26.	Glycinde picta	2	1					9	
27.	Haploscoloplos elongata	66	10	17	6	20	62	100	
28.	Harmothoe imbricata	8						11	
29.	Harpacticoida	3	9	1	6	92	44	20	
30.	Harpiniopsis sp. 1		20						
31.	Hemipodus borealis							3	
32.	Hesionidae	1							
33.	Hiatella arctica							3	
34.	Lacuna sp. 1							11	
35.	Lamprops sp. 1	1	4	5	3	9			
36.	Lumbrineris luti	10	1				2	54	
37.	Lumbrineris sp. 1	4		1				55	
38.	Macoma inquinata	6			1	1	5	78	2

TABLE 22 (CONTINUED)

		A	C	D	G	H	I	J	K
39.	Macoma moesta alaskana	156	5	26	77	123	1	29	3
40.	Macoma sp. 1							69	
41.	Magelona sp. 1	24			6			7	5
42.	Melita dentata			4				5	2
43.	Mitrella gouldi	6				2		1	
44.	Monoculodes sp. 1	4						50	33
45.	Munna sp. 1	33			10	15		16	
46.	Musculus niger	1		1				1	
47.	Mya sp. 1							2	1
48.	Mysella tumida	63	3	208	40	143	1	162	4
49.	Mysella sp. 1			33					
50.	Mysta barbata	4				6			
51.	Mytilidae	11			5	4	57	49	
52.	Nassarius mendicus	7		6	2	1		8	1
53.	Nematoda	4048	682	963	658	2481	1365	653	209
54.	Neosabellides sp. 1	201			177	730	113	7	
55.	Nephtys caeca			1	1				
56.	Nephtys ciliata							1	1
57.	Nephtys cornuta	38		2	10	59		6	2
58.	Nephtys sp. 1					2	1		2
59.	Nereis sp. 1			1					1
60.	Odostomia sp. 1			11	2	1		6	1
61.	Oenopota sp. 1					1		3	1
62.	Oligochaeta					26			
63.	Olivella baetica	1		1	1	1	1		13
64.	Olivella biplicata				1			9	
65.	Ophiuroidea	2		1	17	21		1	2
66.	Orchomene sp. 1			3		1			
67.	Ostracoda	22			5			47	
68.	Oweniidae	1				3			4
69.	Pagarus ochotensis			1				28	
70.	Paraphoxus sp. 1			1				3	
71.	Phloe minuta	182		9	43	239		86	3
72.	Phoxocephalidae								
73.	Pleusymtes sp. 1	1				5		1	1
74.	Polycirrus sp. 1								
75.	Polydora socialis			1				3	
76.	Pontocrates arenarius								

TABLE 22 (CONTINUED)

		L	M	N	O	P	NEFCO GT	NEFCO N-O	St.E.
39.	Macoma moesta alaskana	30	6	3	4	4	1	12	
40.	Macoma sp. 1								
41.	Magelona sp. 1	9	31	20	9	14			
42.	Melita dentata	9						1	
43.	Mitrella gouldi								
44.	Monoculodes sp. 1	2	1	2	1	1		25	
45.	Munna sp. 1								
46.	Musculus niger	1							
47.	Mya sp. 1	1					1	1	
48.	Mysella tumida	74	2	4		19	1	118	
49.	Mysella sp. 1								
50.	Mysta barbata	1							
51.	Mytilidae					1		25	
52.	Nassarius mendicus	23						13	
53.	Nematoda	385	24	6	5	30	1766	1512	4836
54.	Neosabellides sp. 1	3				1	3	304	
55.	Nephtys caeca		2	1	1				
56.	Nephtys ciliata	2							
57.	Nephtys cornuta	8	1		1	5	4	49	
58.	Nephtys sp. 1	2				2	3	4	
59.	Nereis sp. 1	1						4	
60.	Odostomia sp. 1					1			
61.	Oenopota sp. 1								
62.	Oligochaeta	134							
63.	Olivella baetica	35	10			1	1		
64.	Olivella biplicata								
65.	Ophiuroidea		1					3	
66.	Orchomene sp. 1	5							
67.	Ostracoda	28	2	2	3			67	
68.	Owenidae	15						1	
69.	Pagarus ochotensis								
70.	Paraphoxus sp. 1	3	8	15	6	8			
71.	Phloe minuta	2	2				65	190	
72.	Phoxocephalidae		2	28	12	29			
73.	Pleusymtes sp. 1	1							
74.	Polycirrus sp. 1	6							
75.	Polydora socialis						2		
76.	Pontocrates arenarius		2	2	1	2			

TABLE 22 (CONTINUED

		A	C	D	G	H	I	J	K
77.	Prionospio malmgreni	527		224	227	376	6	417	95
78.	Protomedeia sp. 1				1	2		2	4
79.	Protothaca staminea	1	2	11	2	4		18	
80.	Psephidia lordi	6	8	5	10	8	1	3	
81.	Pycnogonida sp. 1			1				2	1
82.	Rhychospio sp. 1	18		19	9	81		28	1
83.	Saxidomus giganteus	1	2	14	2			7	2
84.	Scolelepsis cirratulus								
85.	Scoloplos armiger								
86.	Solariella obscura			1					
87.	Spio filicornis	5		6	5	4	1	1	8
88.	Spiophanes bombyx			1	5				
89.	Sphaerosyllis brandhorsti	4				15		16	
90.	Streptosyllus sp. 1								
91.	Syllidae					15			
92.	Paraonis gracilis	44		13	10	11			6
93.	Turbonilla sp. 1	3				18		2	
94.	Westwoodilla sp. 1								
95.	Yoldia amygdalea	1		1		4		1	
	Total Species Number	52	17	49	44	56	17	63	48

TABLE 22 (CONTINUED)

		L	M	N	O	P	NEFCO GT	NEFCO N-O	St.E.
77.	Prionospio malmgreni	164	3		1	10	69	77	
78.	Protomedeia sp. 1	1						2	
79.	Protothaca staminea							4	
80.	Psephidia lordi	1				42		4	
81.	Pycnogonida sp. 1								
82.	Rhychospio sp. 1			1				31	
83.	Saxidomus giganteus	1				1		9	
84.	Scolelepsis cirratulus				3	1			
85.	Scoloplos armiger				8				
86.	Solariella obscura		2	2	3				
87.	Spio filicornis	21	10	3	6	7		2	
88.	Spiophanes bombyx	1	4	3	2	8			
89.	Sphaerosyllis brandhorsti		1					18	
90.	Streptosyllus sp. 1				4				
91.	Syllidae	4	37	19	33	32		20	
92.	Paraonis gracilis		8	18	20	70			
93.	Turbonilla sp. 1							3	
94.	Westwoodilla sp. 1		19	10	10	40			
95.	Yoldia amygdalea	1							
	Total Species Number	58	32	25	29	31	20	49	6

TABLE 23. DENSITY (N), SPECIES RICHNESS (S), AND DIVERSITY (H') VALUES OF CORDOVA BENTHIC SAMPLES (1 mm SCREENINGS).

Station	N	S	H'
A	1,313	39	2.50
C	71	15	1.93
D	633	45	2.81
G	369	30	2.73
H	851	40	2.54
I	92	15	1.79
J	459	48	2.81
K	102	35	3.05
L	369	49	3.14
M	129	20	2.56
N	127	16	2.28
O	99	20	2.64
P	223	24	2.43
NEFCO GT	84	17	2.35
NEFCO N-O	920	38	2.65
St. E.	263	4	0.21

TABLE 24. DENSITY(N), SPECIES RICHNESS(S), AND DIVERSITY (H') VALUES OF CORDOVA BENTHIC SAMPLES (0.5 mm SCREENINGS)

Station	N	S	H'
A	5,297	27	1.15
C	699	4	0.14
D	1,563	13	1.40
G	1,376	29	2.03
H	4,513	30	1.93
I	1,519	4	0.43
J	1,830	27	2.39
K	467	23	1.88
L	946	22	2.07
M	143	18	2.27
N	108	17	2.24
O	101	16	2.05
P	279	18	2.11
NEFCO GT	1,982	5	0.49
NEFCO N-O	2,905	24	2.00
St. E.	4,904	3	0.08

TABLE 25. DENSITY (N), SPECIES RICHNESS(S), AND DIVERSITY (H') VALUES OF COMBINED CORDOVA BENTHIC SAMPLES (1 mm AND 0.5 mm SCREENINGS)

Station	N	S	H'
A	6,610	52	1.78
C	770	17	0.60
C	2,196	49	2.14
G	1,735	44	2.42
H	5,314	56	2.22
I	1,611	17	0.67
J	2,286	63	2.76
K	501	48	2.26
L	1,282	58	2.71
M	254	32	2.92
N	235	25	2.62
O	200	29	2.76
P	497	31	2.71
NEFCO GT	2,174	20	0.90
NEFCO N-O	3,825	49	2.49
St. E.	5,159	6	0.28

Table 23 indicated a diverse benthic community with the exception of the immediate outfall areas at Stations I and St. E. The lowest species richness (15 and 4, respectively) and diversity values (1.79 and 0.21, respectively) were recorded at these two stations.

For the 0.5 mm data (Table 24) diversity values were lower at all stations with particularly low diversities and species richness values at four stations, C, I, NEFCO GT, and St. E. At these four stations, nematode worms accounted for 89 percent or more of the total species density. The dominance by the nematodes at these four stations, in particular, as well as at other stations, was responsible for the lower diversity values.

Addition of the benthic species retained by the 0.5 mm screen to the 1 mm benthic data reduced species diversity at all stations (Table 25). While stations I and St. E. continued to show low diversity values, a marked reduction in diversity also occurred at Stations C and NEFCO GT. These pronounced reductions, and the overall reductions in diversity, were again the result of the addition of nematode worms from the 0.5 mm data into the total species pool. At Stations C, I, and NEFCO GT, 81 to 89 percent of the total species abundance consisted of nematodes, while at Station St. E, nematodes comprised 93 percent. Of the Cordova stations, St. E, still showed the lowest species richness and diversity values. While species richness was considerably higher at Stations C, I, and NEFCO GT, than at Station St. E., the major dominance by nematodes had

reduced diversity valves. With the exception of Stations C, I, NEFCO G-T and St. E., the diversity data indicated a generally diverse benthic community.

Analysis of the combined data again demonstrated the importance of the 0.5 mm material in providing a complete description of the benthic community.

Numerical classification of the combined benthic data further demonstrated the generally diverse character of the Cordova benthos. Normal classification and sorting of this data according to species similarities (Figure 6) did not delineate species groups characteristic of a particular station type. Species found at outfall stations were also found at other stations. Normal classification analysis and sorting according to station similarities (Figure 7) did not separate the stations into distinct communities with the exception of Station E., and Stations A and C. Station St. E. clearly showed the least similarity to the other stations. Station I, also an outfall station, was not grouped with Station St. E. because several of the species at Station I were also found at other nonoutfall stations. High similarity was only observed between Stations A and C, even though species density, diversity, and richness were considerably different at these stations. Of the 17 species present at Station C, 16 were also present at Station A.

In Figure 7, Stations NEFCO GT and NEFCO N-O, both non-operative outfalls during the 1978 season, are shown to have a diverse benthic community. While the results of the

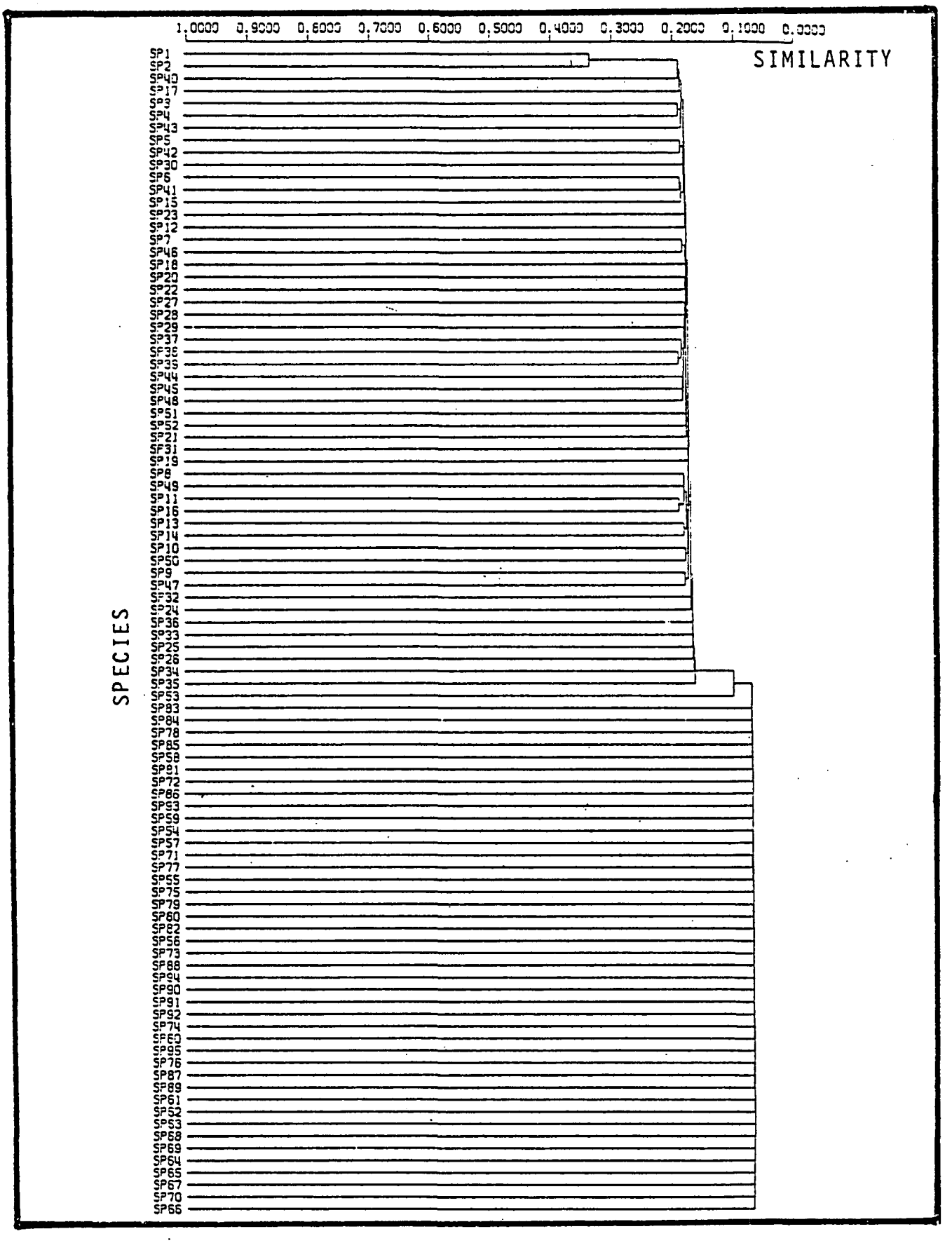


Figure 6. Species group clusters of Cordova samples (1 mm and 0.5 mm screenings).

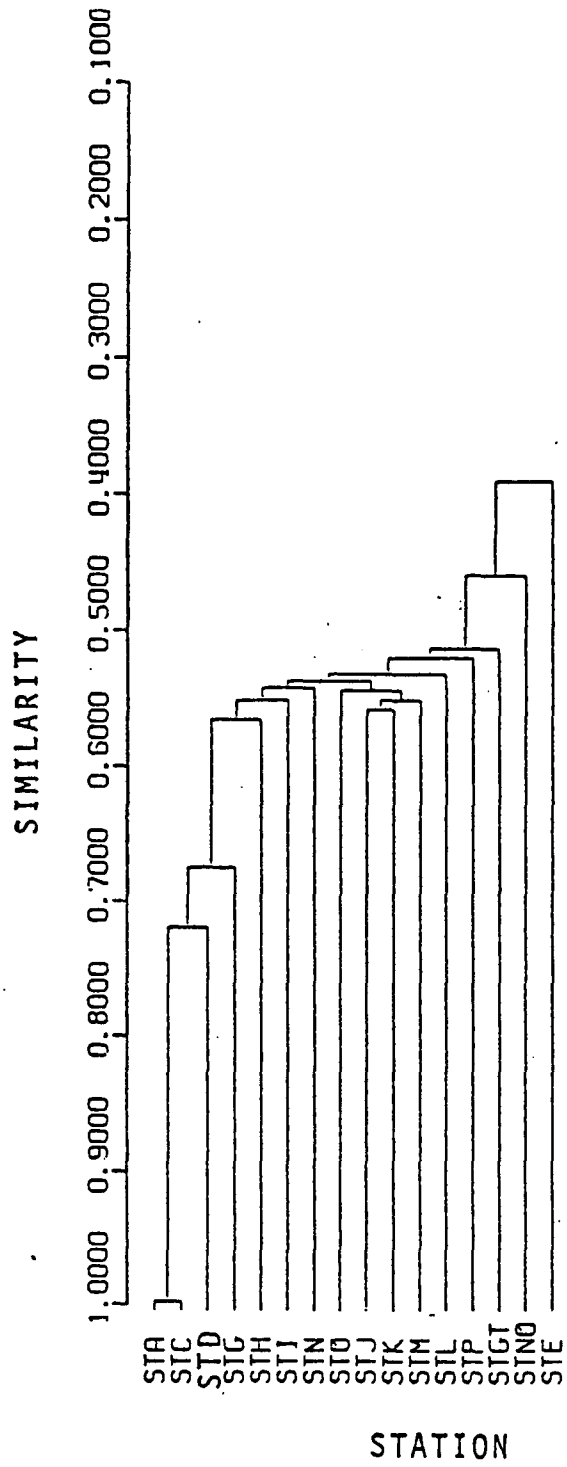


Figure 7. Station group clusters of Cordova samples (1 mm and 0.5 mm screenings).

classification analysis indicated a stable benthic community at the two NEFCO stations, without benthic data from previous years, the present benthic community structure at these sites cannot be interpreted to represent recovery of the benthos from earlier waste discharges.

At Station C, low species diversity and similarity to only one station were recorded. Evaluation of sediment and water quality, and sediment composition data for Station C did not identify a specific factor of factors which were responsible for the observed benthic conditions. At the present time, it appears that some parameter which was not tested in this study is responsible.

Normal classification and data sorting were also performed on the 1 and 0.5 mm data as separate data groups. The species and station similarity dendrograms resulting from these analyses are provided in Appendix 1. Since neither of these separate data sets represented a complete description of the Cordova benthic community, a discussion of these dendrograms was not included in the results and discussion section.

The observed impacts on the benthos at Station St. E., elevated levels of selected water and sediment quality parameters at Stations St. E. and NPP, and the extent of waste accumulation at St. E. and NPP implied that tidal and current flushing at these stations were more restricted than at other stations. Indications of improved waste dispersal accompanied by increased benthic species diversity at Stations I, NEFCO GT,

and NEFCO N-O, suggested better flushing of these outfall stations.

Several authors have reported on situations where tidal or current dispersion were important in determining the effects of cannery effluent (3, 4, 6, 7). Beyer, et. al. (6), in their studies at Petersburg, Alaska, found that strong currents flushed most of the wastes from the Petersburg harbor area, but that some temporary accumulations did occur near the cannery discharges. The number of benthic organisms were reduced in these areas of waste accumulation. With the exception of these areas, however, sediment type, tidal level, and the influence of freshwater input to the system from canneries or rain runoff had a more significant impact on the benthic community than did cannery waste effluent.

CONCLUSIONS

The following conclusions are based on analyses of macrobenthos, sediment and water quality, and hydrological conditions at Kenai and Cordova, Alaska. This study was the result of a single ecological survey during July 23 to 27, at Kenai, and July 29 to August 2, 1978, at Cordova.

KENAI

Aesthetics

- Surface water discolorations and accumulations of whole fish heads, tails, and viscera on the riverbank were observed at the Kenai Packers (KP) egghouse outfall and at the base of the KP Wharf during low tide. The accumulations at the egghouse outfall resulted from discharges which occurred above the low water level. The source(s) of the wastes below the wharf was not determined. River and tidal currents, as well as large fluctuations in tidal height appeared to flush the area of these wastes on a daily basis. Downstream transport and deposition of this waste material was not observed. Neither surface discolorations nor waste accumulations were observed at or near the Columbia-Wards Fisheries Cannery (CWF).

Water Quality and Sediment Conditions

- Water quality conditions in the Kenai River were not affected by cannery waste discharges from KP or CWF. Dissolved oxygen values at all depths sampled were generally at or near saturation, and were never lower than 8.5 mg/ℓ at any station. Only salinity varied dramatically and this variation was entirely a function of changes in tidal and river flow.
- Nutrient concentrations in the river water were very low and variations between stations were negligible. In many instances, concentrations were below minimum detection limits for several of the nutrients. Cannery discharges did not appear to have an effect on nutrient concentrations in the water.
- River configuration, tidal and river currents, and sediment deposition patterns were the principal factors affecting particle size characteristics in Kenai River sediments. The impact of cannery discharges on particle size was negligible.
- Cannery discharges did not affect sediment chemistry with the possible exception of total sulfide at two cannery outfall stations. For the range of total sulfide concentrations observed at all stations, however, the concentration in sediment at these outfalls may not be significant.

Biological Conditions

- Benthic community structure was poorly developed in the Kenai River sediments. At several stations only one species was found and often in very low abundance. The majority of stations had only two species or less; maximum species richness was four, and this occurred at only one station. At all stations, nematodes or oligochaetes were the dominant macrobenthos.

Effects of Cannery Discharges

- Cannery discharges to the Kenai River had no appreciable impact on sediment and water quality, and the macrobenthos. No evidence of persistent waste accumulations at the Kenai canneries was observed. The combined action of tidal currents and large twice-daily variations in tidal height sufficiently flushed the river of seafood processing wastes. While the Kenai River benthic community is poorly developed, attempts to associate cannery discharges to the observed benthic conditions were inconclusive. Limitations on habitat utilization imposed by sediment type, tidal induced scouring and burial by bottom sediments, and daily salinity changes are probably the major factors responsible for low species richness and poor community development.

Aesthetics

- Surface discolorations and floating debris were observed near the St. Elias Cannery Dock (St. E.) and in the vicinity of the North Pacific Processors (NPP) dock.
  - At the St. E. dock, the major aesthetic problem was from floating debris associated with the dumping of whole crab shells and some crab appendages off the center of the dock.
  - At NPP, a whitish-yellowish discoloration of the surface water resulted from intermittent cannery discharges. Patches of floating debris from these discharges were recorded over 45 m from the discharge point.
  - No aesthetic problems were observed at Morpac, New England Fisheries Company (NEFCO), or the nonoutfall stations.

Bottom Accumulations

- Underwater photography identified accumulations of fish and crab wastes around each of the operating cannery outfalls.
  - Whole crab shells and crab appendages had accumulated directly below the center of the St. Elias Cannery dock (St. E.). It appeared that all of the crab wastes had been dumped from the dock. The wastes

extended out from the dock in a semicircle for a distance of 5 m. Maximum pile depth was 25-30 cm. A few fish heads and crab shells were observed off the end of the cannery outfall which was only 16 m from the crab piles and at one end of the dock.

- At the North Pacific Processor (NPP) outfall, waste discharges have cut a trough approximately 3 m wide and over 6 m long in front of the outfall. The depth of the trough was not determined because of considerable debris in the trough. Diver estimates of the depth of the debris were over 1 m. Numerous fishtails and heads were observed in the trough, although crab exoskeletal wastes were estimated at 90 percent of the waste material. The crab waste averaged 5 cm in size. Discharges from the pipe which occurred during filming did not contain particles the size of those represented in the trough.
- In comparison to the waste debris at St. E. and NPP, processing wastes at the Morpac outfall were more finely ground and more evenly distributed over the bottom. No distinct piles were observed. The wastes were confined to a circular area extending 12-16 m from the center of the discharge. Bottom material in this area consisted of a layer of primarily silt and finely ground fish and crab parts, 15 to 30 cm deep.

- Bottom films of the two discharge areas at the New England Fish Company Cannery (NEFCO) showed no evidence of processing waste accumulations from previous years. The NEFCO cannery was not in operation in 1978.

Water Quality and Sediment Conditions

- o At no stations were there indications of depressed oxygen concentrations. Dissolved oxygen values were generally at or above 10 mg/ℓ .
- o The effects of cannery discharges on nutrient levels in the water were very localized. Considerably higher concentrations of ammonia, organic nitrogen, and sulfide occurred at the NPP outfall and the St. E. dock. Total phosphorus concentrations at the St. E. dock were 2 to 3 times greater than at any other station.
- o Bottom sediment samples obtained from outfall stations showed typically higher total Kjeldahl nitrogen and total sulfide concentrations.
- o Analyses of macrobenthos data indicated a generally stable and very diverse benthic community. The effects of cannery effluents on the benthic community were only observed in a localized area immediately off the St. E. dock. Benthic samples from the NPP outfall were not collected, and no assessment of the impacts of cannery discharges on the benthic community at the NPP outfall was made. At the NPP outfall, the depth and horizontal extent of accumulated fish and crab wastes prevented collection of satisfactory benthic samples. Macrobenthic

conditions at Station C, located approximately 100 m from the St. E. dock were poorer than expected. These conditions, however, could not be clearly associated with the sediments or water quality parameters tested, or with cannery discharges.

Biological Conditions

- Flatfish (halibut and flounder), rays, and other unidentified fish species were attracted to the waste accumulations, often in considerable numbers. Large flatfish (>0.3 m in length) numbering 40 to 50 at any one time during underwater filming, were observed feeding and swimming at the NPP waste trough. Lesser numbers of fish were observed at the St. E., Morpac, and NEFCO outfalls. Very few fish were observed at the mid-channel or control stations. Those which were noted were small (<15 cm in length).
- Seasonal variations in benthic populations and the effects these variations may have on interpretation of the benthic data were not considered. Time constraints did not permit collection of seasonal samples.

Effects of Cannery Discharges

- The effects of cannery discharges on sediment and water quality, and on the macrobenthos were localized in the immediate area of waste disposal. The degree of impact on these parameters appeared to be a function of the degree of flushing occurring at the outfall or, in the

case of St. E., the dumping site. Sufficient tidal flushing for dispersal of discharged or dumped wastes did not occur at the NPP outfall or the St. E. dock. Consequently, localized impacts on the above mentioned parameters were observed.

COMPARISON OF ALASKAN SITES

- Hydrological conditions in the vicinity of cannery waste processing outfalls differ considerably. At Kenai, canneries discharge their processing wastes into the Kenai River, a tidal river which experiences twice daily flushing. As a result of this flushing action, there were no apparent problems with persistent seafood waste accumulations, and impacts to sediment and water quality were negligible. A poorly developed benthic community appeared to result from natural rather than man-induced causes. At Cordova, tidal flushing action is poor at three cannery outfall areas; consequently, impacts of processing waste disposal on sediment and water quality, macrobenthos, and waste accumulations are more clearly defined than at Kenai.

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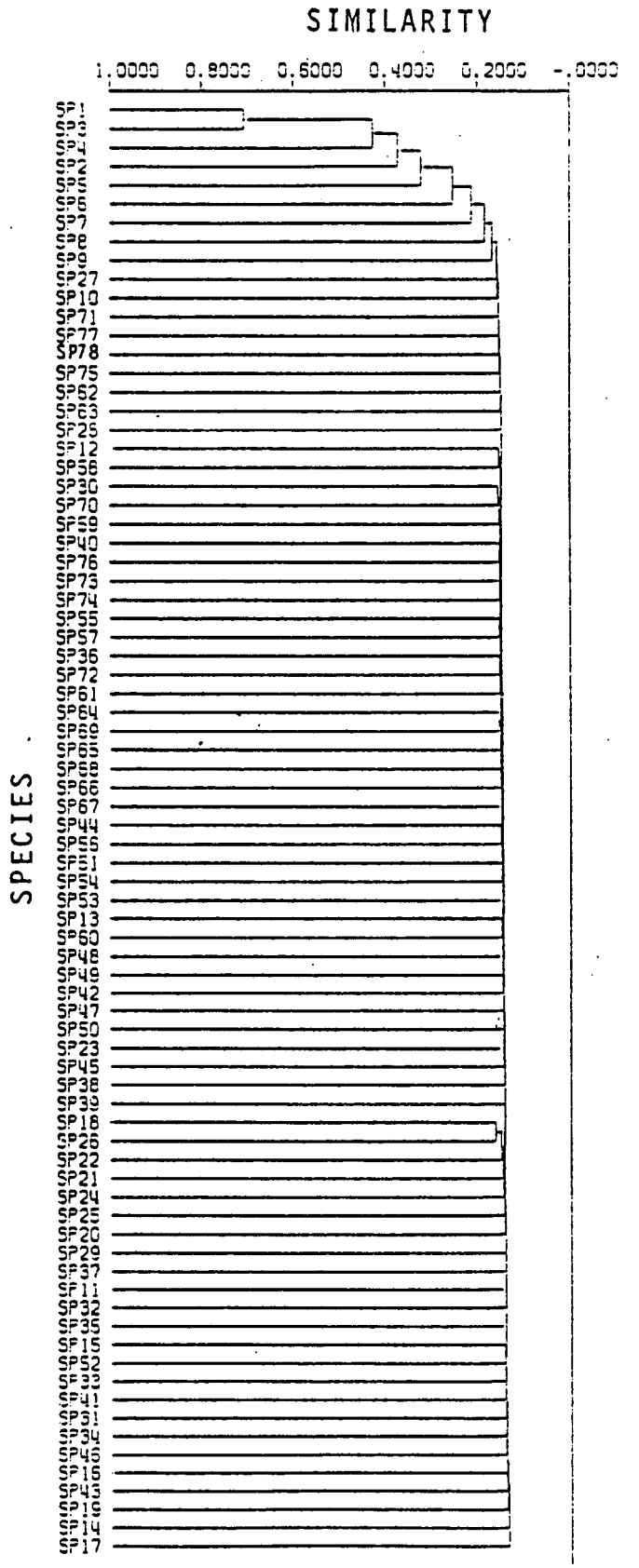
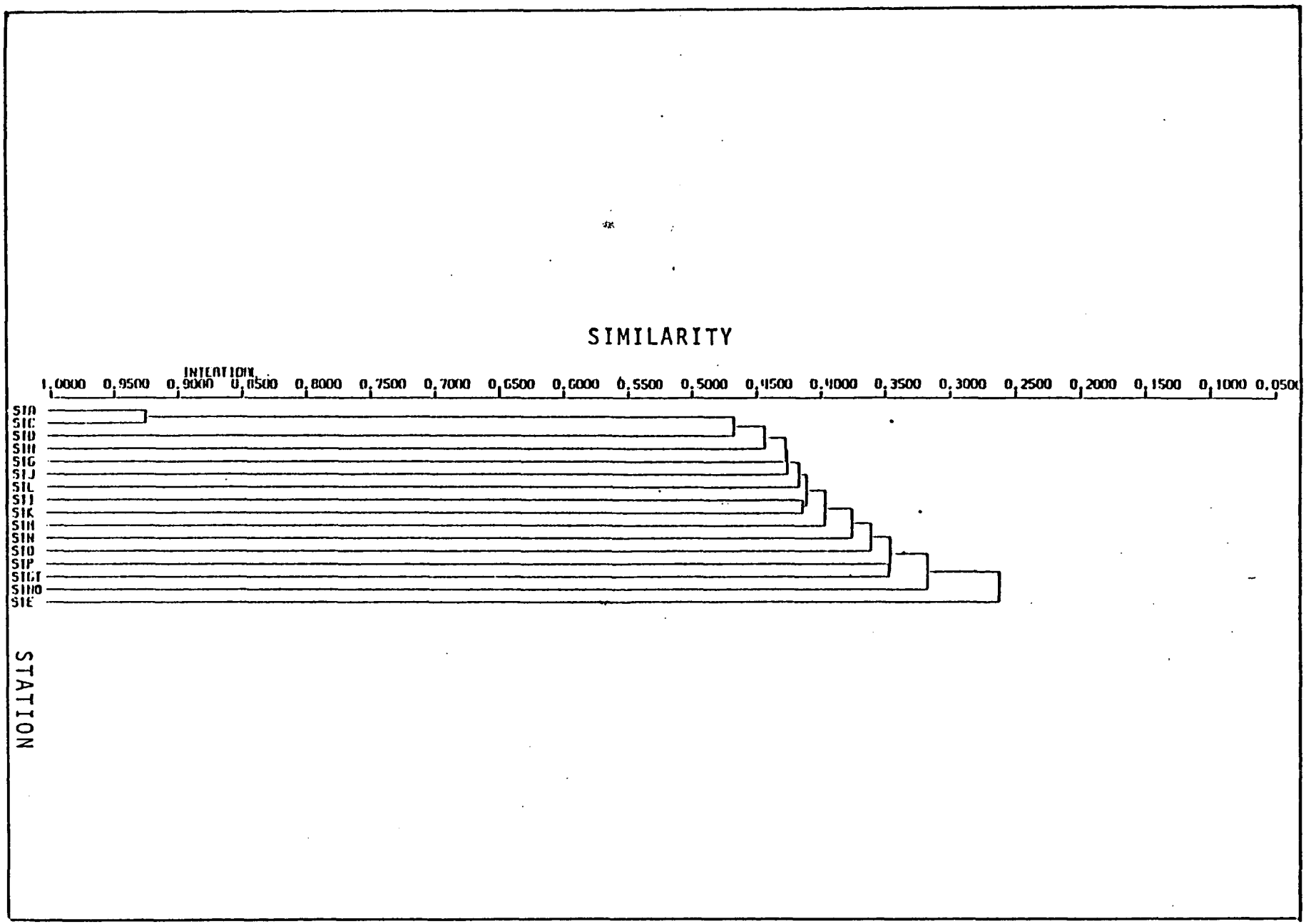
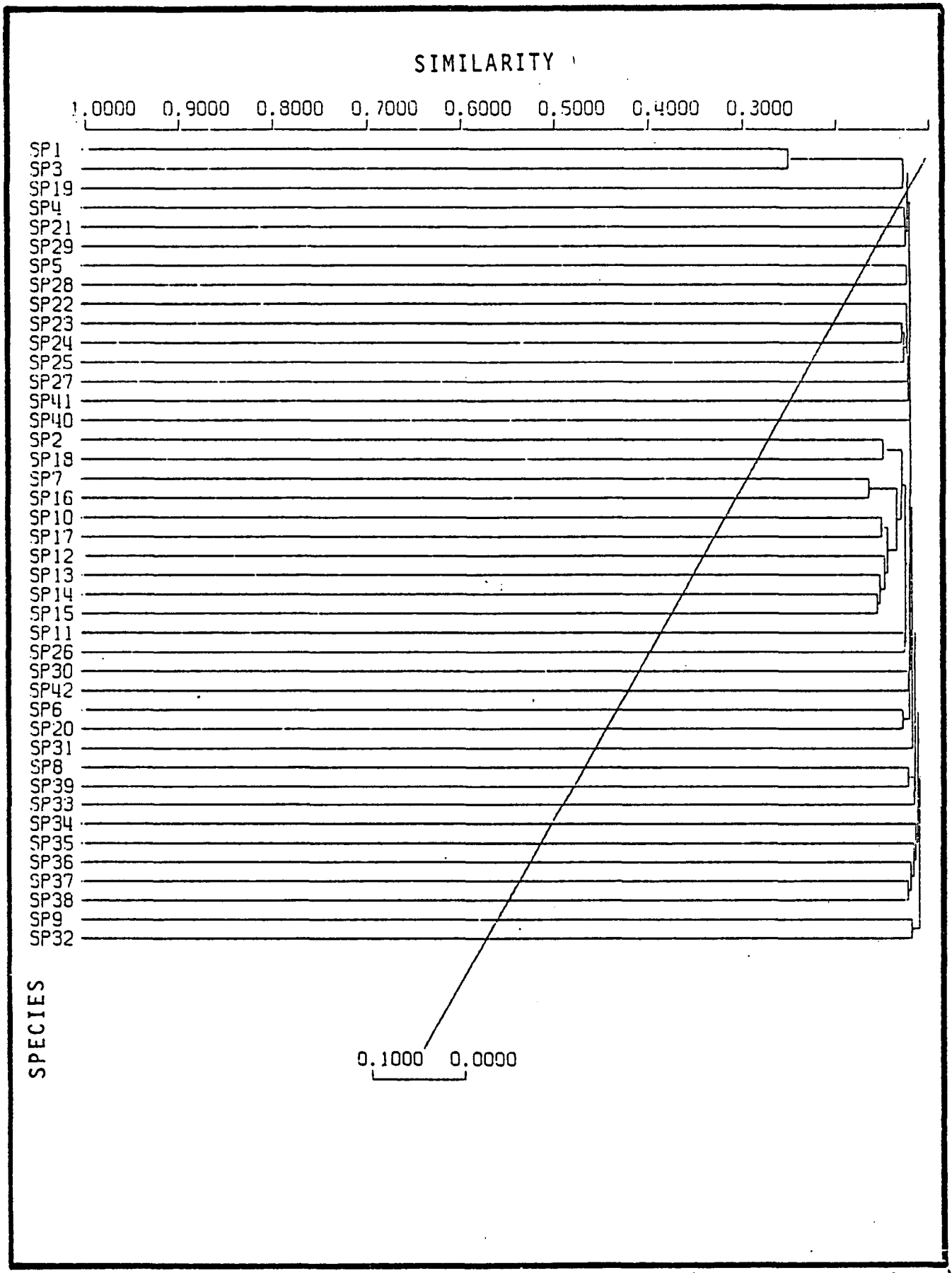
APPENDIX



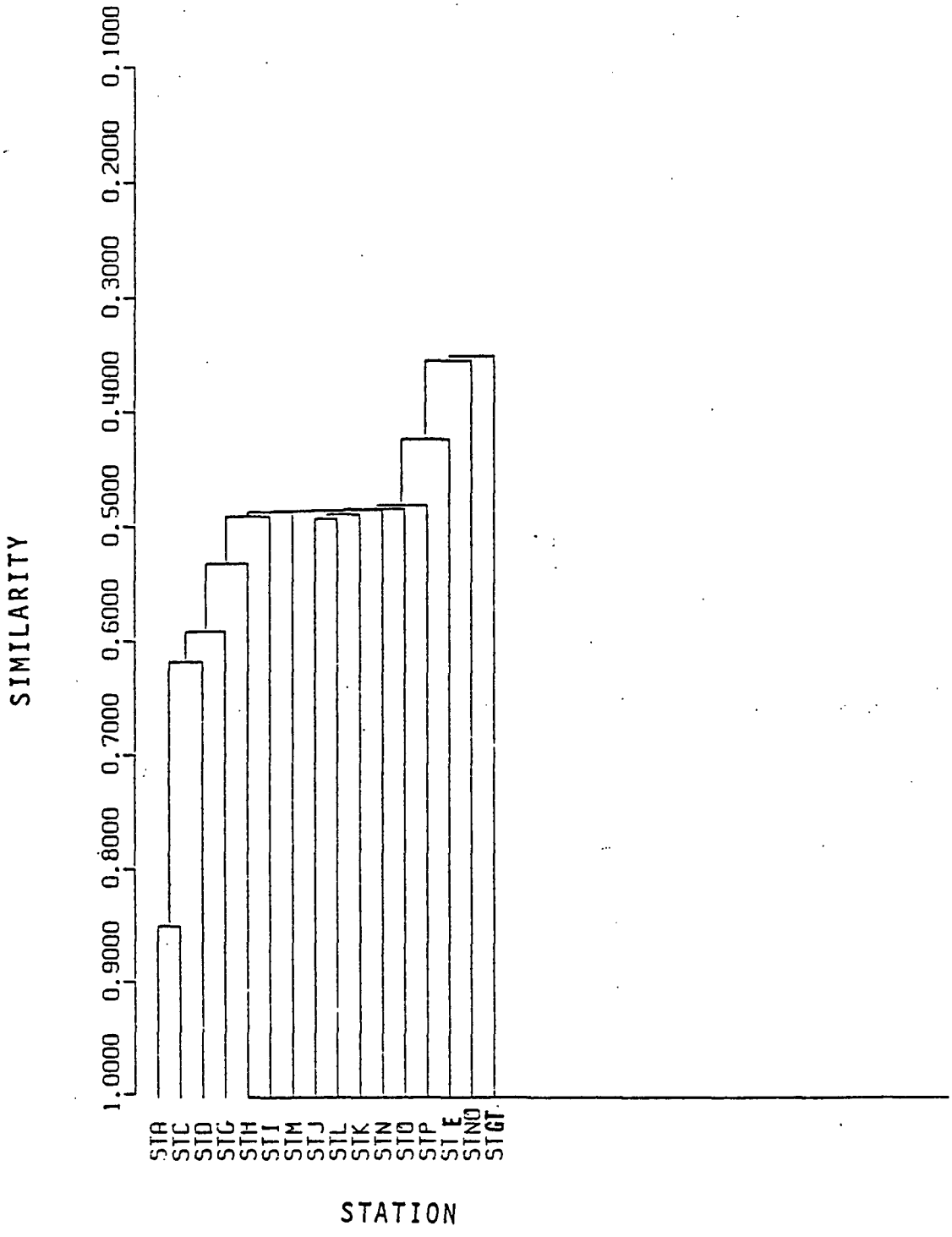
Species group clusters of Cordova samples (1 mm screenings).



Station group clusters of Cordova samples (1 mm screenings).



Species group clusters of Cordova samples (0.5 mm screenings).



Station group clusters of Cordova samples (0.5 mm screenings).

ADDRESS ONLY THE DIRECTOR,
FISH AND WILDLIFE SERVICE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
WASHINGTON, D.C. 20240

In Reply Refer To:
FWS/ES

AUG 31 1979

Mr. Robert B. Schaffer
Director
Effluent Guidelines Division
U.S. Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Schaffer:

In response to your letter of May 23, 1979, as well as a meeting with Mr. Cal Dysinger of your staff on July 24, 1979, we are providing limited comments on your seafood study. We have reserved comments on the report by Ms. Dorthy Soule. We understand that staff from our Laguna Nigel Field Office will provide separate comments on this report. Our comments will be brief and limited to the Alaska and Oregon reports.

In general, we believe the reports received are based on short-term studies under conditions requiring an extremely fast turnaround time. Furthermore, the reports are limited in scope, appear to have significant oversights and omissions, and in most cases no provisions appear to be made for follow-up studies. These reports tend to make rather broad conclusions regarding environmental impacts which we believe are not in keeping with the character of the studies. An additional report by the National Marine Fisheries Service on Finger Bay in Alaska is enclosed for your information.

Specific Comments:

Under this heading brief comments regarding specific reports are provided.

1. An Investigation of Certain Aspects of Crab Processing Waste Disposal Practices: In Situ and In Vitro Responses of Vibrio parahemolitius and Vibrio anguillarium.

   This report by the University of Alaska is very specialized and limited in scope. It is an excellent investigation of the ability of two marine life intestinal pathogens of the genus Vibrio to survive in the marine environment near seafood processing wastes. However, the substance of the report does not justify its use as an evaluation of the potential for diseases of marine life related to the dumping of seafood processing wastes. Such wastes are ideal breeding grounds for large concentrations of fungi, molds, and

other types of decomposers. Many organisms in these groups are well known to be opportunistic parasites which periodically infect marine and freshwater organisms on a large scale. Such groups should be thorougly investigated in any evaluation of seafood dumping sites.

2. Working Papers #EPA 910-8-77-100 and 910-8-78-101: "The Dutch Harbor Studies"

We fully concur with many of the conclusions of report #EPA 910-8-77-100 regarding Dutch Harbor. Seafood wastes are primarily responsible for the adverse conditions observed in Iliuliuk Harbor, inner Iliuliuk Bay, and Dutch Harbor. Investigations by ourselves and others support this conclusion. Referral to other studies of this type suggests that this report does not address the full impact of the discharges of seafood wastes in the bay area. For instance, there was no attempt to analyze for H_2S, a significant environmental by-product of the waste. Certainly the conclusions regarding the elimination of discharges from these areas are appropriate and well supported.

The investigation of the discharges to the west side of the island described in report #EPA 910-8-78-101 appears to be superficial and belie the full impacts which are apparently occurring along the west coast of the island. The fact that decomposition is considerably slower than the rate of addition by the discharges supports this belief. It is also supported by the fact that many of the active discharge pipes were moved during the study period creating adjacent pollution sites of close proximity. The fact that the abandoned sites have significant debris and are totally devoid of life after a period of a year or more would suggest a potential for significant damage near shore by such movement of the pipe. The failure of this report to quantitatively assess the amount of H_2S in these locations or determine the western (seaward) extent of the waste from the discharge pipes also limits the report's value as a tool for assessing impacts of the processing wastes.

3. Benthic Macrofauna, Sediment, and Water Quality Near Seafood Cannery Outfalls in Kenai and Cordova, Alaska.

We believe that the conclusions of the study are somewhat misleading. The report appears to minimize existing problems and fails to address the potential for future problems. Certainly the study at Cordova occurred during a season of minimum productivity and the study was not sufficiently in-depth to justify a solid conclusion that the impacts are of a highly localized nature. Follow-up studies are needed to verify the findings. Extensive

sediment analysis should be incorporated in future studies including nutrient loading, H_2S production, and ammonia production. Trends in the ecosystem near the waste sites and down-current from them need to be ascertained before any firm conclusions can be drawn regarding impacts.

Similar weaknesses are found in the Kenai study. Our experts agree that no significant impacts may be demonstrated at Kenai at this time. However, they raise the question of potential significant impacts at Kenai with increased loading from additional plants. A similar argument can be made for the Cordova situation.

In the review of previous Alaskan studies section, there are several summaries which are misleading and in some cases invalid. For example, we cannot accept the analogy to Iliuliuk Bay presented in the summary of the Brickell and Goering studies. The fact that natural loading of dissolved organic nitrogen and ammonia in an estuary where salmon carcasses accumulated after spawning approximates the ammonia values in Iliuliuk Bay does not mean the two situations are truly comparable. A consideration of the total freshwater drainage area discharging into the estuary or bay versus the loading and other constraints of the two systems would be necessary before comparability could be contemplated.

The summary of the Nakatoni and Beyer mortality studies provides another example, since the studies are summarized without noting the fact that chronic exposure and secondary effects are not addressed.

The community analysis procedure discussed in the methodology could prejudice against any rare or endangered species found in the study area. Furthermore, we disagree with their contention on page 36 that using a 0.5 mm instead of a 1.0 mm screen changes the conditions described. The conditions are the same; the refinement of those conditions is what differs. The decision of whether or not to use more refinement is tied directly to comparability with techniques used in other studies. Without comparability, refinement is of no value.

4. Benthic Macrofauna, Sediment and Water Quality Near Seafood Cannery Outfall in Yaquina Bay, Oregon.

This report appears to be better done than the Alaskan reports, but still suffers from the same basic weaknesses. H_2S was not addressed. No effort was made to evaluate the relationship of carcinogenic benzopyrene effects to the presence of the seafood wastes, nor was there an effort to determine the source or other possible interrelationships of the benzopyrenes to seafood processing wastes.

Follow-up studies would be needed for the conclusions of this report to be concrete. In addition, loading evaluations of the marine system in Yaquina Bay should be conducted.

5. Section 74 Seafood Processing Study.

We agree with the report's observed differences between the Alaskan seafood industry and the industry found in the contiguous United States. Furthermore, we concur that the reluctance of other processors in the vicinity by the Alaskan fish meal plants to screen their wastes has contributed to the limited success of the enterprises. The report's observation that allowing plants to continue grinding waste for discharge to the marine environment does not provide the necessary incentive for effective in-plant water and waste management practices is well taken.

The report only addresses the problem of waste reduction processes. We believe that the potential value and feasibility of waste disposal technology should also be addressed by EPA, but have no indication that it has been seriously addressed in connection with this series of reports. One possible disposal technology that might be explored is the use of the collection system in reverse to spread the waste over a large area of ocean to create a more natural situation for its degradation and eliminate its adverse impact.

We trust these comments will be helpful to you in preparing your final report. Since we realize that these reports are mandated by Congress and provide the potential basis for future decisions, we have emphasized their limitations and oversights and how they might affect any conclusions of negative impacts. If there are any additional questions, please contact my staff for clarification.

Sincerely yours,

Michael J. Spear
Associate Director

Enclosure

BUREAU OF SPORT FISHERIES AND WILDLIFE	
TO: Director (AE), FWS, Washington, DC ATTN: Roger Griffith	DATE 7/18/79 TIME
FROM: Deputy Alaska Area Director (AAD-E/ECE) (907) 276-3800, ext. 506	☐ Deliver on regular mail run ☒ Call to have picked up 235-2534

SUBJECT: National Marine Fisheries Report - Finger Cove, Alaska

The enclosed report is faxformed to you per your telephone request of July 16, 1979.

Leroy W Lovel

INT: 76

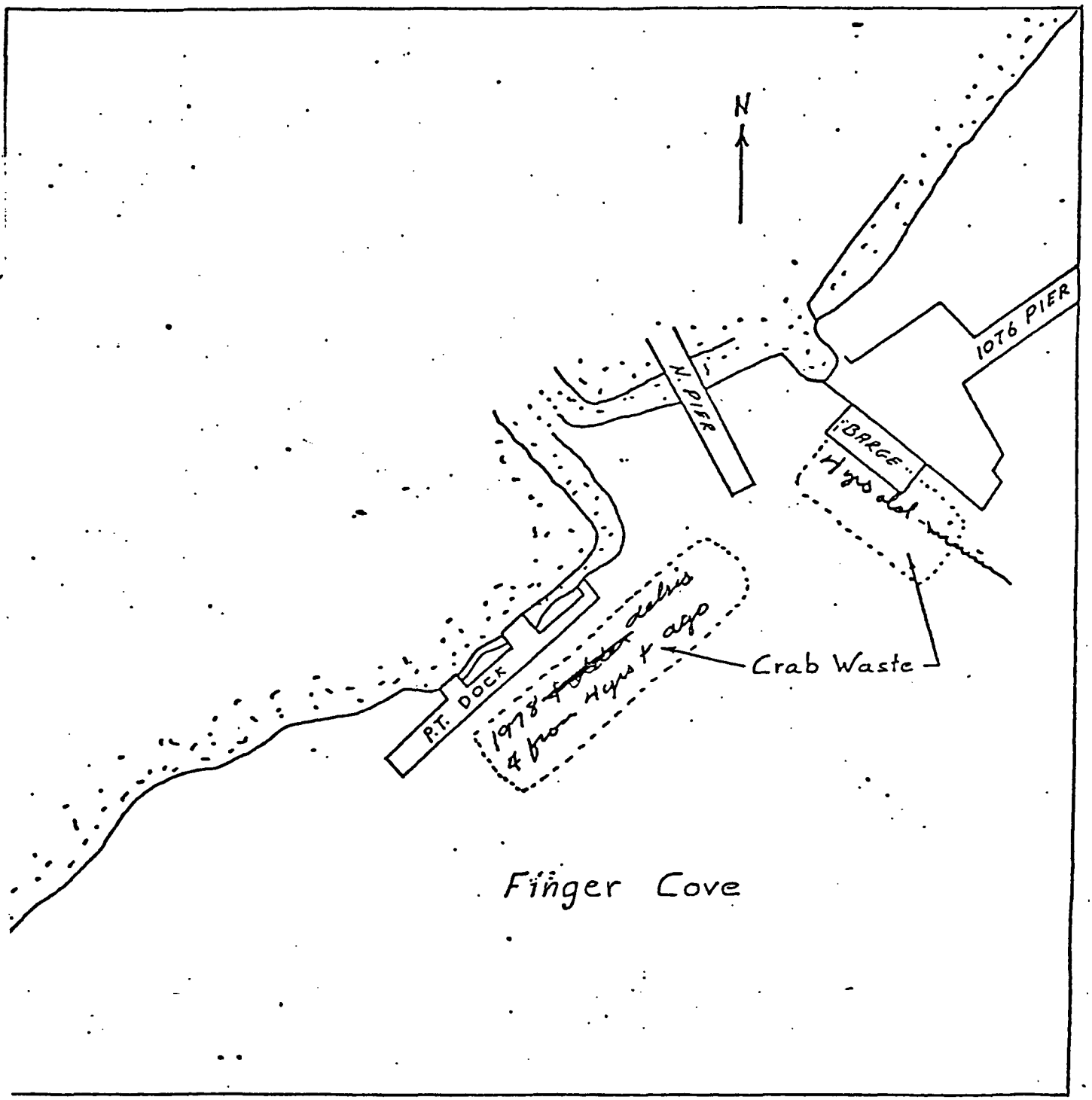


Figure 2. Approximate areas of king crab waste in Finger Cove, Adak Island, on January 17-18, 1979.

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Environmental Assessment Division
Juneau, Alaska

Report of Field Investigations of Finger Cove, Adak Island, January 15-22, 1979

In response to a request from the U.S. Navy, Western Division Naval Facilities Engineering Command, San Bruno, California, the Environmenta Assessment Division of the National Marine Fisheries Service investigated Finger Cove by conducting an underwater bottom survey in the vicinity of the existing piers and near the cove mouth.

OBJECTIVES

1. Determine the extent of biological production in terms of epibenthic animals and plants.

2. Locate waste discharged from previous king crab floating processor ships.

3. Delineate area covered by discharged waste.

4. Investigate area in Finger Cove not impacted by crab waste.

METHODS

Duane Petersen and Ron Berg (NMFS) conducted this survey, utilizing SCUBA to obtain underwater observations. Don Garcia and Steve Dehart, U.S. Navy EOD, provided backup diving and surface support. Transportation to and from Finger Cove was provided by a U.S. Navy tug. Underwater pictures were taken of the area surveyed. A transect line, marked in 1-meter (m) intervals, was used to measure widths of waste deposition. Observations of plant and animal life were made while swimming through the area. Substrate composition and depth were noted and recorded. All observations were recorded on underwater writing paper.

Finger Cove is approximately 2 km. long, 183 m. wide at the narrows part and 460 m. wide at the widest part. Within Finger Cove two areas were investigated (Figure 1).

Site 1. This area was surveyed on January 17 and 18, 1979. Extensive amounts of king crab waste were found (Figure 2). The waste was identifiable to parts of king crab legs and claw parts; pieces were found up to 8 cm. in length. The majority of the debris was black decaying organic matter and assumed to be of the same origin. Samples of each material were collected and sent to the Environmental Protection Agency Laboratory in Seattle, Washington for analysis.

The only area not covered with organic waste was in front of the North Pier as shown on NAUFAC Drawing No. 6016479. The waste along the P.T. Dock and along the west side of the "1076 Pier" ranged from 15-19 m. in width, and from a trace to over 1 m. in depth.

Natural bottom substrate beyond the waste covered area is hard sand with scattered rocks ranging to 25 cm. in diameter covered with a thin layer of silt. Adjacent to and under the piers the substrate is rocks to 60 cm. in diameter. Attached vegatation was not observed while swimming through the area. Maximum depth was 12 m. Table 1 is a listing of fish animals observed during the inner Finger Cove survey.

Site 2. The outer Finger Cove area was surveyed on January 18, 1979. This area is different from the inner cove in three distinct parameters: (1) the substrate is composed of sand and small gravel between outcrops of bedrock to about 12 m. from shore; the bottom then grades into boulder and gravel to 60 m. and beyond; (2) water depth is greater, reaching 21 m. near the midline; and (3) shore-to-shore width is only 38% of the inner cove.

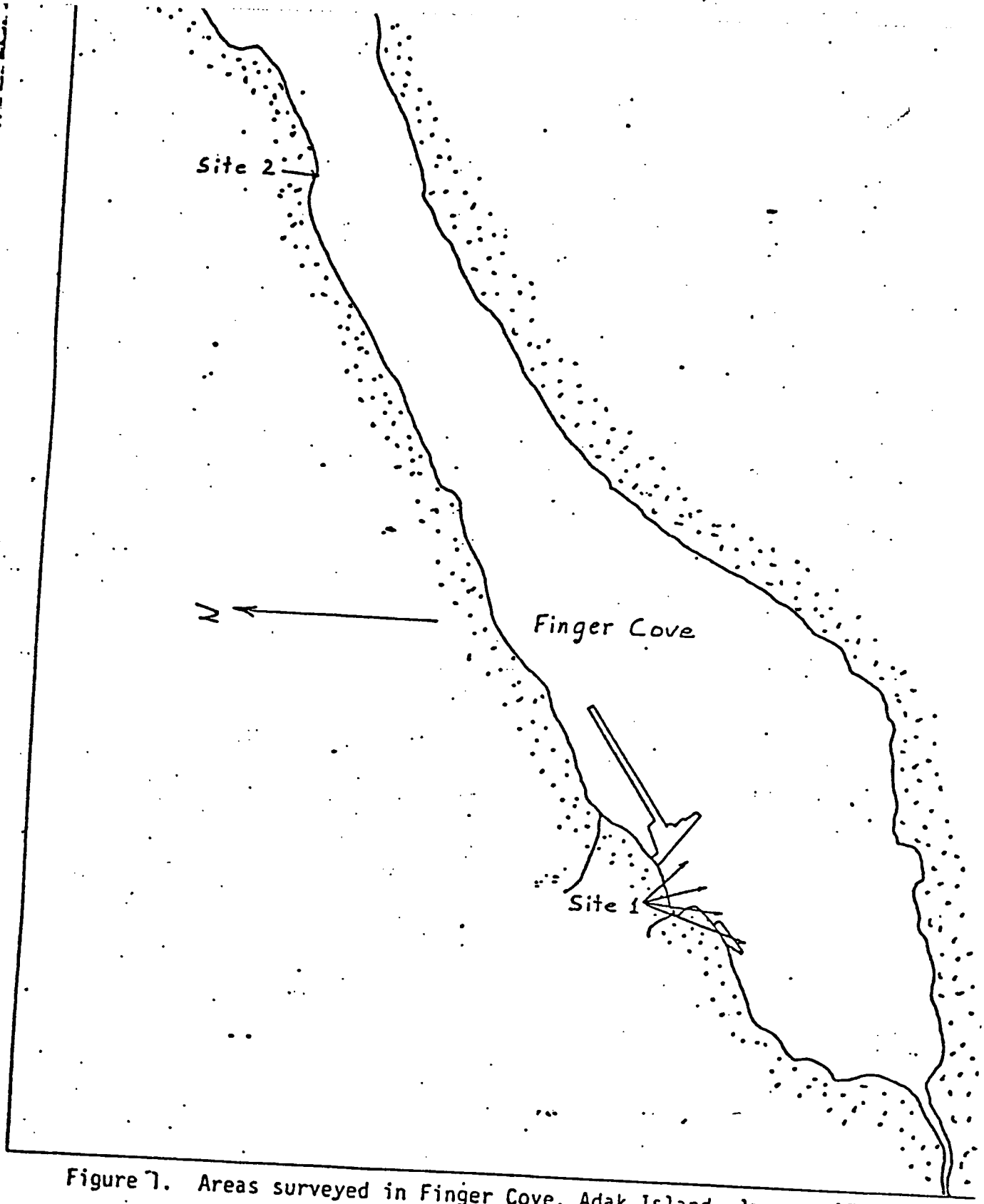


Figure 1. Areas surveyed in Finger Cove, Adak Island, January 17-18, 1979.

Table 1. Species observed during underwater survey of inner Finger Cove, January 17-18, 1979.

Phylum Porifera	Common Name
Unidentified Sponge	Sponge
Phylum Coelenterata	
Metridium senile	Fine tentacled sea anemone
Cribrinopsis fernaldi	Big pink sea anemone
Phylum Annelida	
Unidentified sp.	Worm
Phylum Mollusca	
Littorina sp.	Snail
Dirona aurantia	Golden dirona
Triopha carpenteria	Clown nudibranch
Mopalia muscosa	Mossy chiton
Pododesmus macroschisma	False Pacific jingle
Phylum Arthropoda	
Balanus cariosus (dead)	Barnacle
Pandalus goniurus	Shrimp
Paralithodes camtschatica	King crab
Phylum Echinodermata	
Cucumaria vegae	Sea cucumber
Phylum Chordata	
Phytichthys chirus	Ribbon prickleback
Citharichthys stigmaeus	Speckled sanddab
Myoxocephalus polyacanthocephalus	Great sculpin

Crab waste was not located; however, non-organic debris related to fishing activities was found (e.g., rubber boots, rubber gloves, and beverage containers).

Species of algae and animals were observed in greater abundance and diversity (Table 2).

DISCUSSION AND RECOMMENDATIONS

Inner Finger Cove is impacted by large amounts of organic waste materia from previous king crab processing activities. Evidence indicates that the area, at some time perhaps in the past 2-4 years, has turned toxic to attached sessile animals inhabiting the area. Barnacles, a sessile animal covering the piles and debris, were dead. No living barnacles were located in the inner cove. Limpets, snails, small crabs, sponges, and encrusting algae were either absent or extremely rare.

King crab recovery is about 20%. This means that about 176 kg. of every 220 kg. of crab processed is waste. When any dead organic substance exists in water, it decays. The chemicals comprising the body of a dead animal are broken down by a series of bacteria and fungi. The decaying tissue is eventually converted to nutrients which are reused by all living plants and animals present, and to inert (or slowly decaying) residue. Chiton, a good portion of king crab waste, is degraded slowly in seawater.

The effect of the decay process on the water depends on the concentration of material. When oxygen is present in the water, decay is relatively inoffensive; the organisms causing decomposition are types that require oxygen for respiration, and their major products are water-soluble or odorless nitrates, carbon dioxide, and sulfates. If decomposing material becomes highly concentrated, the population of decomposer organisms may place such a demand on the aquatic oxygen supply that it becomes exhausted. Decay will still proceed, but by means of

Table 2. Species observed during underwater survey of outer Finger Cove, January 18, 1979

ANIMALS	Common Names
Phylum Porifera	
Unidentified sponge	Sponge
Phylum Coelenterata	
Metridium senile	Fine tentacled sea anemone
Cribrinopsis fernaldi	Big pink sea anemone
Tealia sp.	Sea anemone
Phylum Mollusca	
Littorina sp.	Snail
Boreotrophon pacificus	Snail
Buccinum glaciale	Snail
Dirona aurantia	Golden dirona
Triopha carpenteria	Clown nudibranch
Mopalia muscosa	Mossy chiton
Pododesmus macroschisma	False Pacific jingle
Mytilus edulis	Blue mussel
Serripes groenlandicus	Greenland cockle
Macoma calcarea	Chalky macoma
Phylum Arthopoda	
Balanus cariosus	Barnacle
Pandalus goniurus	Shrimp
P. danae	Dock shrimp
Elassochirus tenuimanus	Big-clawed hermit crab
Pagurus sp.	Hermit crab
Phylum Echinodermata	
Henricia sp.	Starfish
Strongylocentrotus polyacanthus	Sea urchin
Cucumaria vegae	Sea cucumber
Phylum Chordata	
Myoxocephalus polyacanthocephalus	Great sculpin
ALGAE	
Agarum cribrosum	Sea colander
Alaria crispa	Wing kelp
Fucus distichus	Rockweed
Halosaccion glandiforme	Sea sac
Iridaea cornucopiae	Red algae
Odonthalia floccosa	Sharptooth brush
Rhodymenia palmata	Dulse

different bacteria, which produce large amounts of nauseating and toxic gasses, such as ammonia, hydrogen sulfide, methane, mercaptan, and cadaverin (Imhoff and Fair, 1956). As a result, all the ordinary aerob flora and fauna of the water are deprived of oxygen and die out. A toxic condition need only last for a few hours to destroy life. Anothe possible cause for the dead barnacles could have been a release of toxi gasses which could advertently affect not only attached life but also any motile animals present. Natural or cyclic mortality was ruled out because of the live attached organisms observed at site 2.

Processing of king crab should not adversely affect Finger Cove if all organic waste material is deposited in the deeper waters off Finger Bay near 51°53'30" N. latitude and 176°28'00" W. longitude. If a large amount of organic waste is deposited within Finger Cove proper, we believe that the area will become unfit for marine life and that the runs of pink and coho salmon in the stream flowing from Betty Lake into Finger Cove could be affected.

The underwater photographs and lab analysis will be forwarded with the proper captions when received.

ACKNOWLEDGEMENTS

LCDR Sam Saltoun, Public Works, met us at the airport and made arrangements for transportation to and from Finger Cove. CWO Art Huffman and crew, EOD, provided equipment and logistics which insured success of the operation.

LITERATURE CITED

Imhoff, K., and G.M. Fair. 1956. Sewage Treatment. 2nd edition. Wiley, New York. 388 p.

APPENDIX C

Benthic Macrofauna, Sediment and Water Quality near Seafood Cannery Outfalls in Yaquina Bay, Oregon

by

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11 September 1978

Rec'd 1/29/79

ABSTRACT

Seafood canneries in lower Yaquina Bay, Oregon process shrimp (Pandalus jordani), Dungeness crab (Cancer magister), a variety of bottom fish and several salmon species. The shrimp wastes are screened and discharged directly into the Bay beneath the cannery docks. During the shrimp processing season about 3.8 million liters of wastes are discharged daily.

We conducted a survey of the macrobenthos, sediment, and water quality in Yaquina Bay in May 1978. The effects of the cannery wastes were restricted to the immediate vicinity of the cannery docks. The effluent plume was quite turbid and had high nutrient concentrations. Because of its initial low salinity it was restricted to the surface layer where it mixed with estuarine water and was rapidly dispersed by strong tidal currents. Dissolved oxygen concentrations were 7.0 mg/l or greater in the plume. The strong currents and screening treatment of the effluent minimized deposition of solids on the sea bed. Bottom water quality was not adversely affected.

A very diverse and abundant macrofaunal benthic community was present along the cannery docks. The community structure of the benthos near the cannery outfalls was very similar to that at the Marine Science Center docks across the Bay. Difference in species composition of benthic assemblages in lower Yaquina Bay were strongly correlated with sediment composition.

INTRODUCTION

The environmental impact of seafood cannery effluents has received relatively little attention by marine ecologists. On the west coast of the United States environmental conditions in the vicinity of cannery outfalls in Los Angeles Harbor have been examined by Soule and Oguri (1976) and Reish (1959); in Dutch Harbor, Alaska by Stewart and Tangarone (1977) and Karna (1978); at Petersburg, Alaska by Beyer, Nakatani, and Staude (1975), and at sixteen Alaskan sites by the Environmental Protection Agency (EPA) (1975). To our knowledge the effects of seafood cannery effluents have never been examined on the Oregon coast.

Section 74 of the Clean Water Act of 1977 (Public Law 95-217) required the EPA to conduct a study of the ecological effects of seafood cannery wastes. As part of that study we have examined biological sediment and water conditions in the vicinity of cannery outfalls in lower Yaquina Bay near Newport, Oregon (Fig. 1). Cannery operations in Yaquina Bay are representative of those throughout the Pacific Northwest. The principal species processed include shrimp (Pandalus jordani), Dungeness crab (Cancer magister), a variety of bottom fish and several salmon species. The shrimp cannery effluents in Yaquina Bay are screened, thus removing crustacean shells.

The macrofaunal benthos was selected as the most appropriate indicator assemblage for determining the effects of cannery effluents because benthic animals are relatively long lived and permanent residents of a given habitat. Thus, they are sensitive to the chronic effects of environmental perturbations. The structure of benthic communities should reflect changes in sediment or bottom water quality that might result from cannery effluents.

Our principal objective was to assess the ecological impacts, if any existed, through a comparison of biological, sediment and water quality at control and cannery sampling sites.

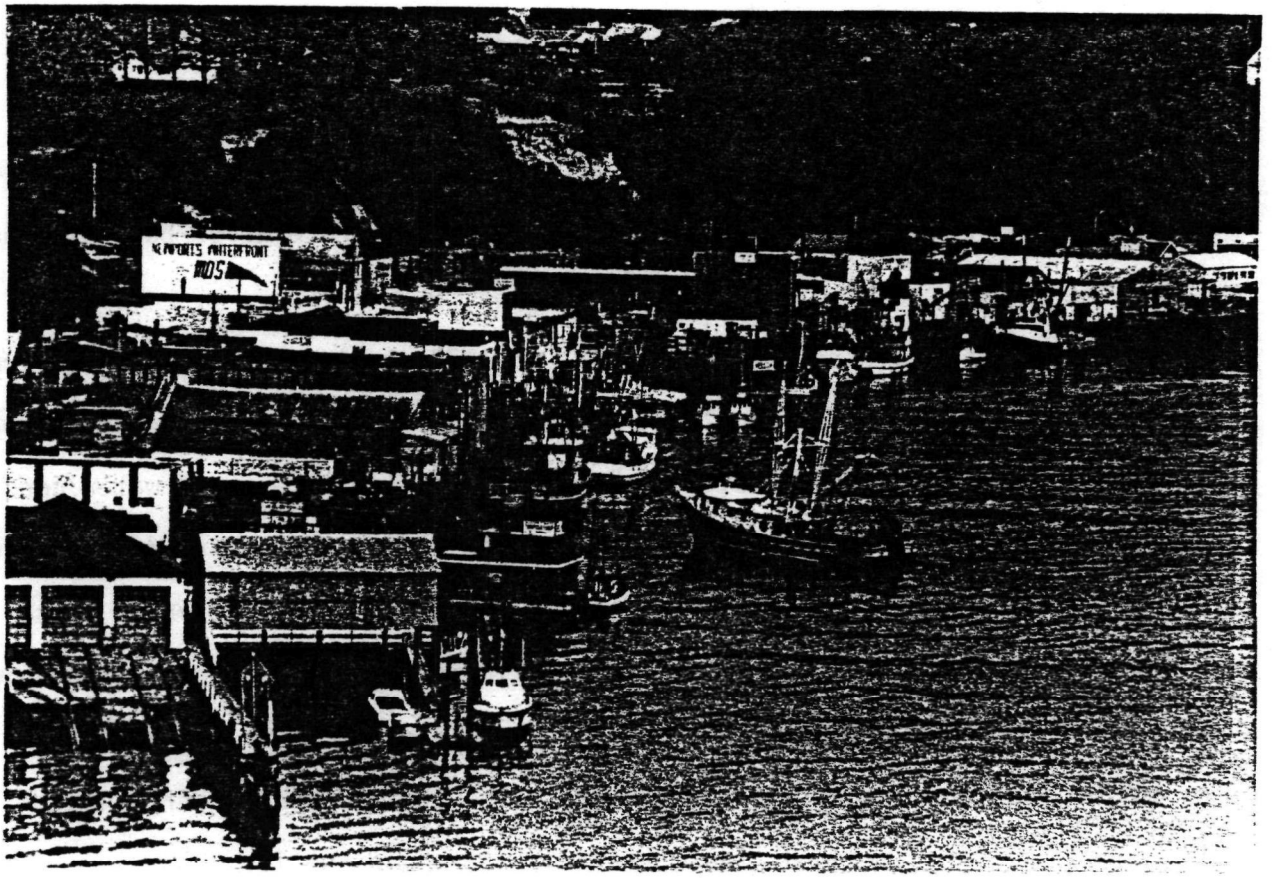


Fig. 1. Cannery row in Yaquina Bay, Newport, Oregon.

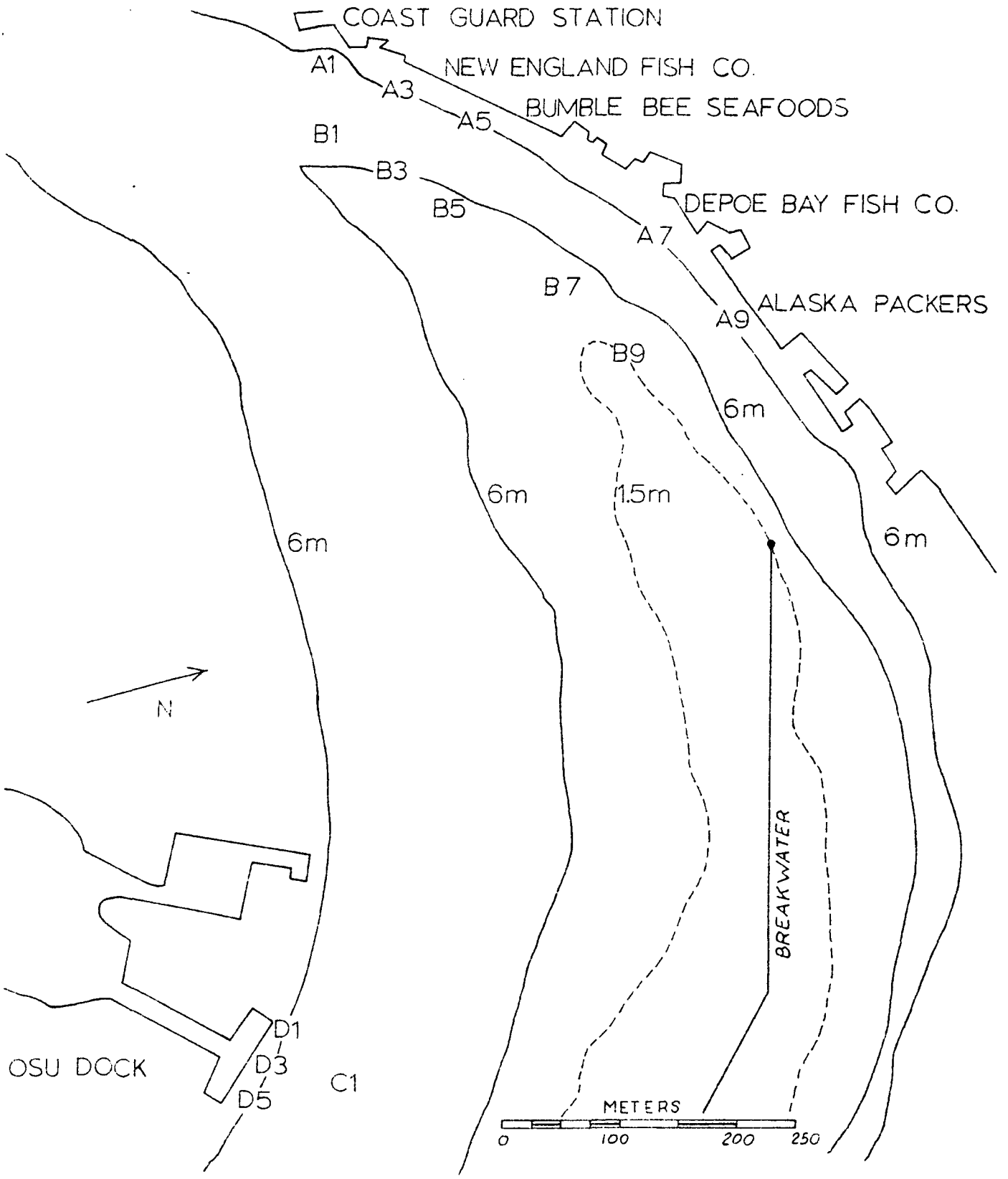
MATERIALS AND METHODS

Stations were located along four transects (Fig. 2). Transect A was immediately adjacent to the docks along cannery row and transect B was parallel to A, 100 m offshore. Five stations were occupied on each of these transects. Transect D included three stations adjacent to the docks for the three oceanographic vessels of Oregon State University. Three stations were originally designated along transect C, 100 m off the OSU docks. However, because of the difficulty in obtaining sediment samples at C, collections were made at only one C station.

The major survey was conducted on 9-10 May 1978. Initially we attempted to collect benthic samples with a 0.1 m^2 Smith-McIntyre grab. Adequate samples could not be obtained with this device because of the shells and coarse sediments found along the A and C transects. Sediment samples were therefore collected with a dredge (mouth: 16.5 x 30 cm, depth: 15 cm, lining: 1 mm mesh screen, (Fig. 3). The dredge was towed for approximately 100 m along the transect to obtain a single sample. Replicate dredge samples were taken at each station for faunal analysis. In the notation used in this report the second replicate collected at the seventh station on transect B is designated sample B7-2. Animals were removed by sieving the sediments through a 1 mm screen, preserved in 10% buffered formalin, later transferred to 70% ETOH, identified to the species level and enumerated. A third dredge sample was taken for sediment chemistry and particle size analyses.

Water samples were collected at the bottom with a 5 l Niskin bottle and at the surface with a bucket. Temperature, salinity, and dissolved oxygen concentration were determined at the surface, 1 meter depth, and bottom with an RS-5 salinometer (Beckman Instr.) and Model 57 DO meter (Yellow Springs Instr.). Surface water clarity was estimated with a standard Secchi disc. Turbidity of the water sample was measured with a Model 2100 Hach turbidi-

Fig. 2. Location of Yaquina Bay stations.


COAST GUARD STATION
NEW ENGLAND FISH CO.
BUMBLE BEE SEAFOODS
DEPOE BAY FISH CO.
ALASKA PACKERS
A1
A3
A5
A7
A9
B1
B3
B5
B7
B9
6m
6m
6m
6m
1.5m
N
BREAKWATER
OSU DOCK
D1
D3
D5
C1
METERS
0
100
200
250

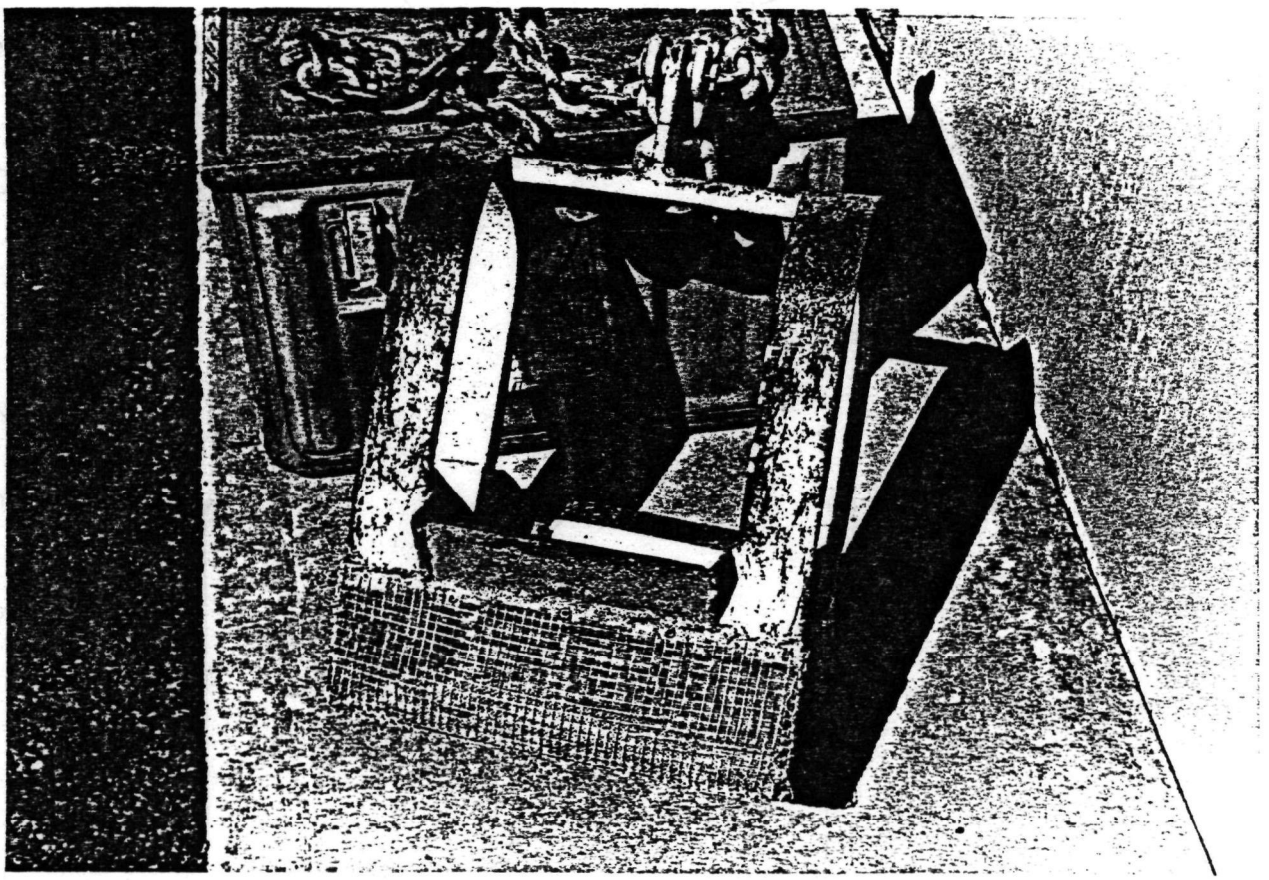


Fig. 3. Dredge used to collect Yaquina Bay sediment samples.

meter and the results expressed in nephelometric turbidity units (NTU).

On 12 May 1978 sediment traps were placed at stations A5, A7, D1 and D5. The traps were aluminum cylinders (diameter 15.2 cm, height 63.5 cm, capacity 11.5 l) covered with a flow straightener. They were strapped to the shoreward side of the most seaward piling beneath the docks. Their bottoms were 1 m above the sea bed. Their contents were retrieved after one week and filtered through a glass fiber filter. The filtrate was preserved with 80 mg/l $H_g\ Cl_2$ and the residue frozen until the chemical analyses were conducted.

On 18 July 1978 divers collected a second series of sediment samples for physical and chemical analyses. One core sample was taken at each station on transects A and D. The cores were 14 cm deep and 10 cm in diameter.

The sediment particle size distribution was determined for sand by sieving through a Wentworth scale screen series and for the silt-clay fractions by the pipette method (Buchanan, 1971). Sediment samples for bulk chemical analyses were freeze dried and finely ground using a Mullite mortar and pestle. Interstitial water was obtained by centrifuging the sediment under a nitrogen atmosphere at 9000 rpm at 5°C for 10 minutes and filtering the water through a 0.45μ millipore filter. Interstitial nutrients were preserved with 40 mg $HgCl_2$ per liter of sample. Sediment samples for sulfides were collected in 10 cc open barrel syringes; the open end was sealed after sample collection with plastic film and the contents frozen until analyzed. Grease and oil samples were collected in clean (hexane washed) glass bottles with aluminum foil lined lids and kept at 5°C until analyzed.

Bulk organic carbon was determined by subtracting the total inorganic carbon concentration (measured on an OIC model 303 carbon analyzer) from the total carbon concentration (measured on a Hewlett Packard C-H-N analyzer. Sediments for total Kjeldahl nitrogen were digested with H_2SO_4 and persulfate and analyzed with a Technicon autoanalyzer using the automated phenate

method (EPA, 1974). Total grease and oil in sediments were determined by the Soxhlet extraction method 502D (APHA, 1975). The hydrocarbon portion of the extracted grease and oil was determined by infrared analysis for hydrocarbons after removal of polar material by silica gel (Method 502E, APHA, 1975). Alkaline soluble sulfide was determined by the method of Green and Schnitker (1974). Total sulfide was also determined by the Green and Schnitker method after the sulfides were liberated with H_2SO_4 and trapped in sulfide antioxidant buffer. Nutrients (organic nitrogen, ammonia, nitrate plus nitrite, total soluble phosphate and orthophosphate) were analyzed on a Technicon autoanalyzer according to EPA methods (1974).

Biological Indices

Specimens which could not be identified to the species level were excluded from the community structure analysis. Replicates taken at each station were not pooled for quantitative faunal analyses. Thus the data set included 28 biological samples. Faunal density was calculated as the number of individuals of all species (N) collected per dredge sample. Areal species richness was estimated as the number of species (S) collected per dredge sample. H' diversity and the complement of Simpson's Index of dominance were calculated as follows:

$$H' = \frac{1}{N}\left(N \log N - \sum_{i=1}^{S} n_i \log n_i\right)$$

$$1 - \text{Simpson's Index} = 1 - \sum_{i=1}^{S} \frac{n_i(n_i-1)}{N(N-1)}$$

where n_i = number of individuals belonging to the i^{th} species.

The statistical significance of differences in mean values of density, richness, diversity and dominance were tested by analysis of variance and Student-Newman-Keuls multiple range test (Sokal and Rohlf, 1969).

Both normal and inverse numerical classifications were applied to the data set (Boesch, 1977). The normal classification clusters samples on the basis of similarity in the composition and relative abundance of species. Inverse classification clusters species on the basis of similarity in distribution among samples. The distribution and characteristics of the collection and species groups formed by numerical classification can be correlated with environmental factors including stress from pollution.

The classificatory procedures we used are described in detail by Boesch (1977). To reduce the data set to a manageable size, rare species represented by less than ten individuals were excluded from the classification. A square root transformation was applied in both normal and inverse analyses. The Bray-Curtis dissimilarity coefficient (D_{jk}) was used in the normal classification:

$$D_{jk} = \frac{\sum_{i}^{S} |x_{ij} - x_{ik}|}{\sum_{i}^{S} (x_{ij} + x_{ik})}$$

where: D_{jk} = dissimilarity between collections j and k

$x_{ij(k)}$ = square root of the number of individuals of the i^{th} species in the j(k) collection

S = number of species.

Prior to the inverse classification the square root of the abundance of species in each collection was standardized by dividing it by the sum of the square roots of the abundance in all collections. This standardization

permits a close affinity between species which differ in abundance but have similar distributions among the collections. The Manhattan metric dissimilarity coefficient (D_{ab}) was used in the inverse classification:

$$D_{ab} = 1/2\sum_{c}^{E}|x_{ca}-x_{cb}|$$

where: D_{ab} = dissimilarity between species a and b

$x_{ca(b)}$ = standardized square root of the abundance in the c^{th} collection of species a(b)

E = number of collections.

Once the matrix of dissimilarity values is generated, the collections (or species) are clustered to form a dendrogram. In this process all entities beginning with the least dissimilar are combined in an hierarchial fashion. This procedure requires a sorting strategy to determine the dissimilarity between a newly combined pair of entities and all other entities remaining in the matrix. The method we used is the flexible sorting strategy of Lance and Williams (1967):

$$D_{hk} = 0.625(D_{hi}+D_{hj})-0.25D_{ij}$$

where: entities i and j are fused to form group k

D_{hk} = dissimilarity between group k and entity h

$D_{hi(j)}$ = dissimilarity between entities h and i(j) in the matrix prior to fusion of i and j

D_{ij} = dissimilarity between i and j before they were combined.

Relationships between collection groups and species groups can be examined in two-way tables in which the original data matrix is reduced according to the normal and inverse classification results. We calculated the mean number of individuals of each species group within the samples of each collection group. We also determined the constancy of each species group in each collection group. Constancy is the observed number of occurrences of a species group in a collection group divided by the number of possible occurrences. Thus, if a species group includes 6 species and a collection group has 5 samples, 30 occurrences are possible. If every species occurs in every sample, the constancy index would be 1.0. If none of the species occur in the collection group, the index would be 0.

RESULTS

Cannery Effluents

The principal species processed by seafood canneries in Yaquina Bay are shrimp (Pandalus jordani), Dungeness crab (Cancer magister), a variety of bottom fish, and several salmon species. By July 1977 all of the Yaquina canneries had installed forty mesh screens which retain fish carcasses and shrimp and crab shells. These materials are used either as agricultural fertilizer or mink food. The canneries are constructed on docks and the effluent passing through the screens is discharged directly into the bay beneath the docks.

Although the canneries operate throughout the year, the effluent volume increases substantially during the shrimp season, April to October. During the 1978 season the Yaquina canneries operated fourteen machines for peeling shrimp, two at the New England Fish Co. near station A3, and four each at Bumble Bee Seafoods (A5), Depoe Bay Fish Co. (A7), and Alaska Packers Association (A9) (Fig. 2). At peak production approximately one million gallons (3.8×10^6 l) of shrimp processing effluent are discharged each day into Yaquina Bay. The BOD of this effluent is 1000-1500 mg/l (David Ertz, pers. comm.).

The shrimp processing effluent resulted in a patchy, whitish discoloration of the water beneath the docks along the bayfront and extending a short distance (10-30 m) into the bay (Fig. 4). This plume was most evident during slack water and was rapidly dispersed by tidal currents which are rather strong (100 cm/sec) in the vicinity of the canneries. Because of its buoyant freshwater nature, the plume was restricted to a relatively thin (<1 m) surface lens. During our surveys we observed large numbers of small fish (probably whitebait smelt, Allosmerus elongatus) apparently filter feeding within the plume.

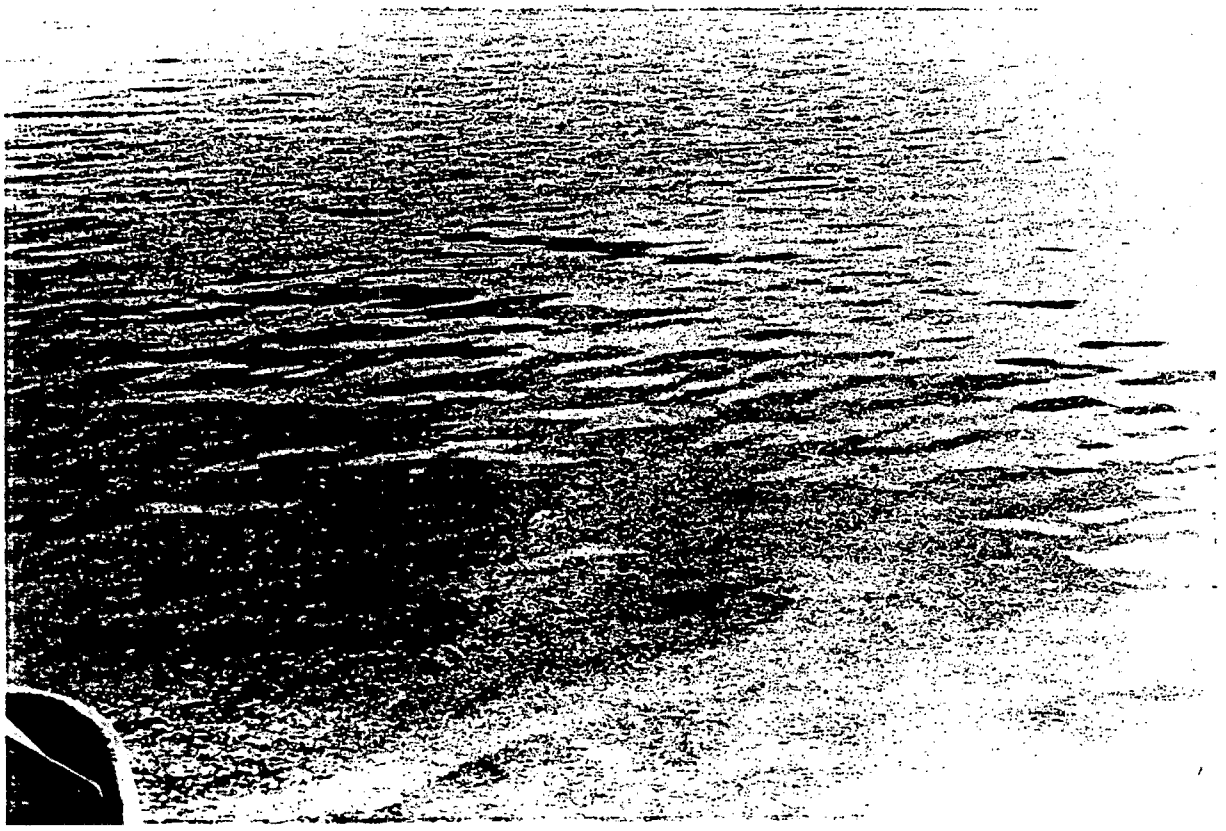


Fig. 4. Seafood cannery effluent plume in Yaquina Bay.

Water Quality and Depth

Stations A1, B1, and C1 were located in channels and were deeper (8 - 13 m) than the other stations (3.5 -6.5 m) (Fig. 2, Table 1). Stations B3 and B5 were at the edge of the channel. Stations B7 and B9 were out of the channel and very near an eelgrass (Zostera marina) bed.

The discoloration of the surface water was evident in secchi disc depths and surface turbidity (Table 1). At transect B, C, and D secchi disc depths ranged from 1.25 to 1.60 m. The secchi depth at stations A1, 3, 7, and 9 ranged from 0.83 to 1.17 m. The highest secchi depth of the survey (1.78 m) was recorded at station A5, indicating the patchy nature of the effluent plume. Surface turbidity showed exactly the same pattern as the secchi depths (Table 1). However, turbidity in bottom water along the A transect (1.3 - 2.1 NTU) was actually less than along the B, C and D transects (2.1 - 3.9 NTU) (Table 1). This reflects the restriction of the plume to the surface layer.

There was very little difference between the four transects in salinity and temperature at the surface, 1 m, and bottom (Table 1). Salinities ranged from 25.4 °/₀₀ on the surface at C1 to 33.4 on the bottom at A3. Temperature ranged from 13.2°C on the surface at A9 and C1 to 10.0°C on the bottom at A1 and A3. At most stations the bottom water salinity was 2 - 3 °/₀₀ greater and the temperature 1-2°C less than at the surface indicating slight stratification of the water column. A slight depression in surface salinity due to the cannery effluents is evident from a comparison of the difference in salinity between the surface and 1 m (Table 1). This difference was considerably higher along the A transect ($\bar{x}$ = 2.1 °/₀₀, range : 0.9 to 3.8 °/₀₀) than at the B, C, and D transects ($\bar{x}$ = 0.5, range : -0.1 to 1.4 °/₀₀). The dissolved oxygen concentration was $\geq$ 7.0 mg/l at all stations and depths

Table 1. Water quality and depth at the Yaquina Bay stations.

Parameter	Station													
	A1	A3	A5	A7	A9	B1	B3	B5	B7	B9	C1	D1	D3	D5
Depth (m)	8.0	5.5	5.5	3.5	4.0	13.0	6.5	4.0	4.5	4.5	10.5	5.0	6.5	6.0
Salinity (°/₀₀) Surface	30.2	27.1	29.1	26.4	26.1	27.1	26.6	26.1	26.2	26.0	25.4	29.4	26.1	27.8
1 m	31.6	30.9	31.0	28.6	28.1	27.4	27.1	26.6	26.7	26.5	26.8	29.3	26.9	27.7
Bottom	33.0	33.4	32.4	28.6	30.1	31.1	30.2	29.4	30.2	31.1	31.2	30.4	29.9	28.3
Temperature (°C) Surface	12.2	12.8	12.3	12.8	13.2	12.9	13.0	13.1	13.1	13.1	13.2	12.2	13.0	12.8
1 m	11.4	11.9	11.7	12.5	12.7	12.8	12.9	13.0	12.9	12.9	13.0	12.4	13.0	12.8
Bottom	10.0	10.0	10.8	12.5	12.0	11.4	11.8	12.2	11.8	11.6	11.8	12.0	12.1	12.5
Dissolved Oxygen (mg/l) Surface	7.2	7.2	7.9	7.0	7.9	8.2	8.2	8.3	8.2	8.4	8.5	8.2	8.4	8.3
1 m	7.3	7.2	7.7	7.1	7.9	8.2	8.1	8.1	8.0	8.2	8.3	8.0	8.2	8.2
Bottom	7.4	7.3	7.8	7.3	7.9	7.7	7.9	8.0	7.8	7.9	7.7	7.8	7.7	8.1
Secchi Depth (m)	1.17	1.07	1.78	0.83	1.06	1.59	1.60	1.53	1.57	1.56	1.45	1.38	1.33	1.25
Turbidity (NTU) Surface	3.8	3.7	1.5	140.0	8.0	2.5	2.4	2.4	2.4	2.1	2.5	3.5	3.3	3.5
Bottom	2.1	2.1	2.0	1.3	1.6	2.5	2.4	2.3	2.5	2.4	3.0	3.9	3.6	3.5
Organic Nitrogen (mg/l) Surface	6.18	2.68	3.30	88.74	3.84	0.14	0.12	0.21	0.15	0.12	0.19	0.15	0.24	0.23
Bottom	0.20	0.24	0.13	0.59	0.28	0.20	0.16	0.19	0.20	0.16	0.26	0.18	0.46	0.29
Ammonia (mg/l) Surface	0.37	0.14	0.13	3.46	0.24	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Bottom	0.04	0.08	0.03	0.06	0.04	0.02	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.04
Nitrate + Nitrite (mg/l) Surface	0.16	0.17	0.18	0.31	0.18	0.17	0.18	0.18	0.18	0.19	0.20	0.13	0.19	0.14
Bottom	0.14	0.12	0.12	0.15	0.14	0.15	0.12	0.12	0.15	0.17	0.14	0.11	0.12	0.16
Total Phosphate (mg/l) Surface	0.48	0.21	0.26	6.23	0.39	0.06	0.08	0.04	0.04	0.05	0.06	0.09	0.08	0.06
Bottom	0.05	0.10	0.07	0.12	0.09	0.04	0.06	0.04	0.07	0.06	0.06	0.09	0.09	0.06
Orthophosphate (mg/l) Surface	0.37	0.16	0.17	5.72	0.29	0.04	0.03	0.03	0.03	0.03	0.03	0.05	0.04	0.04
Bottom	0.05	0.05	0.05	0.06	0.04	0.04	0.04	0.03	0.04	0.03	0.04	0.04	0.04	0.04

(Table 1). DO concentrations at the surface were slightly less along the A transect (7.0 - 7.9 mg/l) than at the B, C and D transects (8.2 - 8.5 mg/l). This difference was less pronounced at 1 m and on the bottom.

The surface concentration of organic nitrogen along the A transect (2.7 - 88.7 mg/l) was more than an order of magnitude greater than surface values at the other transects (0.11 - 0.24 mg/l) (Table 1). However, organic nitrogen concentration at the bottom was very similar at the A (0.13 - 0.59 mg/l) and B, C, and D transects (0.16 - 0.45 mg/l). This same pattern was found for ammonia, total phosphate and orthophosphate (Table 1). Except for the surface concentration of nitrite plus nitrate at station A7 (0.31 mg/l), there was very little variation in this parameter between stations although surface concentrations (0.13 - 0.22 mg/l) were slightly higher than at the bottom (0.11 - 0.17 mg/l).

Sediment Characteristics

Particle Size Distribution

There were substantial differences in the particle size distribution of sediments between and within transects (Table 2). With the exception of samples A1 and A9, sediments along the A transect were poorly sorted and contained a much larger proportion of coarse sands and larger particles (> 20%) than any of the samples collected on the B and D transects. A particle size analysis was not conducted for the sample from the C transect because it contained only large shells and gravel. The only samples with a large proportion (> 40%) of very fine sands or smaller particles were collected at stations B7 and B9. The other samples collected on the B transect were very well sorted fine sands. The D transect sediments were characterized by a large proportion of both fine and medium sands. Human artifacts on the bottom along the A transect were much more numerous than at any of the other stations (Fig. 5).

Table 2. Mean size distribution (percent weight) of Yaquina Bay sediment samples.

Size Class	Station												
	A1	A3	A5	A7	A9	B1	B3	B5	B7	B9	D1	D3	D5
Coarse sands or larger	8.5	62.4	51.5	21.8	2.9	0.5	0	0	0.8	1.2	3.7	7.2	3.2
Medium sands	11.8	10.5	6.2	35.2	27.0	16.1	17.7	9.2	2.4	3.1	23.8	42.0	44.6
Fine sands	73.9	23.6	26.6	34.8	55.9	83.1	79.4	87.0	54.5	39.4	63.0	47.4	49.4
Very fine sands or smaller	5.8	3.5	15.7	8.2	14.3	0.4	3.0	3.7	42.3	56.3	9.6	3.4	2.8

Fig. 5. Human artifacts collected in one dredge sample at Yaquina Bay station A3.

Sediment Chemistry

The results of the chemical analyses performed on sediments collected by dredging and by divers are given in Tables 3 and 4 respectively. Comparison of values between these tables may not be valid because of the difference in collection technique. There was no evidence for a major increase in the concentration of any chemical parameter along the A transect. Concentrations of organic nitrogen, nitrate plus nitrite, and total soluble phosphate in interstitial water at station A9 were within the ranges recorded at the B and D transects. Interstitial concentrations of ammonia and orthophosphate at A9 were slightly higher than in the B and D samples. Organic carbon concentrations in bulk sediment samples were inversely related to particle size and reached a maximum at station B9. Total Kjeldahl nitrogen and total oil and grease concentrations were relatively high along the A transect although the ranges overlapped values for the B and D samples. With few exceptions, concentrations of hydrocarbon oil and grease, total sulfides and alkaline soluble sulfides were higher in the A samples.

Characteristics of the material deposited in the sediment traps placed on pilings under the dock opposite stations A5, A7, D1, and D5 are given in Table 5. The greatest weight of sediment was found in the traps at A7 and D5. The concentration of total nitrogen and organic carbon was slightly greater in the residue collected at A5. The organic nitrogen content of the filtrate was similar in all samples. Nutrients were higher in the filtrate obtained from traps on the A transect.

Macrobenthos

Density, Diversity, and Species Composition

The structure of the benthic assemblage was very similar at each of the four transects (Table 6). Analysis of variance showed no significant

Table 3. Chemical analyses of sediment samples collected by dredging, 10 May 1978.

Parameter	Station								
	A9	B1	B3	B5	B7	B9	D1	D3	D5
Interstitial water (mg/l)									
Organic nitrogen	1.27	0.62	0.00	0.88	5.59	1.43	5.01	5.40	2.31
Ammonia	2.89	0.63	1.26	1.70	2.48	1.91	1.96	2.28	1.31
Nitrate + nitrite	0.23	0.25	0.25	<0.05	0.23	0.10	0.22	0.18	0.25
Total soluble phosphate	0.65	<0.25	<0.25	0.37	0.52	0.42	0.77	0.40	0.26
Orthophosphate	0.45	0.15	0.26	0.28	0.36	0.39	0.17	0.25	0.18
Bulk sediment (mg/kg)									
Total organic carbon	3900	<2000	<3100	<2600	12450	29300	5640	1900	<1000
Total Kjeldahl nitrogen	2100	<200	<200	<500	1300	2300	710	1000	<200
Total oil/grease	790	770	180	420	490	290	380	650	22
Hydrocarbon oil/grease	100	180	<5	19	<5	<5	14	43	28
Total sulfides	360	<1	<2	18	95	31	29	12	15
Alkaline soluble sulfides	8	0	0	<2	4	3	3	2	<1

Table 4. Chemical analyses of sediment samples collected by divers, 18 July 1978.

Parameter	Station							
	A1	A3	A5	A7	A9	D1	D3	D5
Bulk Sediment (mg/kg)								
Total organic carbon	5400	5600	18100	9500	-	12200	12700	3400
Total Kjeldahl nitrogen	440	1250	1700	650	2900	520	<125	<100
Total oil/grease	1950	2120	2110	6620	3590	560	560	4060
Hydrocarbon oil/grease	123	230	554	261	219	79	93	107
Total sulfides	330	700	810	1400	520	350	19	23
Alkaline soluble sulfides	6	11	12	24	27	16	3	2

Table 5. Chemical analyses of Yaquina Bay sediment trap samples.

Parameter	Station A5	Station A7	Station D1	Station D5
Residue				
Weight (gm)	36.2	141.3	21.4	88.3
Total nitrogen (gm/kg)	7.4	6.1	6.2	6.3
Total organic carbon (gm/kg)	52.2	44.1	39.9	41.5
Filtrate (mg/l)				
Organic nitrogen	0.24	0.20	0.27	0.18
Ammonia	0.69	0.76	0.07	0.10
Nitrate + nitrite	0.08	0.14	0.06	0.06
Total phosphate	0.31	0.10	0.05	0.05
Orthophosphate	0.29	0.08	0.04	0.04

Table 6. Mean richness, density, dominance, and diversity of benthic samples at Yaquina Bay transects.

Parameter		Transect A	Transect B	Transect C	Transect D	Analysis of Variance
Areal Richness (S/Dredge)	$\bar{x}$	33.1	31.3	32.0	36.5	F = 0.23 n.s.
	Range	10-50	11-53	24-40	29-48	
Density of Individuals (N/Dredge)	$\bar{x}$	385.3	711.0	129.5	255.2	F = 3.35*
	Range	30-842	43-1283	78-181	104-382	
Dominance (1-Simpson's Index)	$\bar{x}$	0.85	0.81	0.91	0.89	F = 1.64 n.s.
	Range	0.74-0.91	0.54-0.93	0.89-0.92	0.82-0.91	
Diversity (H')	$\bar{x}$	1.04	0.94	1.21	1.20	F = 3.18*
	Range	0.84-1.19	0.49-1.18	1.13-1.28	1.08-1.37	

n.s. not significant; $^{*}F_{0.05(24,3)} = 3.01$; $^{**}F_{0.01(24,3)} = 4.72$

differences in either areal species richness or dominance between the four transects. The mean number of species collected in a dredge sample varied between 31.3 at transect B and 36.5 at transect D. Values for the complement of Simpson's Index varied between 0.81 at transect B and 0.91 at transect C. The range for both of these parameters was much greater at transects A and B than at C or D, indicating greater heterogeneity in benthic community structure at the stations closest to cannery row.

Significant differences were observed between the four transects for mean values of both density of individuals and H' diversity (Table 6). The mean density at transect B (711.0 individuals/dredge) was statistically greater than at any of the other transects. Although the mean density at transect C (129.5) was substantially less than at A (385.3) or D (255.2), the difference was not significant. Mean H' diversity at B (0.94) was signigicantly less than at D (1.20), but not significantly different from H' at C (1.21). This apparent contradiction is due to the sensitivity of the multiple range test to differences in sample size which was greater at D than at C. There were no other significant differences in mean H' between the transects.

The similarity in the structure of the benthic assemblage is also reflected in the nearly ubiquitous presence of dominant species among the four transects. Table 7 includes all species which ranked within the ten most abundant species at any one of the four transects. Of the 24 species selected by this criterion, all 24 were found at transect B, 22 at both B and D, and 21 at C. Despite this ubiquitous pattern, no single species ranked within the 10 most abundant species at all four stations. The differences between the transects are obviously due to the relative abundance of dominants rather than qualitative differences in species composition.

Table 7. Mean density of species which ranked within the ten most abundant species at one or more Yaquina Bay transects. Ranks are given in parentheses.

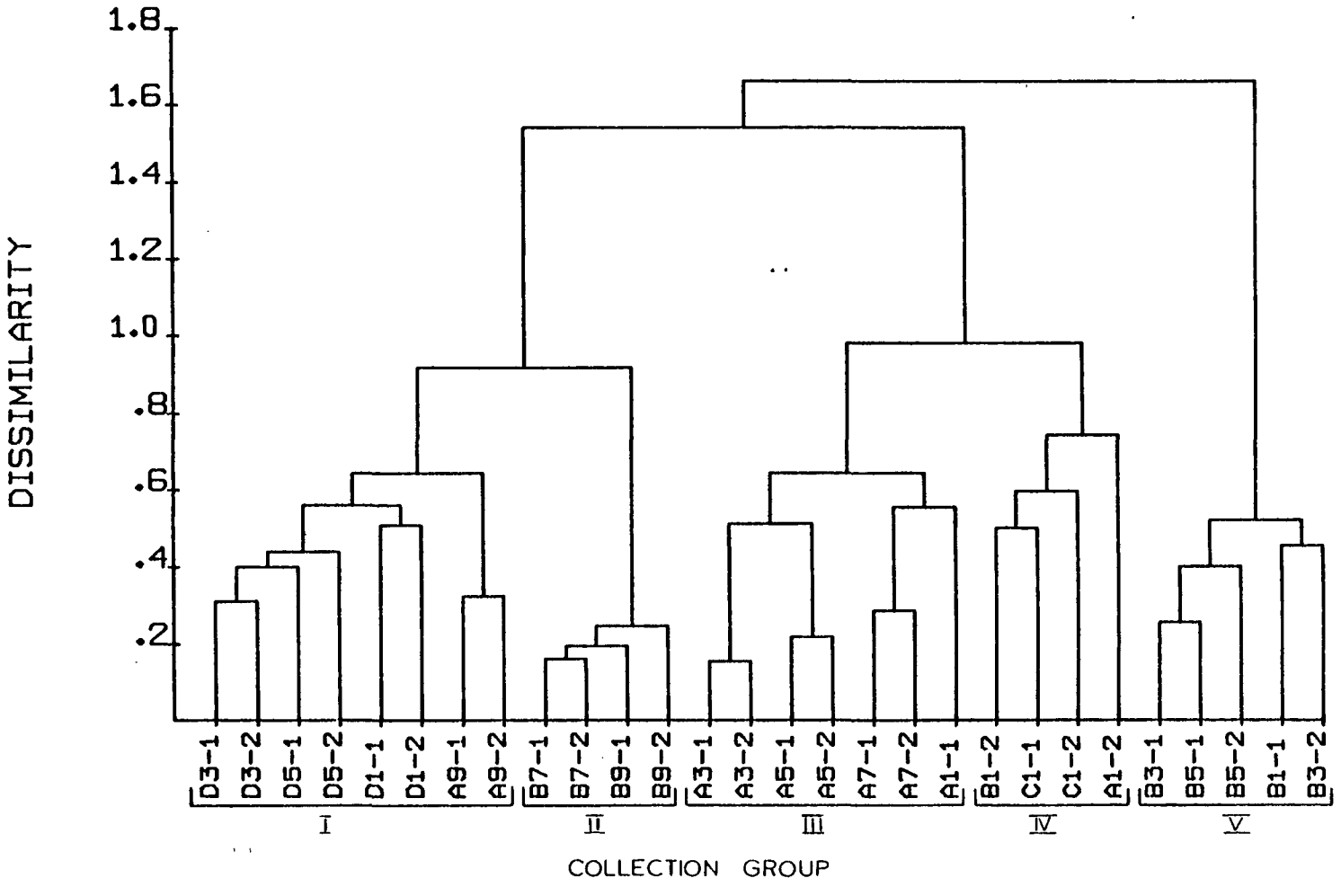
Species	Transect A	Transect B	Transect C	Transect D
Macoma inquinata	63.5 (1)	133.2 (1)	1.5	44.8 (1)
Melita dentata	48.3 (2)	1.4	23.0 (1)	3.7
Anisogammarus pugettensis	44.0 (3)	.3	0	2.5
Capitella capitata	31.0 (4)	5.8	.5	.8
Anaitides williamsi	30.5 (5)	.4	8.5 (4)	.7
Protothaca staminea	24.6 (6)	36.6 (7)	.5	14.3 (6)
Photis brevipes	22.2 (7)	30.1 (9)	1.0	13.5 (7)
Heptacarpus paludicola	16.2 (8)	.2	8.0 (5)	.5
Crangon nigricauda	12.0 (9)	5.0	20.5 (2)	.7
Platynereis bicanaliculata	9.9 (10)	1.3	2.0	3.5
Orchomenella sp. 1	.3	74.1 (2)	1.5	14.8 (5)
Olivella pycna	.7	71.0 (3)	.5	7.3 (8)
Paraphoxus epistomus	.2	61.6 (4)	10.5 (3)	30.3 (2)
Owenia collaris	1.4	42.7 (5)	.5	16.3 (3)
Olivella biplicata	.1	38.2 (6)	1.0	.2
Aglaja diomedea	.2	32.0 (8)	0	2.8
Glycinde picta	8.0	24.2 (10)	.5	7.0 (9)
Pontogeneia inermis	3.1	.4	4.0 (6)	0
Podocerus sp. 1	0	.1	4.0 (6)	0
Caprella laeviuscula	.1	1.4	4.0 (6)	.2
Paleanotus bellis	2.3	.2	3.5 (9)	.2
Archaeomysis grebnitzkii	0	2.5	3.5 (9)	.7
Cryptomya californica	6.1	22.6	1.0	16.3 (3)
Amphissa columbiana	.2	10.3	0	5.8 (10)

The dominant species were most similar at transects B and D (Table 7). The following eight species were among the ten most abundant at both of these transects: Macoma inquinata, Protothaca staminea, Photis brevipes, Orchomenella sp. 1, Olivella pycna, Paraphoxus epistomus, Owenia collaris, and Glycinde picta. Cryptomya californica and Amphissa columbiana ranked within the top ten at D, but not at B although the mean catch of both species per dredge sample was actually greater at B. The mean catch of all ten of the most abundant species at B was greater than at any other transect. The sixth and eighth most abundant species at B, Olivella biplicata and Aglaja diomedea, were relatively rare at the other transects.

The dominant fauna at transect C was not closely related to that of any other transect. The five least abundant dominants at C (Pontogeneia inermis, Podocerus sp. 1, Caprella laeviuscula, Paleanotus bellis, and Archaeomysis grebnitzki) did not rank within the top ten at any other transect and had rather low densities ($\leq$ 4 individuals/dredge). Four of the five most abundant species at C were also dominants at A: Melita dentata, Anaitides williamsi, Heptacarpus poludicola, and Crangon nigracauda. Paraphoxus epistomus was a dominant at C, B, and D. Transect A shared the four dominant species listed above with C, and three species (Macoma inquinata, Protothaca staminea, and Photis brevipes) with both B and D. Two of the most abundant species at A (Capitella capitata and Platynereis bicanaliculata) were present, but not dominant at B, C, or D.

Numerical Classification

The pattern of overlap between transects in the composition of the dominant species suggests a lack of faunal homogeneity within the transects. The normal classification of the data set resulted in five reasonably well-defined collection groups (Fig. 6). Twelve of the 14 station replicate pairs


DISSIMILARITY
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
D3-1
D3-2
D5-1
D5-2
D1-1
D1-2
A9-1
A9-2
B7-1
B7-2
B9-1
B9-2
A3-1
A3-2
A5-1
A5-2
A7-1
A7-2
A1-1
B1-2
C1-1
C1-2
A1-2
B3-1
B5-1
B5-2
B1-1
B3-2
I
II
III
IV
V
COLLECTION GROUP

of samples fell within the same collection group and 11 of these were "nearest neighbors." That result lends credence to a quantitative analysis of dredge samples which are often considered qualitative at best.

Samples taken along individual transects did not always fall into the same collection group (Fig. 6). Group I includes all transect D samples plus the replicates taken at station A9. Group II includes all samples from stations B7 and B9 and possesses the lowest within group faunal dissimilarity. Group III is restricted to the A transect and includes sample A1-1 and both replicates at stations A3, A5 and A7. The two replicates at C1 and samples A1-2 and B1-2 are included in Group IV which has the highest within group dissimilarity. Group V inclues sample B1-1 and the replicates at stations B3 and B5. At higher hierarchical levels, Group I is most closely related to II, and III to IV. Group V is quite distinct from the other collection groups.

In contrast to the statistical comparison of community structure parameters between transects, there were highly significant differences in areal richness, density of individuals, dominance, and H' diversity between the five collection groups (Table 8). Student-Newman-Keule multiple range test at the 0.05 probability level showed that mean areal richness of Group V (21.0 species) was not different from Group IV (23.2), but both means were less than in the other groups. Richness at III (34.1 species) and I (37.6) were not different. Richness at II (47.2 species) was greater than at III, but the difference between II and I was barely insignificant. The mean density of individuals was greater at II (1245.0 individuals) and less at IV (83.0) than at any other groups. Density at I (347.8 individuals), III (367.4), and V (417.4) were not different from one another. Mean values for the complement of Simpson's Index of dominance and H' diversity were very low at Group V (0.73 and 0.76, respectively) and significantly different from all

Table 8. Mean richness, density, dominance, and diversity of benthic samples in Yaquina Bay Collection Groups.

Parameter		Collection Group I	II	III	IV	V	Analysis of Variance
Areal Richness (S/Dredge)	$\bar{x}$	37.6	47.2	34.1	23.2	21.0	F = 7.59**
	Range	29-50	41-53	22-43	10-40	11-35	
Density of Individuals (N/Dredge)	$\bar{x}$	347.8	1245.0	367.4	83.0	417.4	F = 25.95**
	Range	104-842	1180-1283	80-647	30-181	272-549	
Dominance (1-Simpson's Index)	$\bar{x}$	0.86	0.88	0.87	0.90	0.73	F = 4.76**
	Range	0.74-0.93	0.84-0.90	0.81-0.91	0.87-0.93	0.54-0.86	
Diversity (h')	$\bar{x}$	1.13	1.12	1.09	1.12	0.76	F = 5.50**
	Range	0.84-1.37	1.02-1.18	0.94-1.19	0.90-1.28	0.49-1.04	

*$F_{0.05(23,4)} = 2.80$; **$F_{0.01(23,4)} = 4.26$

other groups. Within the other groups there were no differences in either dominance or H" diversity which varied between 0.86 - 0.90 and 1.09 - 1.13, respectively.

The inverse classification resulted in five species groups (Fig. 7, Table 9). Two way analyses of the mean number of individuals/sample and constancy of species groups in collection groups are shown in Tables 10 and 11, respectively.

One of the major results of the numerical classification was a division of all except one of the B transect samples into collection groups (CG) II and CG V which were distinctly different from one another. Group V included both replicates from stations B3 and B5 plus sample B1-1. It was strongly dominated by Olivella pycna, O. biplicata and Paraphoxus epistomus. These three species had a total mean abundance of 334.8 individuals/sample and accounted for 80% of the individuals collected in CG V. Their dominance accounts for the very low mean values for H' diversity (0.76) and the complement of Simpson's Index (0.73). None of the other species collected in these samples were very abundant. The high constancy and abundance of species group (SG) 5 in CG V merely reflects the ubiquity and density of the three dominants. The other ten species in SG 5 had only a moderate constancy (0.36) and low mean density (2.1 individuals/species/sample). Glycinde picta was the only species other than the dominants that appeared in all five samples. CG V had the lowest areal richness ($\bar{x}$ S/sample = 21.0) and, excluding the three dominants, the lowest mean density (82.6 individuals/sample) of any collection group.

The replicates from stations B7 and B9 constituted collection Group II which had the highest density of individuals, areal species richness, and within group faunal homogeneity of any of the collection groups. Species

Fig. 7. Species group clusters for Yaquina Bay samples.

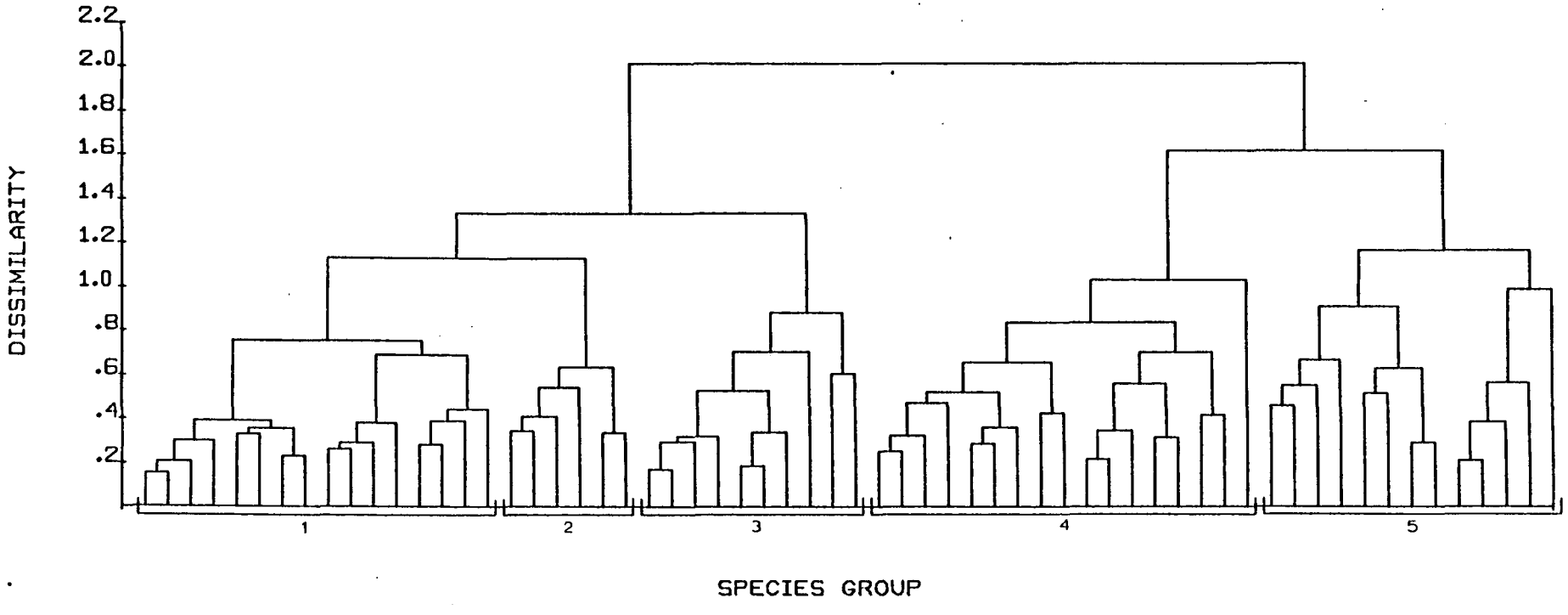

DISSIMILARITY
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
1
2
3
4
5
SPECIES GROUP

Table 9. Mean density of individuals in dredge samples within each collection group for members of each species group. Rank of the ten most abundant species within each collection group is given in parentheses.

	Collection Group				
	I	II	III	IV	V
Species Group 1					
Glycinde picta	12.8 (7)	56.0 (8)	2.7	.5	3.6
Macoma inquinata	96.2 (1)	331.5 (1)	19.2 (6)	.8	1.2
Protothaca staminea	36.6 (2)	89.2 (4)	5.6	.2	1.8
Haploscoloplos elongatus	6.4	11.0	.4	0	.2
Sphaerosyllis californiensis	1.5	7.8	2.0	0	0
Diastylis alaskensis	4.4	8.8	1.3	.2	1.0
Photis brevipes	12.5 (8)	74.8 (6)	28.7 (4)	1.2	.2
Cryptomya californica	13.9 (6)	56.5 (7)	6.3	1.5	0
Mediomastus californiensis	4.5	11.5	.4	0	2.2
Owenia collaris	14.0 (5)	90.5 (3)	0	.2	13.0 (4)
Protomedeia zotea	1.8	12.5	0	0	.2
Prionospio malmgreni	1.5	1.2	0	0	.8
Odostomia phanea	2.2	20.5	.6	0	2.4
Lamprops quadriplicata	2.8	30.8 (9)	0	.2	3.8 (9)
Tellina modesta	3.1	10.0	0	0	8.2 (5)
Amphissa columbiana	4.4	17.2	.3	0	6.8 (7)
Species Group 2					
Mytilus edulis	5.0	2.2	1.0	.5	0
Cancer magister	6.5 (10)	1.2	1.6	1.8	1.4
Pinnixia schmitti	6.4	1.0	.3	0	0
Gemma gemma	3.8	.5	.9	0	0
Cirratulus cirratus	6.2	.5	.7	0	0
Eupolymnia crescentis	1.8	0	0	.5	0
Species Group 3					
Tharyx parvus	0	30.5 (10)	0	0	0
Mitrella tuberosa	0	27.5	0	0	0
Ampharete arctica	0	3.2	.4	0	0
Dendraster excentricus	.1	3.0	0	0	.2
Aglaja diomedea	2.2	80.0 (5)	.1	0	0
Orchomenella sp. 1	11.2 (9)	184.8 (2)	.3	.8	.4
Nassarius mendicus	.5	27.2	0	0	.2
Nephtys caecoides	.6	1.2	0	0	0
Rhyncospio arenicola	.2	1.8	.3	0	0
Epitonium indianorum	0	4.5	0	0	0
Species Group 4					
Crangon nigricauda	1.1	1.8	16.1 (8)	12.5 (2)	7.2 (6)
Pontogeneia inermis	.1	0	4.1	2.5 (7)	.6
Melita dentata	3.6	1.0	67.6 (1)	13.0 (1)	1.4
Gnorimosphaeroma oregonensis	.1	0	1.4	.2	0
Cancer productus	.4	0	7.4	.2	.2
Cancer oregonensis	.2	0	3.3	.2	0
Paleanotus bellis	.4	.2	3.0	2.0	0
Heptacarpus paludicola	.6	0	22.3 (5)	5.2 (4)	.2
Pholis ornata	.1	0	2.3	0	0
Anaitides williamsi	.9	0	42.7 (3)	5.0 (5)	.8
Lumbrineris zonata	.5	0	7.9 (10)	.2	0
Anisogammarus pugettensis	3.6	.8	59.6 (2)	2.2 (9)	0
Harmothoe imbricata	1.1	1.5	6.1	.2	0
Platynereis bicanaliculata	3.9	2.8	12.7 (9)	1.0	.4
Armandia brevis	1.1	0	.7	0	.4
Capitalla capitata	24.4 (3)	14.2	17.1 (7)	.2	.2
Petrolisthes eriomerus	0	.2	6.0	0	0
Species Group 5					
Clinocardium nuttalli	1.0	1.0	.1	.8	.4
Parapleustes pugettensis	.9	.2	0	2.2 (9)	.6
Paraphoxus spinosus	2.1	.2	.9	2.5 (7)	1.6
Caprella laeviuscula	.1	0	.1	3.8 (6)	1.4
Archaeomysis grebnitzkii	.5	0	0	1.8	5.0 (8)
Mandibulophoxus gilesi	0	0	0	0	2.2
Hippomedon denticula	0	0	0	.5	2.0
Eohaustorius estuarius	.2	0	0	0	3.8 (9)
Olivella pycna	5.5	5.5	1.0	.5	137.4 (1)
Olivella biplicata	.1	.5	.1	1.0	75.6 (3)
Paraphoxus epistomus	22.8 (4)	1.0	.3	6.0 (3)	121.8 (2)
Parophrys vetulus	0	1.2	.6	0	3.6
Caprella californica	.1	0	1.4	.8	.2

Table 10. Mean density of species groups in dredge samples within Yaquina Bay collection groups.

	Species Group				
Collection Group	1	2	3	4	5
I	218.5	29.6	15.0	42.2	33.4
II	829.8	5.5	363.8	22.5	9.8
III	67.4	4.4	1.1	280.4	4.6
IV	5.0	2.8	0.8	45.0	19.8
V	45.4	1.4	0.3	11.4	355.6

Table 11. Constancy of species groups within Yaquina Bay collection groups. Very high values (>.75) are underlined twice, high values (.50-.74), once.

	Species Group				
Collection Group	1	2	3	4	5
I	.78	.77	.24	.43	.28
II	.97	.62	.85	.26	.31
III	.44	.43	.09	.80	.19
IV	.20	.29	.03	.41	.38
V	.40	.13	.06	.18	.51

Groups 1 and 3 are dominant (Tables 9, 10). Constancy was high or very high for both of these species groups plus SG 2, although the latter was represented by very few individuals (Table 11). SG 3 was almost entirely restricted to CG II. SG 1 reached its maximum abundance in CG II, but it was also the dominant species group in CG I.

Macoma inquinata and Orchomenella sp. 1 were the first and second most abundant species in each of the four CG II samples. The tremendous faunal homogeneity of this group was also due to the ubiquitous presence of 25 species in all samples. The other dominants include Owenia collaris, Protothaca staminea, Aglaja diomedea, Photis brevipes, Cryptomya californica, Glycinde picta, Lamprops quadriplicata, and Tharyx parvus. All of these species reached their maximum abundance in this collection group.

The benthos at B7 and B9 was very different from that at the other B transect stations, especially CG V. Only two species, Owenia collaris and Glycinde picta, ranked within the ten most abundant species in both CG II and CG V. The three dominants at CG V, Olivella pycna, O. biplicata and Paraphoxus epistomus had a total mean abundance per dredge sample of only 7.0 individuals within CG II.

Numerical classification also subdivided the A transect stations. The replicates at A9 clustered with all D transect samples in collection Group I. The remainder of the A samples (except for A1-2) formed collection Group III. The structure of the benthos in these groups is very similar, but the dominant species are rather different (Table 9). Only three species (Macoma inquinata, Capitella capitata, and Photis brevipes) appear within the ten most abundant species in both collection groups. The dominants in CG III (Melita dentata, Anisogammarus pugettensis, and Anaitides williamsi) were not abundant in CG I. CG I was much more closely related to CG II (stations B7, 9) in dominant species composition. Species groups 1 and 2 were abundant and had very high

constancy within CG I (Tables 10, 11). Species group 4 was most abundant and ubiquitous in CG III.

The distribution of the opportunistic polychaete Capitella capitata is shown in Table 12. Although C. capitata ranks as the third most abundant species in CG I, it was present in only three (D3-1, A9-1, A9-2) of the eight CG I samples. Its spatial distribution indicates a gradient of increasing density along both the A and B transects. It reached its maximum abundance at stations A7, A9, and B9. These collections contained a great variety of other species and relatively high faunal densities.

The two replicates taken on the C transect and samples A1-2 and B1-2 form collection Group IV. These samples contained relatively few species and individuals. The lack of any real dominant species resulted in relatively high values of H' diversity and the complement of Simpson's Index (Table 8). The constancy and abundance of all species groups was low in CG IV (Table 10, 11). Melita dentata was the most abundant species, but its mean density/sample was only 13.0 individuals. The composition of the "dominant" species in CG IV most closely resembles that of CG III.

Unidentified Species

The preceding results are based on those individuals which were identified to the species level. Specimens which could be identified only at higher taxonomic levels are listed in Table 13 for both transects and collection groups. The highest density of unidentified individuals was found at the A transect and in collection Group III which includes 7 of the 10 A transect samples. A relatively high abundance of anomuran megalopae is evident in CG III and of ophiuroideans in CG II (stations B7 and B9).

Table 12. Distribution of Capitella capitata in Yaquina Bay samples.

	Number of Individuals									
	Dredge Sample									
Transect	1-1	1-2	3-1	3-2	5-1	5-2	7-1	7-2	9-1	9-2
A	2	0	19	8	7	15	46	23	25	165
B	1	0	0	0	0	0	5	3	41	8
C	1	0								
D	0	0	5	0	0	0				

Table 13. Distribution of taxa not identified to the species level in Yaquina Bay transects and collection groups.

Taxon	Transect				Collection Group				
	A	B	C	D	I	II	III	IV	V
Anomuran megalopae	10.7	.1	0	1.3	1.9	.2	10.4	.8	0
Pycnogonida	3.2	5.2	8.5	2.5	2.1	1.2	4.3	6.2	7.8
Ophiuroidea	1.4	7.7	.5	0	0	18.5	2.0	.2	.6
Nudibranchia	4.8	1.7	2.0	.3	.2	0	6.7	1.2	3.4
Brachyuran megalopae	3.2	.5	3.0	3.8	3.0	.5	4.3	1.8	.6
Nemertea	2.5	.3	0	1.0	1.5	.8	2.7	0	0
Polycladida	.1	.1	5.5	0	0	0	.1	2.8	.2
Anthozoa	.3	0	.5	0	0	0	.3	.2	.2
TOTAL	26.2	15.6	20.0	8.9	8.7	21.2	30.8	13.2	12.8

DISCUSSION AND CONCLUSIONS

Cannery Effluents

The effects of seafood cannery effluents on water and sediment quality in Yaquina Bay are restricted to the immediate vicinity of the cannery docks. The effluent plume is quite turbid and has high nutrient concentrations. Because of its initial low salinity it is restricted to the surface layer where it mixes rapidly with estuarine water and is dispersed by strong tidal currents. The quality of water at the bottom along the A transect was comparable to that at other stations in the Bay. The dissolved oxygen concentration at both the surface and bottom was not less than 7 mg/l.

The strength of the currents along cannery row and the screening treatment of the effluents minimize the deposition of waste materials on the sea bed. There was no evidence for a major increase in the concentration of any chemical parameter in the sediments along the A transect. However, concentrations of Kjeldahl nitrogen, total and hydrocarbon oil and grease, and total and alkaline soluble sulfides were generally higher than at the other transects although the ranges often overlapped. Television observations and the dredged samples did not indicate the accumulation of shells or other waste products on the bottom. There was, however, a greatly increased incidence of human artifacts on the bottom at the A stations.

A very diverse and abundant macrofaunal benthic community was found immediately adjacent to the cannery outfalls (transect A). Although this assemblage differed in species composition from the benthos collected across the Bay at the Oregon State University docks (transect D), there were no statistical differences in community structure parameters of density, dominance, diversity or richness.

Tidal or current dispersion of wastes seems to be the major factor determining the impact of cannery effluents. Beyer, Nakatani and Staude (1975)

examined environmental conditions near salmon cannery outfalls in an area of strong tidal action at Petersburg, Alaska. Their results are similar to ours. DO concentrations near the Petersburg canneries were not lower than ambient values. Turbidity was high only in the immediate vicinity of the outfalls. Their analysis of intertidal communities indicated that spatial differences could not be attributed to outfall effects. The Petersburg effluents were not screened, resulting in temporary accumulations of heads, tails and viscera in a small area north of the outfalls. The subtidal benthos was less diverse beneath these accumulations. Beyer et al. (1975) believed that grinding wastes would alleviate this problem.

Cannery effluents can cause major environmental degradation if flushing is inadequate. Stewart and Tangarone (1977) and Karna (1978) examined water and sediment quality in the vicinity of seafood cannery outfalls in Dutch Harbor, Alaska. They found that DO concentrations in bottom water were often less than 6 mg/l and in one instance the bottom water was anaerobic. Concentrations of ammonia and total phosphorus at the bottom were substantially greater than at control locations. Most of the shells and heavier wastes accumulated on the bottom within a 30 m radius of the outfalls. Deposits of less dense material extended well beyond the 30 m radius. These deposits resulted in high concentrations of hydrogen sulfides and organic matter in the sediments. Qualitative observations during diving surveys indicated a greatly reduced richness of benthic species in the area of waste deposits.

Reish (1959) and Barnard and Reish (1959) reported a tremendous degradation of the macrobenthos in poorly flushed embayments next to fish canneries in Los Angeles Harbor and Newport Bay, California. Only 7 species and 134 individuals were collected from the cannery area in Newport Bay, and 3 species and 88 individuals in Los Angeles Harbor. The widely recognized pollution indicator species, Capitella capitata, accounted for about 90% of

the individuals in both cases. This polychaete reached its maximum density in our survey at stations A7, A9, and B9. The collections at these stations contained an average of 45 species and 715 individuals per dredge sample. C. capitata accounted for about 7% of the individuals. We do not believe that a significant ecological alteration is indicated by the presence of an opportunistic species in the midst of such an abundance and variety of other benthic invertebrates.

This report concerns cannery effluent impacts on the macrobenthos, sediment and water quality as determined from a single ecological survey. Limitations in time and resources prevented an analysis of temporal changes or effects on other biological communities. One assemblage that certainly warrants additional study is the intertidal fauna and flora on the pilings and rocks beneath the cannery docks. Michael Mix (personal communication) has observed a high incidence of mortality, abnormal and possibly neoplastic cells, and inhibited gametogenesis in mussels, Mytilus edulis, collected from the cannery dock pilings in Yaquina Bay. These disorders were correlated with increased body burdens of benzo(α)pyrene, a carcinogenic petroleum hydrocarbon. The source of the benzo(α)pyrene is uncertain. Dunn and Stich (1976) attributed elevated levels of benzo(α)pyrene in mussels growing near pilings in Vancouver harbor to the creosote used as a piling preservative.

Spatial Heterogeneity in Yaquina Bay Benthos

We observed substantial within and between transect variations in the structure and species composition of Yaquina Bay benthic assemblages. The characteristics of the benthos on the A transect do not seem to be attributable to cannery outfall effects. There were no substantial differences between any of the stations in the temperature, salinity or dissolved oxygen in water near the bottom. Water depth was slightly greater at the channel stations (A1, B1, C1), but major differences in the benthos were found

between stations of comparable depth. Sediment particle size distribution is the only environmental factor that was closely related to spatial changes in the benthos.

The numerical classification of the Yaquina Bay samples produced five collection groups. The stations which clustered together on the basis of faunal similarity are also similar in sediment characteristics. In Table 14 the sediment preferences as described in the scientific literature are given for benthic species collected in Yaquina Bay. Species are listed in Table 14 within the collection group in which they achieved their maximum abundance (see Table 9 for density data).

Most of the species reached maximum density in collection groups II or III. Sediments at these two groups of collections were distinctly different. CG II includes stations B7 and B9 which were the only stations in which the sediment contained a large proportion of fine particles. Almost all species which were most abundant at CG II are described in the literature as having a preference for muddy sand or similar fine sediment types (Table 14). All species which reached their maximum abundance in CG II were clustered in species groups 1 and 3 by the inverse numerical classification. The distinction between these two species groups is that the members of SG 3 have a stronger preference for muds and were almost entirely restricted to CG II (Tables 14, 9). SG 1 however was more tolerant of sandier sediments and therefore had a wider spatial distribution in the Bay.

In contrast to the muddy sediments at CG II, the sediments at CG III (sample A1-1 and both replicates at A3, 5, 7) were poorly sorted and contained a large proportion of coarse sands, gravel and shells. The literature indicates that the species with a maximum density at CG III had a preference for coarse sediment types (Table 14). These species were restricted to SG 4 which was also present, but much less abundant in CG IV

Table 14. Sediment preference of Yaquina Bay macrobenthos as described in the scientific literature. Species are assigned to the collection group in which they achieved their maximum density.

Collection Group Stations Sediment Type	Species	Species Group	Sediment Preference	Reference
Collection Group II Stations B7, B9 Fine sand, silt and clay.	Glycinde picta	1	sandy mud	1,2
	Macoma inquinata	1	silt and mud	1
	Protothaca staminea	1	sandy mud, sands, gravel, rocks	1,3,4
	Haploscoloplos elongatus	1	very fine sands, muddy sand	5,6,7
	Sphaerosyllis californiensis	1	silt, mud, and mixed sediment	1,7
	Cryptomya californica	1	mud or sand	1
	Mediomostus californiensis	1	mud, fine or very fine sand	1,2,6,8
	Owenia collaris	1	muddy sand, fine sand	1,9,10,11
	Lamprops quadriplicata	1	fine sand	12
	Tellina modesta	1	silty sand, sand	1,13
	Amphissa columbiana	1	sand, gravel, rocks	1
	Tharyx parvus	3	fine silty muds, muddy sands	1,8,14
	Mitrella tuberosa	3	sand and gravel	1
	Ampharete arctica	3	mud	15
	Aglaja diomedea	3	mudflats	1,3,16
	Nassarius mendicus	3	mud, sand, rocks	1
	Rhyncospio arenicola	3	muddy sand	17
	Orchomenella sp.	3	sandy mud	18
Collection Group III Stations A1,3,5,7 Poorly sorted sands, gravel and shell.	Crangon nigricauda	4	rocks, sand	1
	Melita dentata	4	rocks, stones	19
	Gnorimosphaeroma oregonensis	4	sand, stones, gravel, rocks	20
	Anisogammarus pugettensis	4	marshes	1
	Cancer productus	4	coarse sands, gravel, rocks	21
	Heptacarpus paludicola	4	pools on mudflats and rocky intertidal	1
	Anaitides williamsi	4	muddy sand, shell fragments	1,14
	Lumbrineris zonata	4	mixed sediments or clean sand	7
	Harmothoe imbricata	4	rocks	1
	Platynereis bicanaliculata	4	sand, shells, rocks	1,14
	Petrolisthes eriomerus	4	rocks	22,23
Collection Group V Stations B1,3,5 Very well sorted fine sands	Eohaustorius estuarius	5	clean, medium sand	24
	Paraphoxus epistomus	5	medium fine unstable sand	19,25
	Olivella biplicata	5	clean sand	1
Collection Group I Stations A9, D1,3,5 Fine and medium sands	Cancer magister	2	sand	1,21
	Gemma gemma	2	sands or muddy sands	26
	Cirratulus cirratus	2	sand, rocks	1,27
	Eupolymnia crescentis	2	sandy mud	1
	Capitella capitata	1	organically enriched fine sediments	1,14,28

1 Smith and Carlton (1975), 2 Barnes (1966), 3 Ricketts and Calvin (1952), 4 Fitch (1953), 5 Reish (1963), 6 Reish (1964), 7 Hartman (1968), 8 Vassallo(1970), 9 Perkins (1974), 10 Hartman (1969), 11 Fager (1964), 12 Given (1965), 13 Maurer (1967), 14 Barnard and Reish (1959), 15 Sanders (1960), 16 Abbott (1974), 17 Wieser (1959), 18 Hurley (1963), 19 Bousfield (1973), 20 Rees (1975), 21 Schmitt (1921), 22 Gonor and Gonor (1973), 23 Knudsen (1964), 24 Bosworth (1973), 25 Maurer et al. (1974), 26 Narchi (1971), 27 Reish (1949), 28 Warren (1977).

(samples A1-2, B1-2, C1-1 and 2). The sediments at CG IV were shells and gravel [sediment data given in Table 2 are representative of the first replicate taken at stations A1 and B1]. The depauperate fauna in CG IV may be related to the location of these stations in channels where they are subjected to dredging and a great deal of ship activity.

Very well sorted fine sands occurred in sample B1-1 and both replicates at stations B3 and B5 (CG V). Species group 5 was dominant and its members are known to prefer clean fine or medium sands (Table 14). Medium and fine sands are present at CG V (the D transect and station A9). Species group 2 reached its maximum abundance at CG V and with the exception of Mytilus edulis, it is a sand dwelling assemblage.

In summary, sediment composition is a major factor controlling the distribution of subtidal benthic invertebrates in Yaquina Bay. Two major assemblages were encountered in our survey. The muddy sands at stations B7 and 9 support a very abundant and diverse benthic community dominated by Macoma inquinata, Orchomenella sp. 1, and Owenia collaris. The more psammophilic species in this community were also abundant in the medium and fine sands at station A9 and the D transect. The second major assemblage was found in the coarser sediments along most of the A transect. The more abundant species there were Melita dentata, Anisogammarus pugettensis, and Anaitides williamsi. A depauperate example of this community was encountered in coarse channel sediments. The fine clean sands along channel banks were densely populated by only three species, Olivella pycna, O. biplicata, and Paraphoxus epistomus.

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Appendix 1. Raw data set for the macrofaunal benthic collections made in Yaquina Bay, Oregon on 9-10 May 1978.

	A1-1	A1-2	A3-1	A3-2	A5-1	A5-2	A7-1	A7-2	A9-1	A9-2
ACMAEA SP	1									
ACTEOCINA CULCITELLA									1	
AGLAJA DIOMEDEA			1						1	
AMAENA OCCIDENTALIS	1									
AMPHARETE ARCTICA								3		
AMPHISSA COLUMBIANA	1					1				
AMPITHOE LACERTOSA				1						
ANAITIDES WILLIAMSI	6	3	74	93	4	27	35	60	1	2
ANISOGAMMARUS CONFERVICOLUS					2					
ANISOGAMMARUS PUGETTENSIS	6	9	162	232		2	7	8	2	12
ANOMURAN MEGALOPA	3	1	28	19	17	5	18	9	1	6
ANTHOZOAN UNID		1						2		
ARMANDIA BREVIS			2			1	2		1	7
BARNEA SUBTRUNCATA				1						
CANCER MAGISTER	2		3	3	1	1		1	5	14
CANCER OREGONENSIS			6	1	3	2	6	3		1
CANCER PRODUCTUS	4		14	11	8	7	4	4		3
CAPITELLA CAPITATA	2		19	8	7	15	46	23	25	165
CAPRELLA CALIFORNICA					1		9			
CAPRELLA LAEVIUSCULA					1					
CIRRATULUS CIRRATUS					1	3		1	8	8
CISTENIDES BREVICOMA						1			1	
CLINOCARDIUM NUTTALLI			1						1	2
COROPHIUM OAKLANDENSE			3							
CRAB MEGALOPA	1	1	10	6		7	1	5	1	
CRANGON NIGRICAUDA		2	11	12	29	58		3		5
CRYPTOMYA CALIFORNICA	2	4	6	5	3	7	12	9	6	7
DIASTYLIS ALASKENSIS			2	3		1	3		6	9
DYNAMENELLA SHEARERI			2			1				
ENOPHRYS BISON			1		1			1		
EOHAUSTORIUS ESTUARIUS										1
EULALIA AVICULISETA				2			1			
EUPOLYMNIA CRESCENTIS									1	2
EUSYLLIS BLOMSTRANDI			2			2				
GEMMA GEMMA			2	4					5	9
GLYCINDE PICTA		1	2	1	1	2	6	7	12	48
GNORIMOSPHAEROMA OREGONENSIS	1		4	1	3	1				
GYPTIS BREVIPALPA										1
HAPLOSCOLOPLOS ELONGATUS						3			7	20
HARMOTHOE IMBRICATA			12	8	4	15	3	1	2	
HEPTACARPUS PALUDICOLA	1	4	4	1	71	77	1	1	1	1
HETERMASTUS FILOBRANCHUS							1			1
HIATELLA ARCTICA					1					
ICOTEA FEWKESI				1		2	1			
ISOPOD A				1						
JASSA FALCATA									2	
LACUNA MARMORATA						1	1			
LAMPROPS QUADRIPLICATA									7	1
LETOCHELIA DUBIA										2
LIMNORIA LIGNORUM								1		
LUMBRINERIS ZONATA	1		20	19	1	1	5	8		2
MACOMA INQUINATA	11		20	14	21	24	29	15	172	329
MACOMA NASUTA							1			
MEDIOMASTUS CALIFORNIENSIS								3	3	6
MELITA DENTATA	27	3	121	119	83	106	4	6	1	6
MICROPODARKE DUBIA			2	2		2				2
MIMULUS FOLIATUS			1							
MYTILUS EDULIS				1	1	1	2	2		9
NEMERTEAN UNID					12	3		4	1	5
NEPHTYS CAECOIDES										1
NEPHTYS FERRUGINEA										2
NUDIBRANCH UNID	1	1	15	14	3	5	5	4		
ODONTOSYLLIS PARVA							1			
ODOSTOMA SP					1	4				
ODOSTOMIA PHANEA	1				1	2			2	3
OLIVELLA BIPLICATA			1							
OLIVELLA PYCNA	1		3		2			1		
OPHIUROIDEA UNID			1	1	2	7	2	1		
ORCHOMENELLA SP I				1			1			1
OWENIA COLLARIS									1	13
PAGURUS SAMUELIS	1									2
PALEANOTUS BELLIS			10		3	4	1	3		2
PARAPHOXUS EPISTOMUS					1	1				
PARAPHOXUS SPINOSUS			4	1				1		
PARAPLEUSTES PUGETTENSIS										2
PAROPHRYS VETULUS			1	1	2					
PEISIDICE ASPERA					1					
PETROLISTHES ERIOMERUS			29	13						
PHOLIS ORNATA			4		7	4	1		1	
PHOTIS BREVIPES	2	2	53	61	28	26	21	10	8	11
PINNIXIA SCHMITTI			1	1					6	10
PIONOSYLLIS GIGANTEA						1				
PISASTER BREVISPINUS										1
PLATYNEREIS BICANALICULATA	1		12	13		19	36	8	1	9
POLYCLADIDA UNID				1						
POLYNOID SP A			2							
POLYNOID SP B			1	1						
PONTOGENEIA INERMIS		1	5	5	12	6		1		1
PRIONOSPIO CIRRIFERA			1							2
PRIONOSPIO MALMGRENI									1	1
PROTOTHACA STAMINEA	6		12	2	2	3	5	9	117	90
PSEUDOPOTAMILLA SOCIALIS								2		
PUGETTIA PRODUCTA							2			
PYCNOGONID UNID	1		4	12	3	4	6		1	1
PYCNOPODIA HELIANTHOIDES	1	1					1			
RHOMBIDELLA COLUMBIANA								1		
RHYNCOSPIO ARENICOLA							1	1	1	
SAXIDOMUS GIGANTIUS				1						1
SCYRA ACUTIFRONS						1				
SPHAEROSYLLIS CALIFORNIENIS			3	2		4	5			9
SPIOPHANES FIMBRIATA										1
SYLLIS SP (BANSE)				1			2	2		2
TELLINA MODESTA										2
TIRON BIOCELLATA					1		1			
TRANSENNELLA TANTILLA										1
TRITELLA LAEVIS	1									
VENERUPIS PHILIPPINARUM			1							

	B1-1	B1-2	B3-1	B3-2	B5-1	B5-2	B7-1	B7-2	B9-1	B9-2
ACTEOCINA CULCITELLA								1		
ACTEOCINA HARPA							2	1	2	1
AGLAJA DIOMEDEA							79	79	34	128
AMPHARETE ARCTICA							5	2	6	
AMPHISSA COLUMBIANA					6	28		2	23	44
ANAITIDES WILLIAMSI	2									
ANISOGAMMARUS PUGETTENSIS								3		
ANOMURAN MEGALOPA										1
APCHAEOMYSIS GREBNITZKII	25									
ARMANDIA BREVIS	1					1				
CALIANASSA CALIFORNIENSIS										1
CANCER MAGISTER	3	1	1	1		2	1	1	1	1
CANCER OREGONENSIS		1								
CANCER PRODUCTUS						1				
CAPITELLA CAPITATA	1						5	3	41	8
CAPRELLA CALIFORNICA						1				
CAPRELLA LAEVIUSCULA	7	7								
CIRRATULUS CIRRATUS								1	1	
CISTENIDES BREVICOMA								1	1	1
CITHARICHTHYS SORDIDUS						1				
CLINOCARDIUM NUTTALLI	1			1			2		1	1
COROPHIUM OAKLANDENSE										1
CRAB MEGALOPA	2				1			1		
CRANGON NIGRICAUDA	27	7	1		5	3	5	1	1	
CRYPTOMYA CALIFORNICA							50	18	90	68
CUMELLA VULGARIS									1	
DENDRASTER EXCENTRICUS	1						3	4	5	
DIASTYLIS ALASKENSIS						5	11	13	2	6
ENOPHRYS BISON		1								
EOHAUSTORIUS ESTUARIUS	14		2	3						
EPITONIUM INDIANORUM									8	10
EUSYLLIS BLOMSTRANDI	1									
GEMMA GEMMA							1			1
GLYCINDE PICTA	1		1	1	6	9	56	70	58	40
HALOSYDNA BREVITOSA	1									
HAPLOSCOLOPLOS ELONGATUS					1		18	9	11	6
HARMOTHOE IMBRICATA							4		2	
HEPTACARPUS BREVIROSTRIS	1	1								
HEPTACARPUS PALUDICOLA	1	1								
HETEROMASTUS FILOBRANCHUS					1			1	3	1
HIATELLA STRIATA								1	1	
HIPPOMEDON DENTICULATUS	8	1	1	1						
IDOTEA FEWKESI								1		
LACUNA MARMORATA			1							
LAMPROPS QUADRIPLICATA			2		5	12	60	15	7	41
LETOCHELIA DUBIA								3		
LITTORINA SCUTULATA										1
LOXORHYNCHUS CRISPATUS									1	
LUMBRINERIS CALIFORNIENSIS								1		
LUMBRINERIS CRUZENSIS									1	
LYONSIA CALIFORNICA									1	
MACOMA INQUINATA					3	3	356	401	318	251
MANDIBULOPHOXUS GILESI	11									
MEDIOMASTUS CALIFORNIENSIS					10	1	6	7	16	17
MELITA DENTATA	4	3			1	2	1	1	1	1
MITRELLA TUBEROSA							46	17	45	2
MONOCULODES SPINIPES	3					1				
MYRIOCHELE HEERI								1	3	2
MYTILUS EDULIS							2	1	3	3
NASSARIUS MENDICUS					1		30	5	29	45
NEMERTEAN UNID								1	2	
NEPHTYS CAECA										1
NEPHTYS CAECOIDES							2	2		1
NEPHTYS CILIATA	4		1	1						
NEPHTYS FERRUGINEA								1		
NUDIBRANCH UNID	13		2		1	1				
ODOSTOMIA PHANEA						12	26	15	8	33
OLIVELLA BIPLICATA	68	2	133	25	105	47		1	1	
OLIVELLA FYCNA	88	1	202	55	207	135	2	3	5	12
OPHIUROIDEA UNID	1				1	1	20	13	22	10
ORCHOMENELLA SP I						2	160	243	151	185
OWENIA COLLARIS			4	1	41	19	81	75	112	94
PAGURUS SAMUELIS		1								
PALEANOTUS BELLIS		1							1	
PANDORA GLACIALIS									1	
PARAPHOXUS EPISTOMUS	98	3	146	179	138	48				4
PARAPHOXUS SPINOSUS	8	4								1
PARAPLEUSTES PUGETTENSIS	3	4					1			
PAROPHRYS VETULUS	7		1		7	3	1	1	1	2
PETROLISTHES ERIOMERUS							1			
PHOLOE TUBERCULATA								1		
PHOTIS BREVIPES	1	1					111	83	50	50
PINNIXIA SCHMITTI							1	2		1
PLATYNEREIS BICANALICULATA						2	8		3	
PODOCERUS SP I	1									
POLYCIRRUS SPI						1				
POLYCLADIDA UNID						1				
PONTOGENEIA INERMIS	3	1								
PRIONOSPIO CIRRIFERA							1		1	
PRIONOSPIO MALMGRENI			2		2		1	2	2	
PROTOMEDEIA ZOTEA					1		3	5	7	35
PROTOTHACA STAMINEA	1		1			7	63	128	140	26
PSEUDOPOTAMILLA SOCIALIS	1									
PYCNOGONID UNID	37	8	1		1		1	1	2	1
PYCNOPODIA HELIANTHOIDES	1									
RHYNCOSPIO ARENICOLA							1		1	5
SABELLARIA CEMENTARIUM	1									
SAXITOMUS GIGANTIUS						1			1	1
SILIQUA PATULA									1	
SPHAEROSYLLIS CALIFORNIENIS							5	10	8	8
SPIONIDAE SP 6								1		
SPIOPHANES BOMBYX								4		1
SPIOPHANES FIMBRIATA								2		1
SPIOPHANES SP A							1			
SYLLIS ELONGATA		2								
TELLINA BODEGENSIS									1	2
TELLINA MODESTA	5			11	9	16	9	8	9	14
TELLINA NUCULOIDES	1									
THARYX PARVUS							15	30	58	19
TRANSENNELLA TANTILLA									2	

	C1-1	C1-2	D1-1	D1-2	D3-1	D3-2	D5-1	D5-2
ACTEOCINA HAPPA	1				1			
AGLAJA DIOMEDEA			5	7	1	4		
AMAENA OCCIDENTALIS					1	1		1
AMPHISSA COLUMBIANA			1	25	2	7		
AMPITHOE LACERTOSA						1		
ANAITIDES SP A				1			2	
ANAITIDES WILLIAMSI	17			1	1		1	1
ANISOGAMMARUS PUGETTENSIS			1	2	2	7	1	2
ANOMURAN MEGALOPA			3		3	2		1
ANTHOZOAN UNID	1							
ARCHAEOMYSIS GREBNITZKII	7		3				1	
ARCHIDORIS ODHNERI	1							
ARMANDIA BREVIS					1			
AUTOLYTUS VERRILLI	2							
CALLIOSTOMA LIGATUM		1						
CANCER MAGISTER	4	2	3	1	3	24	1	1
CANCER OREGONENSIS					1			
CANCER PRODUCTUS		1						
CAPITELLA CAPITATA	1				5			
CAPRELLA CALIFORNICA		3	1					
CAPRELLA LAEVIUSCULA	6	2						1
CIRRATULUS CIRRATUS				1	18	3	12	
CLINOCARDIUM NUTTALLI	2	1	2	1		1	1	
COROPHIUM BREVIS				3				
CRAB MEGALOPA	5	1	2	4		7	6	4
CRANGON NIGRICAUDA	31	10	2		2			
CRYPTOMYA CALIFORNICA		2	8	59	3	17	5	6
DENDRASTER EXCENTRICUS				1				
DIASTYLIS ALASKENSIS		1		12	2	1		5
DIASTYLOPSIS DAWSONI					1			
DORIDELLA STEINBERGAE	1							
EOHAUSTORIUS ESTUARIUS				1				
ETEONE LACTEA							1	
ETEONE LONGA							1	
EULALIA AVICULISETA	3				1			
EUPOLYMNIA CRESCENTIS	1	1			4	2	5	
EXOGENE LOUREI	2							
GEMMA GEMMA						15	1	
GLYCINDE PICTA	1		2	6	10	10	13	1
GNORIMOSPHAEROMA OREGONENSIS	1		1					
HAPLOSCOLOPLOS ELONGATUS			2	3	9	5	4	1
HARMOTHOE IMBRICATA	1		1		4	1		1
HARMOTHOE LUNULATA					1		1	
HEPTACARPUS BREVIROSTRIS		3						
HEPTACARPUS PALUDICOLA		16	1		1			1
HIPPOMEDON DENTICULATUS	1							
IDOTEA FEWKESI	1							
ISCHYROCERUS ANGUIPES			2					
LACUNA MARMORATA		1		1				1
LAMPROPS QUADRIPLICATA	1		9	5				
LIMNORIA ALGARUM								1
LITTORINA SCUTULATA		2						
LOPHOPANOPEUS BELLUS		1			1			
LOXORHYNCHUS CRISPATUS		1						
LUMBRINERIS CRUZENSIS					1			
LUMBRINERIS ZONATA	1					1		1
MACOMA INQUINATA	2	1	10	82	45	80	22	30
MAGELONA SACCULATA					1			
MEDIOMASTUS CALIFORNIENSIS			1		12	1	10	3
MELITA DENTATA	29	17	5		3	4		10
MESOCHAETOPTERUS TAYLORI						3	1	
MONOCULODES SPINIPES	2							
MYTILUS EDULIS	1	1	3		10	14	2	2
NAINERIS UNCINATA						1	1	
NASSARIUS MENDICUS				4				
NEMERTEAN UNID					3		3	
NEOAMPHITRITE ROBUSTA					1			
NEPHTYS CAECOIDES			3				1	
NUCELLA LAMELLOSA					1	1	1	
NUDIBRANCH UNID	3	1				1		1
ODOSTOMIA PHANEA				8	1	4		
OLIVELLA BIPLICATA	2		1					
OLIVELLA PYCNA	1		27	14		3		
OPHIUROIDEA UNID	1							
ORCHOMENELLA SP I	3		17	36	15	10	8	3
OWENIA COLLARIS	1			26	5	18	44	5
PALEANOTUS BELLIS	7		1					
PARAPHOXUS EPISTOMUS	21		108	1	27	33	10	3
PARAPHOXUS SPINOSUS	6			11	3	3		
PARAPLEUSTES PUGETTENSIS	2	2	2	2	1			
PHOTIS BREVIPES	2		8	22	8	13	15	15
PIANNIXIA SCHMITTI			3	16	3	8	4	1
PIDNOSYLLIS GIGANTEA	1							
PISASTER OCHRACEUS					1			
PLATYNEREIS BICANALICULATA	3	1	6	3	5	4	1	2
PODOCERUS SP I	5	3						
POLYCLADIDA UNID	6	5						
PONTOGENEIA INERMIS	5	2						
PRIONOSPIO CIRRIFERA								1
PRIONOSPIO MALMGRENI					3	3	3	1
PROTOMEDEIA ZOTEA				1	4	1	7	1
PROTOTHACA STAMINEA		1	9	21	5	49		2
PSEUDOPOTAMILLA SOCIALIS			1		1			
PYCNOGONID UNID	15	2	3		2	5		
PYCNOPODIA HELIANTHOIDES								1
RHYNCOSPIO APENICOLA					1			
SABELLARIA SPINULOSA	1							
SAXIDOMUS GIGANTIUS				1				
SCOLOPLOS ARMIGER	1							
SPHAEROSYLLIS CALIFORNIENIS				1	1		1	
SYLLIS SP A			1			1	1	
TELLINA MODESTA			16	2	2	3		
TIRON BIOCELLATA			1					
TRANSENNELLA TANTILLA			1	1		2	1	

APPENDIX D

TRIP REPORT

SECTION 74 SEAFOOD PROCESSING STUDY

ALASKAN WATER QUALITY INVESTIGATIONS

JULY 25 THROUGH AUGUST 3, 1978

By

PETER M. MAHER

Edward C. Jordan Co., Inc.

Portland, Maine

July 25, 1978

On this day, I visited the two major salmon processing plants in Kenai, Alaska; Kenai Packing Company and Columbia Wards Fisheries. The purpose of these visits was to collect information relative to production, processing methods, processing periods, waste disposal and water use. The following account presents the information collected. Prior to visiting each plant, I contacted the plant managers to make arrangements to meet with them.

Kenai Packing is situated on the Kenai River. It is the last fish processor located on the river before it empties into Cook Inlet. Salmon is the only commodity presently processed at Kenai Packing. Like most major processors, Kenai Packing markets the canned and frozen varieties of salmon. No fish were being processed during my visit because the season was closed on July 21 to increase the escape rate for spawning Red salmon. They anticipated that fishing would be reopened on July 26 or 27, and processing would be initiated the following day.

The following information was provided by Mr. Fred McGill, Plant Manager, who was very cooperative throughout our discussion. Kenai Packing employs a maximum of about 270 people. The plant does not operate any fishing vessels, but purchases fish from approximately 150 privately-owned fishing boats. Only a portion of the people employed at Kenai Packing are provided with housing and meals at the cannery.

The last three years of salmon production at Kenai Packing is summarized as follows:

	1977	1976	1975
Hand-Butchered	923,860 lbs	349,849 lbs	263,558 lbs
Mechanically-Butchered	6,996,000 lbs	5,532,384 lbs	3,691,425 lbs
Salmon Roe	389,434 lbs	225,814 lbs	189,175 lbs

The above figures represent finished product weights. For raw production figures, Mr. McGill indicated that 11.5 percent could be added to the hand-butchered figures, and 43 percent could be added to the mechanically-butchered product which is subsequently canned. The processing of hand-butchered salmon yields approximately 90 percent finished product and 10 percent waste by weight.

About 90 percent of the hand-butchered salmon produced by Kenai Packing is exported to Japan. Fish exported to Japan are generally Red salmon with the head-on, as opposed to the remaining 10 percent which are shipped to Seattle with the head-off. The quantity shipped to Seattle represents mostly King salmon. All of the roe (eggs) is exported to Japan.

Mechanically-butchered salmon yields approximately 70 percent finished product and 30 percent waste by weight. Pink salmon is always canned. The Silver and Chum species are usually canned, but at times they are hand-butchered and frozen for export to Japan. Again, the roe is cured, packaged and exported to Japan.

Average production figures are difficult to develop due to the variability in salmon fishing. Mr. McGill estimated the average weight of hand-butchered salmon processed to be 8,000 lbs of raw product per day and 100,000 lbs of mechanically-butchered salmon per day (raw product). He also estimated the average number of processing days at 20. Typically, processing will take place during one shift, consisting of 6 to 8 hours.

During approximately seven days per year, Kenai Packing reaches peak production levels. On these days, approximately 15,000 lbs per day of hand-butchered salmon and 300,000 lbs per day of mechanically butchered salmon is processed (weights represent raw product). One 12-hour shift per day is operated during peak production periods. The normal canned salmon processing period in this area extends from June 25 to August 10.

Kenai Packing utilizes three Model G iron chinks to mechanically butcher salmon. Each chink has a capacity of approximately 70 fish per minute. The chinks supply fish to six canning lines which may all be operated simultaneously. There is one tall (15-1/2 oz), three 1/2-pound (7-3/4 oz), and two 1/4-pound (3-3/4 oz) lines.

Hand-butchered salmon is frozen in seven Dole contact (plate) freezers which have a total capacity of 3,120 fish (624 pans at 5 fish per pan). Three air-blast freezer rooms, each with a capacity of 100 tons per 24 hours are also utilized.

There are no byproducts separated from the waste stream at Kenai Packing with the exception of a small amount of salmon heads for oil extraction. According to Mr. McGill, all waste solids are ground and discharged via two outfalls. Canning line wastes are washed into floor drains which direct the wastewaters into three wet wells located beneath the iron chinks. Waste solids from the iron chinks are also directed to the three wet wells. Wastewater containing the solids then flows into a main collection sump from which the solids are screw conveyed approximately 10 feet to an Autio grinder. Once ground, the solids are flushed through a 10-inch outfall which discharges into the Kenai River, a distance of approximately 75 feet. The outfall is in very poor condition and several leaks were noted by SCS Engineers while sampling in the area of Kenai Packing. SCS Engineers also mentioned that an extra length of pipe was added to the outfall on the day preceding my visit. Prior to the installation of the additional pipe length, the outfall discharged above the low tide level. Wastes from the roe processing building are also directed to this outfall.

Waste solids generated by the hand butchering operation are discharged via a separate 8-inch, 40-foot outfall. These solids are washed into floor drains which discharge to a wet well. A 7-1/2 horsepower DeLumper grinder pump had been used to grind these solids prior to discharge. Prior to my visit, the DeLumper grinder had been removed from operation because it often became clogged. Mr. McGill indicated that a Vaughan grinder pump has been ordered to replace the DeLumper. The 8-inch outfall appears to be in good condition with no leaks noted. According to Mr. McGill, the two grinders and respective outfalls have been in operation for more than 15 years.

Several non-point discharges were observed at the Kenai Packing facility. From visual observations, these appeared to be water used for fluming and washdown with some flow originating at the roe building.

In-plant modifications for reducing water use are presently absent at this processing plant. Hoses were continuously running and there are no nozzles of any kind being employed. Kenai Packing obtains its water from six wells, each having a 300 gpm pump. The May 1978 NPDES monitoring report estimated an average water use of 600,000 gpd.

Columbia Wards Fisheries (CWF) is also located on the Kenai River. This facility discharges the furthest upstream of all the processors situated along the Kenai River. CWF processes a small amount of herring in addition to its major commodity, salmon. Salmon is marketed as both the frozen and canned products. No fish were being processed during my visit because fishing was temporarily closed on July 21.

The following information was provided by Mr. Ray Landry, Plant Manager. This is Mr. Landry's first year as plant manager of the Kenai facility. CWF is a self-contained cannery which houses, feeds and clothes the majority of the workers. The cannery owns 30 fishing vessels and buys fish from 120 privately-owned boats. Mr. Landry was very cooperative in supplying the information presented below.

Historical data regarding production could not be provided by Mr. Landry because this information is kept in the main office located in Seattle, Washington. He thought that this data could be obtained through the mail or over the phone at the beginning of September. The 1978 production information through July 23 is as follows:

Hand-Butchered Salmon	1,000,000 lbs (round)
Mechanically-Butchered Salmon	2,390,328 lbs (round)
Frozen Herring	120,000 lbs (round)

Herring is processed early in the year prior to initiating salmon operations. The fish are frozen in the round for export to Japan. Herring has not been processed every year.

Kenai Packing processed 130,000 lbs of frozen (custom) salmon for CWF. The gurry from the hand-butchered fish were disposed of by Kenai Packers. Approximately 20,000 lbs of salmon were custom frozen by Kenner Packers with the gurry transported to CWF for disposal.

All of the hand-butchered salmon processed at CWF is shipped to Seattle, Washington. The heads are generally removed prior to shipment. Mr. Landry estimated the percent yield for hand-butchered salmon to be approximately 82 percent. The percent yield for canned salmon was estimated to be 70 percent. Most of the hand-butchered fish are King and Red salmon. The canned product includes Pink, Chum and Silver salmon. All salmon roe is processed and exported to Japan for sale.

Average production levels at CWF are difficult to estimate because of the variability in fishing. CWF processes fish a short time after they are delivered to the plant due to the limited storage facilities. During the current year, CWF has operated for 29 canning days and 35 freezing (hand-butcher) days. All of the herring was processed over four days. By dividing the number of processing days into the raw product figures, average production levels are approximately 24,000 lbs of hand-butchered salmon per day, 82,000 lbs of canned salmon per day and 30,000 lbs of herring per day.

Production reaches peak levels at CWF during seven days per year. During this period, approximately 40,000 lbs per day of hand-butchered salmon and 430,000 lbs per day of mechanically butchered salmon is processed with weights representing raw product. Two 12-hour shifts per day are operated during peak production for hand butchered fish. One shift per day for 12 to 16 hours is operated during peak production periods for mechanically-butchered salmon. The normal salmon processing season extends from around June 26 to August 14 at CWF. Herring is normally processed during the middle part of May.

CWF has three Model G iron chinks available to mechanically butcher salmon. Only two chinks may operate at one time. Each chink has a capacity of approximately 70 fish per minute. The chinks are set-up to supply fish to two canning lines. Any combination of two tall, one 1/2-lb or one 1/4-lb canning lines may be utilized. The one-pound lines have a capacity of 250 cases per hour. The half-pound lines have twice this capacity and the one-quarter pound lines have four times this capacity. According to Mr. Landry, there are 72 lbs of raw product per case of 1-lb cans, 36 lbs of raw product per case of 1/2-lb cans and 18-lbs of raw product per case of 1/4 lb cans.

Hand-butchered salmon is frozen in three Dole contact (plate) freezers which have a total capacity of approximately 15,840 fish (288 pans at 5.5 fish per pan with head-off).

A small amount of oil is produced from rendered salmon heads. Other byproducts are not recovered from the wastes generated at CWF. According to Mr. Landry, all waste solids are ground and discharged through the outfall. Solids from the canning lines and hand-butchering operations are washed into floor drains which discharge into wet wells located beneath the iron chink area. All wastes then flow into the main collection sump. A 10-Hp, 800 gpm Vaughan pump grinds the gross solids, which are then discharged through a 6-inch, 100-foot PVC outfall into the Kenai River. The outfall appeared to be in good condition and no leaks were observed. The Vaughan grinder was installed this year and replaced a DeLumper grinder. A small Autio grinder handles the heads for the oil extraction process. The rendered solids are discharged via the same 100-foot outfall.

No in-plant measures for reducing the use of water are presently employed at CWF. Process water is obtained from three wells. Accurate water use records are kept at CWF. During the first 24 days of July, the average daily flow was 290,379 gallons. Maximum daily flow was 681,900 gallons and minimum daily flow was 81,900 gallons.

July 26, 1978

This day was spent on the charter boat, Tres Cher, observing the water quality sampling program being undertaken by SCS Engineers for the Kenai River. Four representatives of SCS took part in the water quality sampling including the Technical Project Manager, Michael Caponigro. Mr. Caponigro, Terry Boston and Libby Lundt are all full-time employees of SCS. Steven Petrich was hired as a private consultant to assist in this work. Mr. Petrich is a M.A. candidate in Marine Biology at California State University, Long Beach.

Samples were taken at stations located in the Kenai River in the vicinity of Kenai Packers and Columbia Ward Fisheries. Tidal fluctuations in the Kenai River are greater than 20 feet. The bottom is generally comprised of cobbles and the water is very turbid since the river is fed for the most part by glacial streams. Visibility is less than one foot at all times. Because of the high tidal fluctuations, the currents in the river are strong. The intensity of the currents restricted most of the sampling effort to approximately 1.5 hours early in the morning, and one hour during the late afternoon. These time periods coincided with slack tide when the currents are at a minimum. Considerable effort was required to obtain representative duplicate sediment samples even at slack tide, due to the presence of large cobbles which would jam the benthic grab in an open position.

Samples were obtained at predetermined stations in front of Kenai Packers and Columbia Ward Fisheries. Neither plant was processing fish during the sampling program. There were 12 sampling stations located by Mr. Caponigro in front of Kenai Packers. One station was located in the vicinity of each outfall operated by Kenai Packers. Stations located

across the river from this facility served as control sites. The remaining stations were selected along the near shore (Kenai Packers) and at mid-river transects. Additionally, three stations were located in the immediate area of Columbia Ward Fisheries with one at the discharge and the others at upstream and downstream locations.

Three types of samples were taken at each station. Duplicate water chemistry samples were collected at three different depths. Aliquots were taken at surface, mid and bottom depths for each station. The samples were obtained with a Van Doren bottle for the following analyses: pH, dissolved oxygen, salinity, temperature, nutrients and sulfides. On board, dissolved oxygen concentrations were determined by the modified Winkler titration method and salinity analysis was accomplished with a refractometer calibrated against a standard sea water sample. Temperature and pH were measured with stem thermometers and a field pH meter, respectively. Samples for nutrients and sulfide analyses were preserved and iced for shipment to the Dames and Moore laboratory in Fairbanks, Alaska. When facilities were available, water samples were frozen following collection.

Duplicate sediment chemistry samples were also taken at each station. These samples were obtained with a 0.1 m^2 Van Veen bottom sampler operated from a winch on the boat. Each duplicate was pulled up from the bottom and deposited into a galvanized steel tub. If the grab was considered to be representative (based upon size and amount of sample), a plastic jar was filled (approximately 500 ml) with bottom sediment to be analyzed for hydrogen sulfide, total Kjeldahl nitrogen, total organic carbon and volatile solids. A separate jar was filled for determining particle size distributions by SCS Engineers at Long Beach. Benthic samples were obtained in the same manner as sediment chemistry samples. Duplicates were taken for each station. Deposition of each sample was accomplished in a galvanized steel tub. The supernatant was decanted into a plastic pail with a screened bottom. The remaining sediment was then washed into five-gallon plastic pails along with the screened material from the supernatant. Sample preservation was accomplished with buffered formalin. Benthic analysis includes identification of the species present and population density of specific microorganisms.

July 27, 1978

To obtain general information concerning processing facilities, population and work force for the Kenai area, I visited city hall on this day. Currently, there are four salmon processors operating in Kenai, Alaska, all of which are located on the Kenai River. Columbia Wards Fisheries and Kenai Packing Company are the major ones. Dragnet Fisheries and R. Lee Seafoods are much smaller operations. At the time of my visit, both R. Lee and Dragnet were idle.

Based on a 1976 census, the city of Kenai has a population of 5,000. Approximately 2,700 employable people reside within the city limits. Of these, 2,200 or 81 percent are employed. This information was obtained from the Kenai Peninsula Borough Planning Agency.

There is one landfill operated by the Borough which is located within the Kenai city limits. Road conditions and accessibility to the landfill are good. The city has been operating a primary treatment plant since 1972, which at the present time, does not have the capacity to accomodate flows from the local seafood processors. Information concerning the average number of days per year acceptable weather conditions for barging occur could not be provided.

R. Lee Seafoods is located upstream of Columbia Wards Fisheries and on the same side of the Kenai River. Salmon is manually butchered at R. Lee and frozen. Eggs are extracted, boxed and exported to Japan. Two butchering tables are used to process up to 150,000 lbs of raw product per day at this facility. Three Dole plate freezers are employed to generate the final product. Waste solids are ground and discharged. An Autio 1101 grinder is located outside of the processing building. The discharge pipe (6" PVC) was disconnected on the shore approximately 30 feet from the grinder.

July 31, 1978

The charter boat Tres Cher arrived in Cordova from Kenai on July 29. The Cordova water quality sampling effort began on July 30 and was terminated on August 2.

On this day, I was aboard the Tres Cher to observe the sampling effort and videotaping of the bottom areas adjacent to the outfalls of St. Elias Ocean Products, North Pacific Processors, Morpac, Inc., and New England Fish Co. (NEFCO). The SCS Engineers crew was joined on board by three divers from Industrial Underwater Services of Tacoma, Washington.

There were 20 sampling stations selected, including three control stations in Orca Inlet. Four of the stations were located at the outfalls operated by the four processing plants in Cordova. The control stations were located across the channel approximately 2,000 meters from the processing plants. The remaining stations were located at distances of 100 to 300 yards from the shore along transects parallel to the shore and included stations which were up-current and down-current from the discharge points.

The sampling procedures for collecting water, sediment and benthos samples employed at Cordova were identical to these in Kenai. Since Orca Inlet experiences only 10-foot tides, the sampling was more routine than that experienced in Kenai.

The divers videotaped the areas surrounding each outfall pipe at varying distances (up to 50 feet). The videotaping was accompanied by an audio account which was also recorded. The following is a summary of observations as seen on the TV monitor on board the boat and supplemented by the divers comments.

The St. Elias outfall is located approximately 10 feet from the left side of the dock area as observed from off-shore. The pipe is 4-inch

PVC and positioned a few inches off the bottom. The pipe end is jagged, apparently the result of a tender shearing it earlier this summer. At the very end of the outfall, there was no significant buildup of waste material observed. Only a very few crab shells were located at this point. A number of flounder and starfish were observed to be feeding off small solids discharged from the outfall. Moving radially away from the end of the outfall, the diver noted that the bottom consisted mostly of crab shells covered with one-half inch of silt. As he moved out to a distance of 22 feet, the depth of material (shells) increased to approximately 18 inches. At a distance of 28 feet, old fish heads were observed every 2 to 3 feet. These deposits of large solids were probably the result of dumping wastes at the dock face as opposed to discharges from the outfall. The visibility also improved and the depth of material decreased. At 40 feet the bottom was noted to be sandy and barren with an absence of significant animal life. A stronger current was detected at 40 feet and the visibility improved, approaching 3 feet.

Next, the diver filmed the bottom areas at the other side of the St. Elias pier. St. Elias has been dumping crab shells overboard due to a breakdown in its grinder. Close to the pier, 80 percent of the bottom was covered mostly with whole crab shells. At the center of the pier and in 19 feet of water, the bottom was 80 percent covered with 8 inches of crab shells. The shell density began to thin out at a distance of 10 feet from the pier. Fifteen feet from the pier, there was 50 percent bottom coverage with crab shells. One fish head was observed 40 feet from the pier and approximately 5 percent of the bottom was covered with crab shells.

Very few shells were detected beneath the St. Elias pier. The divers collected samples for sediment chemistry and benthic analysis at the outfall as well as the location where crab shells were being dumped.

The North Pacific Processors outfall extends to the end of the dock and is approximately 40 feet north-northeast of the dock face. The pipe situated approximately 10 inches off the bottom is 4-inch galvanized steel. As a result of discharging wastes through the outfall, a 10-foot wide by 2-foot deep trough developed in the ocean bottom which extended from the outfall. A large quantity of unground, gross fish solids were noted in the area of the galvanized steel pipe. The depth of solids, including crab shells and unground fish parts, increased from 8 to 12 inches at the discharge to 4 feet at a radius of 40 feet. The accumulation of solids continued farther than this distance and the termination could not be seen by the diver. At a distance of 10 feet from the discharge pipe, 90 percent of the solids were crab shells. At any one time, approximately 50 flounder could be observed feeding on the debris. The divers did obtain bottom samples at this location.

The discharge line originating at Morpac, Inc. is 4-inch PVC which extends horizontally for approximately 200 feet directly beneath the dock and makes a 90-degree vertical turn into the water at the very end of the dock. The pipe extends downward and terminates 5 feet from the bottom. The discharge has scoured a 2-foot hole directly below the

pipe. The solids were observed to be 6 to 12 inches deep of finely ground fish parts and very few crab shells. No gross solids were encountered. Moving away from the outfall, the solids depth increased to approximately 3 feet at a distance of 15 feet. Very little marine life was encountered at Morpac.

August 1, 1978

Visits were made to the three seafood processors operating during the 1978 salmon season in Cordova, Alaska; St. Elias Ocean Products, North Pacific Processors, Inc., and Morpac, Inc. All three processors are located on Orca Inlet which empties into Prince William Sound and the Gulf of Alaska. Prior to visiting each plant, I contacted the plant managers and made arrangements to meet with them.

At St. Elias Ocean Products (SEOP), I met with Walter Crow, the Plant Manager and Jim Poor, the Plant Foreman. SEOP employs a maximum of 110 people during the peak of the salmon processing season. The peak usually occurs around the last two weeks of July when pink and chum salmon are canned. Approximately 50 people are housed at SEOP. All fish and crab are purchased from independent fishermen which is common practice for the processors in Cordova. St. Elias initiated processing in its new $3 million plant this year. For the previous eight years, processing took place in an old ferry tied up adjacent to the new plant. SEOP processes Tanner, Dungeness and a very small amount of King crab, hand-butchered and mechanically-butchered salmon, halibut, and herring. As predicted, this season has been a poor year for salmon fishing. During my visit, fishing was closed because the Pink run had just finished and the Silver run had not yet started. Very few Pink salmon were caught as compared to previous seasons. Historical production data could not be provided by SEOP. According to Mr. Crow, this data can be obtained from the main office in Seattle.

Generally, crab processing begins in mid-November at SEOP. Tanner (Snow) crab is processed from this date through June 1. In 1978, 2.3 million lbs of live crab were processed. Approximately 20 percent of the raw product is converted to meat while 80 percent is discharged as wastes. Depending on the market conditions, the meat is either canned or frozen. Of the 1978 Tanner crab meat production, 90 percent was canned and 10 percent was frozen. Last year's production placed emphasis on the frozen product with only 10 percent being canned. There are no peak processing days for Tanner crab. Approximately 30,000 lbs of raw product is processed during one 8-hour shift per day throughout the season. Rollers are used to remove the meat from the shell.

This year was the first time that significant amounts of Dungeness crab were processed at SEOP. Dungeness crab processing starts around June 1 and extends to mid-September. It is packaged as either frozen whole crab or crab sections. Since June 1, 1978 approximately 1 million lbs

of live Dungeness crab have been processed. Mr. Crow expected that another 500,000 lbs would be processed before the end of the season. When processing sections, approximately 35 percent of the live weight becomes waste. There is essentially no waste when Dungeness crab is processed whole. Since there is no peak processing days for this commodity, about 20,000 lbs of raw product is processed in one 8-hour shift per day throughout the season at SEOP.

At SEOP, salmon processing begins in mid-May. The majority of the fish processed from this date through early July are hand-butchered for the frozen market. Approximately 90 percent of the fish hand-butchered are Red salmon. Almost all of the Red salmon are frozen with the head-on for export to Japan. The remaining 10 percent of the hand-butchered fish are King, Silver and Chum salmon which are beheaded and marketed within the United States. Head-on fish yield approximately 89 percent product, while head-off fish yield between 80 and 83 percent final product depending on the species. Average production of hand-butchered salmon approximates 30,000 lbs during an 8-hour shift. During peak production days, approximately 60,000 lbs of salmon are hand-butchered in an 12-hour shift. At SEOP this occurs only four or five days per year.

Salmon which are mechanically-butchered for canning are normally processed during a three to five-week period beginning in early July and running through mid-August. The majority of the fish canned at SEOP are Pink and Chum salmon. Mechanically-butchering salmon yields approximately 77 percent final product at SEOP. During the canning season, average production approximates 80,000 lbs of raw fish in an 8-hour shift. Approximately 350,000 lbs of salmon are canned at SEOP during peak production. Maximum production occurs over an 14-hour shift during an average of six days per year.

The halibut fishing season is regulated by the federal government and is usually opened for 3 two-week periods. Halibut is butchered by the fishermen on the boat so there is essentially no solids generated by the processing plants. Last year, SEOP froze approximately 100,000 lbs of halibut. To date, SEOP has processed approximately 60,000 lbs.

Approximately 200 tons of herring were frozen in the round in 1978 at SEOP. The entire quantity of herring was processed during four days in May. The bulk of the processing time is involved with freezing the fish. At the St. Elias facility, crab, halibut and salmon can be processed simultaneously.

Since the St. Elias plant is a very modern facility, it utilizes the latest in processing equipment. It is well laid out and operates with relatively low water use.

On the day of my visit, SEOP was processing a small quantity of Dungeness crab. All crab is brought into the plant by bucket and crane.

Seven large stainless steel tanks hold crab and fish until they can be processed. Crab is maintained alive by pumping sea water through the tanks. The sea water is discharged directly beneath the pier supporting the processing facility. For whole crab processing, the live crab is washed prior to cooking. The washing process consists of spray jets located directly above a conveyor line for the crab. A continuous stream of water runs through the conveyor line and is directed into floor drains located beneath the processing line. The washed crab is next conveyed into a stainless steel tub of boiling water for cooking (a flow-through cooker). From the cooker, crab is scrubbed with mechanically rotating brushes and washed once again. The Dungeness crab is then tied with rubber bands for freezing whole.

When processing sections, crab is butchered prior to the flow-through cooking process. The operation continues in the same manner as whole crab from that point on. The brine freezing process has a capacity of 15,000 lbs of whole crab in eight hours, and 25,000 lbs of crab sections (raw product) during the same period.

Tanner crab is handled utilizing a process similar to that employed for Dungeness species except for the butchering operation. Prior to cooking, the crabs are butchered and the body and viscera are discarded as waste. Subsequently, the legs are removed from the body sections by sawing. After precooking, legs are fed through rollers which extract the meat from the shells. The crab meat is then either frozen or canned depending on market demand. For freezing, the meat is cooked a second time, rinsed, frozen and packaged. Canned meat is hand-packed and retorted. According to Mr. Poor, crab shells are belt conveyed to the 30 hp Vaughan grinder pump.

Salmon is unloaded from the fishing vessels via a Temco pneumatic system. From the Temco unit, the fish are belt conveyed to the holding tank for subsequent processing. The salmon are washed into a wet sluice which transports the fish to an elevator which feeds another conveyor. Two Model G iron chinks are available for butchering in addition to a hand-butchering table. According to Mr. Poor, very little waste from the chinks hits the floor. Most of the solids are channeled into the sump which feeds the grinder pump. Sliming table wastes are washed directly into a drain which directs them to the grinder. St. Elias packs salmon in 4, 1, 1/2 and 1/4 pound cans. This facility is capable of simultaneously operating any combination of two canning lines, except the four and one-pound lines. The four-pound cans are hand packed. Canning line wastes are washed into floor drains which flow to the grinder pump. Solids from the hand butchering table are dry conveyed to a floor drain which channels them to the grinder pump. St. Elias has installed spray nozzles on 70 percent of the hoses utilized in the plant. Mr. Crow expects to provide nozzles for the remaining hoses.

St. Elias employs two blast freezers for salmon, halibut and herring. The combined maximum capacity of the two freezers is 60,000 lbs of fish.

No byproducts are recovered at the St. Elias facility. All fish solids, crab shells and washwater collected by the 57 floor drains available throughout the facility are directed to a central wet well. The grinder pump discharges through a 4-inch PVC outfall into the Inlet. According to Mr. Crow, the outfall extends a distance of 200 feet.

The grinder and wet well are located beneath the dock in the vicinity of the sliming tables. Last year, a tender rested on the outfall at low tide and sheared it 10 feet from the end of the pier.

St. Elias uses water supplied by the city of Cordova for its processing operations. The meter which measures water use was installed on June 28, 1978. Since that date it has recorded an average water use of 207,700 gpd, a maximum consumption of 396,300 gpd and a minimum use of less than 1,000 gpd.

At Morpac, Inc., Mr. James Forsell, Plant Manager and Mr. John Hewett, General Foreman were available to meet with me. Morpac employs a maximum of 85 people during peak processing periods. Employees are not housed at the cannery. Production data could not be supplied because the files are maintained in Seattle. Mr. Forsell indicated that the data could be obtained from the Seattle office by mail.

A small amount of whole Dungeness crab was being processed the day of my visit to Morpac. This plant processes Dungeness crab whole and in sections, while Tanner crab is marketed as sections. The Dungeness crab season normally extends from July 1 through October 14. So far this year, Morpac has processed approximately 450,000 lbs of Dungeness crab. Production involves the packaging of frozen whole crab or frozen sections. The Tanner (Snow) crab processing season normally occurs from January 10 to May 30 at Morpac. Approximately 1,150,000 lbs of Tanner crab was processed as frozen sections during 1978. Morpac does not market the frozen or canned meat variety of this specie. Average Tanner and Dungeness production approximates 40,000 lbs of raw product per day for each commodity. Typical days involve one 6-hour shift for either type of crab. During peak production periods, approximately 65,000 lbs of live crab are processed per day over an 8-hour shift. Since crab can be kept alive for relatively long periods, the occurrence of peak days is rare. When processing Dungeness crab sections, approximately 60 percent of the live weight is packaged. For Tanner crab sections, the useable portion of the raw product approximates 58 percent.

The salmon processing season extends from May 15 through the first week of September. Through July 14, the majority of the fish processed are Red and King salmon which are hand-butchered and frozen. By August 1 of this year, approximately 550,000 lbs of Red salmon had been hand-butchered Japanese style (head-on), while 165,000 lbs of King, Chum and Pink salmon were hand-butchered American style (head-off). Most of the American style fish were King salmon. Japanese style fish yield approximately 88 percent final product as opposed to American style fish which have a 75 percent yield.

The canning season normally extends from the first week of July through the middle of August. Pink and Chum salmon are the two varieties which are normally canned. As of August 1, 1978 approximately 1,585,000 lbs of raw material had been canned by Morpac in two can sizes. When packing tall (1-lb) cans, the product yield is approximately 65 percent. One-half pound cans will generally realize 70 percent yield. Mr. Forsell would not provide any information relative to average salmon processing due to fluctuations in the industry. The maximum production day for hand-butchered fish was 70,000 lbs of raw product which occurred in 1977. Most peak days involve the processing of approximately 45,000 lbs of salmon over one 14-hour shift. On the average, this may occur three days per year. Peak canning days entail the processing of approximately 200,000 lbs of Pink salmon in one 14-hour shift. During the season, this usually takes place on six or seven days. Morpac can process Dungeness crab and salmon simultaneously.

Herring was processed for three days during April of 1978 at Morpac. The herring were frozen in the round for export to Japan. Approximately 65 tons was processed during this time.

Crab processing methods and equipment are typical for the industry. Morpac processes both Dungeness and Tanner crab either as a whole product or for sections. Meat products are not processed at this facility. Morpac employs a process which is similar to the operation at St. Elias. However, Morpac does use batch cookers instead of a flow-through cooker. For crab, one brine freezer which has a capacity of 3,000 lbs finished product per hour is available. The crab operation at Morpac does not appear as efficient as the St. Elias set-up. Processing equipment is spread out over a large area. Spillage is frequent and the floors were littered with waste during the day of my visit. Most of the floor drains in the crab area are connected to the grinder; however, the connections leak and a significant portion of the waste spills into the water directly under the crab area.

Morpac processes herring, crab, salmon roe and hand-butchered salmon in a building which is separate from the canning operations. Hand-butchered salmon, Tanner crab and herring are subjected to blast freezing. Approximately 70,000 lbs of raw salmon may be frozen during two shifts. Waste solids are washed into several floor drains which empty into an Autio 801 grinder located beneath and adjacent to the hand-butchering table. The grinder is in extremely poor condition and was not operational at the time of my visit. They plan to replace it next year with a Vaughan grinder pump. No spray nozzles are employed at Morpac and water use appears to be excessive. Ground solids from the Autio 801 are pumped to a main collection sump from which they are again pumped to the end of the dock, a distance of 200 feet from shore. The pipe is approximately five feet from the bottom and is exposed at low tide. The discharge pipe is 6-inch PVC in good condition and no leaks were observed.

Salmon is canned in a larger, separate building. Most fish are unloaded using a Temco system; however, Kings are unloaded with buckets in a

manner similar to crab. Salmon operations employ the same procedures as those noted for St. Elias. Fish are flumed from seven holding bins to belt conveyors. The remaining transport operations are accomplished by dry conveying. Morpac utilizes a Model K (90 fish per minute) and a Model G (70 fish per minute) iron chinks. Both can be operated simultaneously, but this occurrence is rare. Salmon is canned by either the one-pound or one-half pound line, but the two lines are never operated at once. Heads removed by the chink fall into a pipe which connects to an Autio 1101 grinder. All other solids are washed into floor drains which connect to the same grinder. The mechanism is located beneath the pier and in the vicinity of the sliming tables. Flow from the Autio 1101 enters the main collection sump where it combines with the flow from the Autio 801 for discharge via the outfall.

Byproducts, such as Salmon oil, are not recovered at Morpac. All waste solids are ground for discharge. The crab grinder (Autio 801) has been in use since 1969. The salmon grinder (Autio 1101) and outfall was installed in 1974.

Morpac purchases its water from the city of Cordova. Water use in April, 1977 (peak Tanner crab season) was measured at 35,900 gpd, average; and 210,000 gpd, peak. Water use in July 1977 (peak salmon canning season) was measured at 137,100 gpd average; and 325,000 gpd, maximum.

Later, I met with Mr. Ken Roemhildt, Superintendent and Mr. Al Fulton, General Foreman at North Pacific Processors, Inc. (NPP). Both gentlemen went to great lengths to explain to me their reason for the decline of halibut and crab catches in Orca Inlet over the past years. According to them, the implementation of grinding has decreased the available food supply for these species.

The NPP plant employs between 10 and 100 people throughout the year. Approximately 40 people are housed and fed at the plant during peak salmon processing periods. All fish and crab are purchased from independent fishermen.

A small amount of Dungeness crab was being processed at NPP during the day of my visit. The NPP plant processes Dungeness crab (whole and sections), Tanner crab (canned and frozen meat, frozen claws), hand-butchered salmon, canned salmon, halibut and herring (frozen in the round). This year was the first time herring was handled by the NPP facility.

Salmon production data provided by NPP was given in terms of total number of cans packed for each species. Approximately 75 lbs of whole fish are required to fill one case (48, one-pound cans). All conversions have been based on this figure. Production at NPP in pounds of raw product for 1975 through 1977 is as follows:

	1977	1976	1975
Whole cooked Dungeness crab	13,650 lbs	0 lbs	28,775 lbs
Cooked Dungeness crab sections	4,714 lbs	0 lbs	4,927 lbs
Canned Tanner crab meat	0 lbs	N/A	387,600 lbs
Frozen Tanner crab claws	0 lbs	83,256 lbs	0 lbs
Hand-butchered salmon	1,392,760 lbs	754,389 lbs	550,325 lbs
Mechanically-butchered salmon	6,249,959 lbs	4,929,801 lbs	4,517,068 lbs
Frozen halibut	20,624 lbs	21,368 lbs	40,430 lbs

In 1978, 252,285 lbs of herring was frozen in the round and exported to Japan. Another 272,000 lbs of herring was frozen and sold for bait. The herring season was short term and occurred from April 10 to April 20. It was recommended that the production figures be checked with records kept in Seattle.

Crab processing begins November 15 at NPP. Tanner crab is processed from this date through April 15, and is marketed as frozen or canned meat. When canning, approximately 23 percent of the raw product is converted to final product while a slightly greater yield is realized when freezing meat. Average production of Tanner crab approximates 14,000 lbs of raw product per day. This is accomplished during one 7-hour shift. During peak Tanner crab season, 35,000 lbs of raw product is either canned or frozen during a 12-hour shift. Peak processing days generally occur six times per year.

Dungeness crab is processed in small incidental quantities at NPP. When processing sections, approximately 70 percent of the raw product is recovered with the remainder discarded as waste. Dungeness crab processing is usually limited to three days at the beginning of September. During an average day, approximately 10,000 lbs of raw crab is processed in one 7-hour shift.

At NPP, salmon processing season is initiated on May 15 and extends through August 5. Most of the fish processed are hand-butchered and frozen through July 15. Approximately 60 percent of the fish are butchered Japanese style. Most of these fish are Red salmon with a small portion being Silvers which are processed at the very end of the salmon season (August 1 to August 7). The majority of the canned fish are Pink and Chum salmon with a small amount of Reds. Most of the canning is accomplished from July 15 through August 5. Head-on salmon have an approximate yield of 79 percent, while head-off and canned products yield approximately 68 and 65 percent, respectively.

Approximately 30,000 lbs of whole salmon are hand-butchered during an average day at NPP. Typical days consist of one 8-hour shift and occur approximately 45 days per year. About 150,000 lbs of whole salmon are canned during an average day. An average canning day occurs 20 times

per year and one 12-hour shift is necessary to achieve this production. At peak processing levels, 100,000 lbs of whole salmon is hand-butchered in one 12-hour shift. This occurs three or four times per year. Approximately 400,000 lbs of whole salmon are processed for canning in one 18-hour shift during peak conditions. Maximum canning days occur six to eight times per year. With its current set-up, NPP cannot process more than one commodity at any one time.

Dungeness crab processing at NPP occurs in the same manner as that adopted by Morpac, Inc. As previously mentioned, Dungeness crab is processed on a small scale as a fill-in during the salmon season. Processing techniques were observed to be inefficient in terms of waste management. The butchering area was spread out and solids littered the floor area. The relative distances between the areas where the crab is butchered, washed, cooked and frozen appeared to be excessive for an efficient operation. However, this could be attributed to the intermittent processing of Dungeness crab on a random basis between salmon runs. According to Mr. Fulton, Tanner crab is processed in the same manner as at St. Elias, except NPP employs batch cookers. The meat is extracted from the legs through the use of rollers.

Fish are transported to holding tanks by an elevator conveyor and wet fluming. Two Model G iron chinks are used to mechanically-butcher salmon at NPP. Butchered fish are transported to one sliming table and subsequently conveyed to three canning lines (1/4, 1/2 and 1 lb). Normally, the one-pound line can handle salmon under normal conditions. Depending on the market conditions, the 1/4 and 1/2 lb lines can be run simultaneously.

Five Dole plate freezers are employed at NPP for producing frozen salmon. These units have a maximum total capacity of 40 tons per day over three shifts. An additional plate freezer is used for fish and Tanner crab processing. This unit can handle 20 tons of salmon during a single shift per day. A six basket brine unit is used to freeze crab in the shell.

NPP grinds approximately 85 percent of the waste salmon heads in an Autio grinder for shipment to Seattle. Approximately 500 tons per year are frozen for future use in petfood production at a Seattle facility.

According to Mr. Roemhildt, all other solids and waste materials are ground and discharged through a 100-foot, 4-inch galvanized steel outfall. The outfall originally extended 240 feet into the ocean; however, a tender severed 140 feet of pipe in the fall of 1977. NPP utilizes a 30 hp Vaughan grinder pump which is located beneath the crab butchering areas.

The galvanized steel outfall has been in use for a period of four or five years. The divers inspection of the outfall revealed that it extends approximately 200 feet from shore or about 60 feet from the

grinder pump. Moreover, the actual amount of waste which enters the grinder is not 100 percent. Upon visual inspection of the plant, I noticed there was only one collection flume which extends from the crab butchering area, beneath the salmon holding tanks and continues to the end of the canning lines. The majority of the floor drains discharge directly beneath the pier into the water below. These drains are located in the crab butchering and processing area, the egg building and the hand-butchering area. None of the floor drains present in these areas were found to be connected to the main flume which direct flows to the grinder pump.

NPP purchases process water from the city of Cordova. Mr. Roemhildt estimated the average water use during the crab season to be 40,000 gpd with a peak consumption of 50 to 55,000 gpd. Average water use during the salmon canning season is 250,000 gpd and maximum usage was estimated at 600,000 gpd.

August 2, 1978

On this day, I met with Mr. James Jacobsen, Plant Manager for the New England Fish Company (NEFCO) plant. NEFCO is located approximately 3 miles along Orca Inlet from Cordova. Until six years ago, the NEFCO plant was isolated from the city and the only way one could reach the plant was by boat. Normally, 125 people are employed during the salmon canning season at NEFCO with 80 percent being housed at the cannery. NEFCO is the largest processor of salmon in the Cordova area. Other commodities, such as crab, are not handled by this facility. No salmon were being processed by NEFCO this year due to the poor fishing season. According to Mr. Jacobsen, large quantities of fish are required to operate at a profit. Arrangements were made with St. Elias to process the fish purchased by NEFCO.

Production data could not be provided by Mr. Jacobsen because the records are maintained in Seattle. On an average day, NEFCO processes 20,000 lbs of hand-butchered salmon and 187,500 lbs of canned fish (raw product). Hand-butchered fish are processed during one 12-hour shift with canning operations occurring over one 8-hour shift. Hand-butchered salmon yields 75 percent product and canned fish provide a 70 percent yield. During peak processing days, 30,000 lbs of salmon are hand-butchered and 420,000 lbs of fish are canned. Peak days involve one 18-hour shift for each commodity. On the average, seven peak processing days occur during the season.

NEFCO utilizes two model K chinks (90 fish per minute each) which are operated simultaneously to butcher fish. Fish are placed into cans by the available one-pound tall, two 1/2 lb or one 1/4 lb lines. Any three of these lines may be operated at once. For hand-butchered fish, six Dole plate freezers are used to process 30,000 lbs of raw fish per day. The salmon season normally extends from May 15 to September 15 each year. A small portion of the Sockeye heads are rendered for oil which is added to the canned salmon. Salmon eggs are cured and boxed for export to Japan.

All wastes generated by NEFCO are ground and discharged through a 6-inch flexible plastic hose, extending approximately 300 feet beyond the end of the pier. The outfall is stored at the end of each processing season. The outfall has been in use for the last five or six years. Prior to the purchase of the plastic hose, solids were discharged through a gurry trench which terminated at the end of the dock. Heads from the chinks are ground by two Autio 1101 grinders located adjacent to each machine. The ground heads and other wastes are directed to a 25 hp drum grinder before being pumped through the outfall. NEFCO appeared to be conscious of waste management with all floor drains and waste solids being directed to the grinder. At the present time, NEFCO employs an elevator system for unloading fish but will convert to a Temco pneumatic unit for the 1979 season.

NEFCO maintains its own water system to supply the plant. Water is captured from streams originating in the mountains adjacent to the plant. The collected water flows into a 50,000-gallon tank for storage. Mr. Jacobsen estimated the average water use at 250,000 gpd with a maximum consumption of 350,000 gpd.

Later, I visited Cordova City Hall to obtain pertinent information relative to the city and the processing plants. Cordova has an approximate population of 2,500 people. Mountains surround the city so it is not accessible by road. The four processing plants located in Cordova are: North Pacific, NEFCO, St. Elias and Morpac. In June 1976, approximately 950 of 2,500 people were employed. Approximately 200 residents were involved with the seafood processing industry at that time. There is one publicly-owned landfill site located 1/2 mile outside the city. However, the city is receiving pressure from state and federal agencies to close the dump. A primary treatment plant which is not capable of accomodating the process flows generated by the salmon canneries is also operated by the city.

August 3, 1978

During my visit to Cordova, I had the opportunity to speak with Mr. Don Endicott of Endicott Diving Company to discuss his recent (February 6, 1978) proposal for barging fish solids for the local processors. Mr. Endicott said that he had received an encouraging response from St. Elias; however, Morpac and NPP indicated they would only join in the barging operation if forced to. St. Elias has contacted a contractor to obtain a quote for a storage hopper which would be constructed at the end of the pier for dumping into the barge. Although NEFCO was not contacted by Mr. Endicott, he felt that they would consider his proposal if the other processors in Cordova had initiated efforts to do so.

Mr. Endicott's proposal was based on a 285-day processing season and prices were estimated on a per trip basis. He estimated that each cannery would be charged $73.93 per trip. The estimate includes: a 60-day season for Red salmon at two trips per day per cannery; a 30-day

seining season at four trips per day per cannery; a 30-day Silver season at two trips per day per cannery; and a 165-day crab season at two trips per day per cannery. The total number of trips is 630, for an annual cost of $46,576 per cannery.

AN INVESTIGATION OF CERTAIN ASPECTS OF CRAB PROCESSING WASTE DISPOSAL PRACTICES: *IN SITU* AND *IN VITRO* RESPONSES OF *VIBRIO PARAHEMOLITICUS* AND *VIBRIO ANGUILLARUM*

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FOREWARD

ABSTRACT

Current seafood processing operations in Alaska discharge untreated, or minimally treated, wastes into the waters adjacent to the site of operation. When wastes accumulate, markedly increased concentrations of soluble nutrients and hydrogen sulfide, and decreased concentrations of dissolved oxygen are observed. Sediment organic content increases with associated anoxia and visible sludge accumulation. Although these circumstances will result in increased microbial populations, the nature of the populations developing, and their possible hazards to the environment, are unknown.

This project utilized a dual approach, with the objectives of determining if pathogenic populations could develop in sediment where processing wastes accumulated. Field samples were analyzed for *Vibrio parahemolyticus* and coliforms, while *in vitro* techniques were utilized to determine if *V. parahemolyticus* and *V. anguillarum* could grow on nutrients supplied by the crab wastes at *in situ* temperatures.

Forty-six sediment samples were obtained from Dutch Harbor, Kenai, and Cordova, from areas adjacent to processing outfalls. No significant accumulations of coliforms were observed, and although *V. parahemolyticus* was not isolated from any sample, *V. alginolyticus* was isolated from one Cordova sample. Marked increases in the bacterial populations were observed in sediments where wastes accumulated.

Both *V. parahemolyticus* and *V. anguillarum* were shown to use crab processing wastes in sea water as nutrients. Although *V. parahemolyticus* grew well at 25 and 37°C, little or no growth was observed at either 5 or 10°C. *Vibrio anguillarum*, on the other hand, grew well at all temperatures tested.

CONTENTS

Foreword ii
Abstract iii
List of Figures. vi
List of Tables vii
Acknowledgment viii

1. Introduction. 1
2. Conclusions 2
3. Recommendations 3
4. Experimental Procedures 4
    Field samples 4
    Vibrio enrichment 4
    Enterobacteriaceae enrichment 8
    Biochemical identification. 8
    Cultures and controls 8
    In vitro experiments. 8
5. Results 9
    Field samples 9
        Dutch Harbor. 9
        Kenai 9
        Cordova 9
    In vitro experiments. 13
        Tolerance of reduced salt concentration by *Vibrio parahemolyticus*. 13
        Bacterial content of crab meal. 13
        Growth of *V. parahemolyticus* in sea water and crab meal based media 14
        Growth of *V. parahemolyticus* at 5, 10 and 25°C. 14
        Growth of *V. anguillarum* at 25°C and 5°C in sea water and crab meal 18
6. Discussion of Results 21
    Field samples 21
    Physiological ecology of *Vibrio* spp.. 21
    General ecological conditions 22

References 24

DISCLAIMER

FIGURES

Number		Page
1	Sampling sites in the vicinity of Dutch Harbor, Alaska	5
2	Sampling sites in the vicinity of the Kenai River, Alaska. . . .	6
3	Sampling sites in the vicinity of Cordova, Alaska.	7
4	Growth of *Vibrio parahemolyticus* at 37°C in crab meal supplemented artificial and natural seawater	16
5	Growth of *Vibrio parahemolyticus* at 5°, 10°, and 25°C in artificial seawater and artificial seawater and crab meal. . .	17
6	Growth of *Vibrio anguillarum* in natural and artificial seawater media, with crab meal, at 5° and 25°C	20

TABLES

Number		Page
1	Analysis of Dutch Harbor sediment for pH, *Vibrio*, total coliforms, and total heterotrophic counts	10
2	Analysis of Kenai sediment samples	11
3	Analysis of Cordova sediment samples	12
4	Effect of saline concentration of suspending medium on survival of *Vibrio parahemolyticus* - qualitative assay	13
5	Effect of saline concentration of suspending medium on survival of *Vibrio parahemolyticus* - quantitative assay	13
6	Biochemical profile on API-20E of selected isolates from original culture of *Vibrio parahemolyticus*	14
7	Growth of *Vibrio parahemolyticus* at 37°C in artificial and natural seawater-based media	15
8	Growth of *V. parahemolyticus* at 5°C in artificial seawater and crab meal medium	15
9	Growth of *V. parahemolyticus* at 10°C in artificial seawater and artificial seawater and crab meal medium	15
10	Growth of *V. parahemolyticus* at 25°C in artificial seawater and artificial seawater plus crab meal medium	18
11	Growth of *Vibrio anguillarum* in several media at 5°C	18
12	Growth of *Vibrio anguillarum* in several media at 25°C	19

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We thank Captain Ken Turner and the crew of the R/V *Acona* for sampling assistance in the vicinity of Dutch Harbor. The Publications Department of the Institute of Marine Science, University of Alaska, Fairbanks assisted in the final phases of the report.

SECTION 1

INTRODUCTION

Seafood processors in Alaska, with few exceptions, discard their processing wastes in waters near the processing site. In general, the wastes are simply piped to a depth of at least seven fathoms, although some processors screen and grind wastes to reduce effluent particulate size (1,2,3). At several locations, wastes have been shown to accumulate and to result in environmental changes associated with microbial activity, including nutrient and hydrogen sulfide accumulation, anoxia, and visible accumulations of debris (2,3). However, except for two reports (1,4), little is known about the nature of the developing microbial communities.

Vibrio spp. has long been associated with marine environments, particularly where chitinous material accumulates (1,5,6,7,8). *Vibrio parahemolyticus* and *V. anguillarum* have been pathogenically associated with humans (8) and marine organisms (9), respectively, the former being transmitted in contaminated seafoods. There is only one reported isolation of *V. parahemolyticus* and *V. alginlyticus* from Alaskan waters (1,4), although that study was limited to southeastern waters.

This project had as its specific objectives, (1) to attempt isolation of *V. parahemolyticus* from sediment samples obtained from processing waste disposal sites at Dutch Harbor, Kenai, and Cordova and (2) the determination of whether or not *V. parahemolyticus* and *V. anguillarum* would utilize crab waste products as nutrients in sea water, at temperatures approximating those found at the disposal sites.

SECTION 2

CONCLUSIONS

1. *Vibrio parahemolyticus* was not isolated from any of forty-six samples of sediment from Dutch Harbor (18 samples), Kenai (14 samples) and Cordova (14 samples), although *V. alginolyticus* was isolated from one Cordova sample.

2. No significant accumulation of enteric bacteria was observed in any sample, although a marked increase in total bacterial biomass was observed in sediments where wastes accumulated.

3. *Vibrio parahemolyticus* could efficiently use crab meal as a nutritional source in sea water, producing good growth at 25° and 37°C, but not at 5° or 10°C.

4. *Vibrio anguillarum* could also use crab meal as a nutrient source, producing good growth at 5°C.

5. *Vibrio parahemolyticus* does not appear to be a health hazard at disposal sites in waters that remain below 10°C; however, isolation of *V. alginolyticus* from one sample suggests that current practices could become hazardous to humans at sites where water temperature exceeds 10°C.

6. Current disposal practices, in light of the growth of *V. anguillarum* under these conditions, may be assumed to create hazards to fish and susceptible marine fauna.

SECTION 3

RECOMMENDATIONS

1. Current seafood waste disposal practices should be improved to ensure dispersion of wastes by discharging effluent into waters with vigorous current flow.

2. Additional studies on the temperature requirements of *Vibrio parahemolyticus*, as well as the bacterium's susceptibility to temperature and osmotic changes should be encouraged.

3. Refined techniques for rapid isolation of *Vibrio* spp., especially *anguillarum*, from marine environments and food products should be developed.

SECTION 4

EXPERIMENTAL PROCEDURES

FIELD SAMPLES

Grab sediment samples were taken from Dutch Harbor, Alaska, by Dr. Howard Feder, University of Alaska, Institute of Marine Sciences, aboard the R/V *Acona*, and from Kenai and Cordova, Alaska, by Mr. Michael Caponigro, of S.C.S. Engineering, Long Beach, California, under contract with the Environmental Protection Agency. Exact locations of sampling sites and adjacent river outfalls and processing discharge sites are shown in Figures 1 through 3.

Fifty to one hundred gram portions of the samples, chosen to obtain surface (sediment-water interface) sediment were placed into sterile glass containers or Whirl-Pak bags and held for analysis. The Dutch Harbor samples were processed for *Vibrio* enrichment onboard immediately upon sample recovery, but other analyses and the Kenai and Cordova sample analyses were performed in Anchorage, no later than 72 hours after sampling. All samples were maintained at temperatures above 10°C until analysis for *Vibrio* was completed (10), and then stored at 4-5°C until discarded.

VIBRIO ENRICHMENT

Primary enrichment and Most Probable Number (MPN) analyses for *Vibrio* spp. was accomplished with techniques similar to those previously described (4,11), using alkaline peptone medium (APM), consisting of 0.5% tryptone, 0.25% yeast extract, 0.1% destrose in artificial sea water (Aquarium Systems, Inc., East Lake, Ohio), adjusted to pH 8.0. All tubes or bottles were streaked for isolation after 48 hours incubation at 25°C on TCBS agar (Difco). Typical green colonies on TCBS were picked, purified, and maintained for further study on sea water plate count agar (SWPC), made with Plate Count Agar (Difco) in artificial sea water, at pH 8.0.

Dutch Harbor samples were quantitatively assayed by suspending 10 g of sediment in 100 ml of APM and using aliquots of the resulting 1:10 suspension to inoculate a three tube - three set MPN series (0.1 ml, 1.0 ml, and 10.0 ml) made with APM. After 48 hours incubation, all tubes, as well as the original suspension, were streaked for isolation on TCBS and scored positive if oxidase positive, yellow or green *Vibrio*-like colonies developed.

Samples from Kenai and Cordova were subjected to primary enrichment by suspending 10 g in APM and streaking for isolation after 48 hours, as previously described.

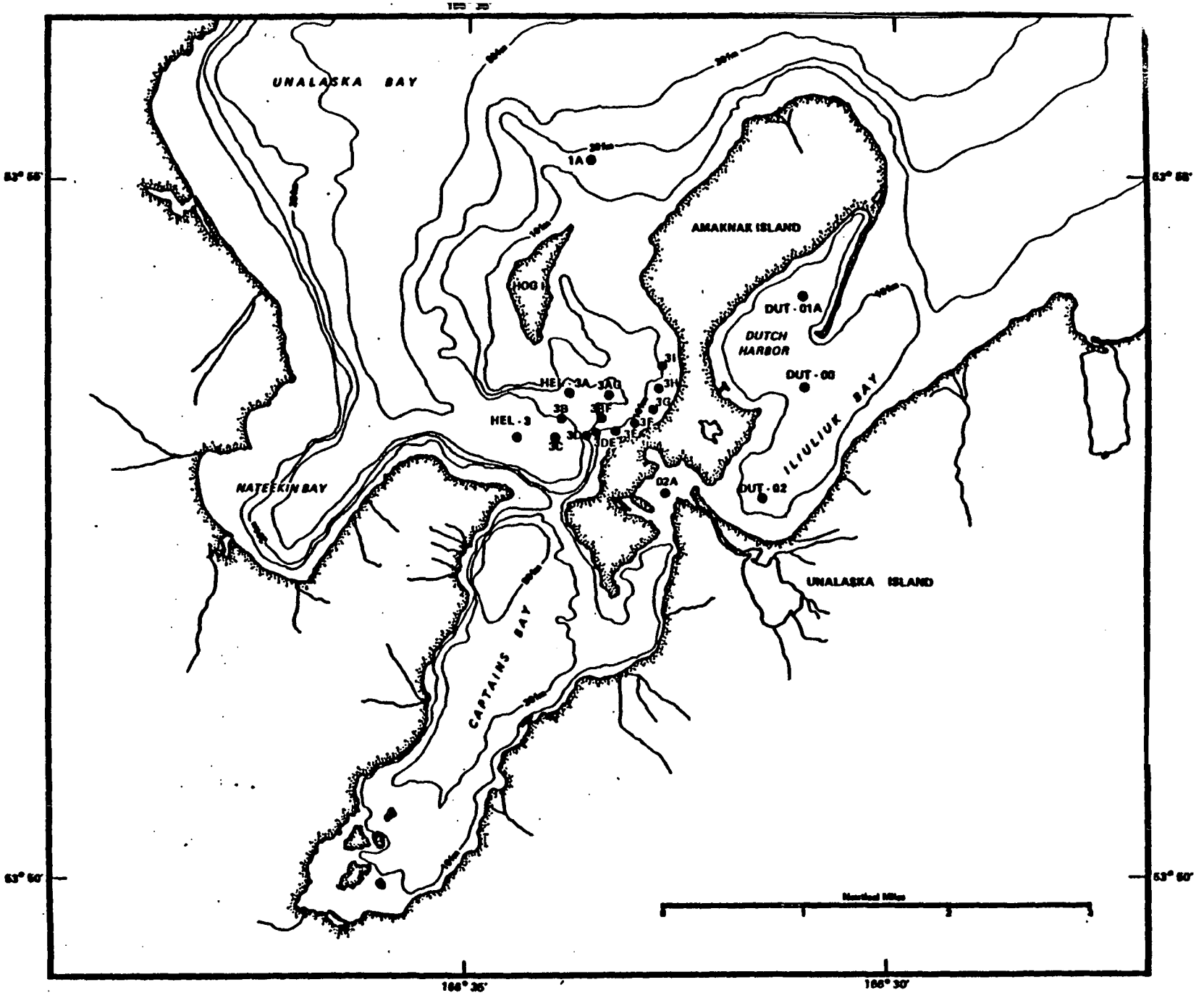


Figure 1. Sampling sites in the vicinity of Dutch Harbor, Alaska.

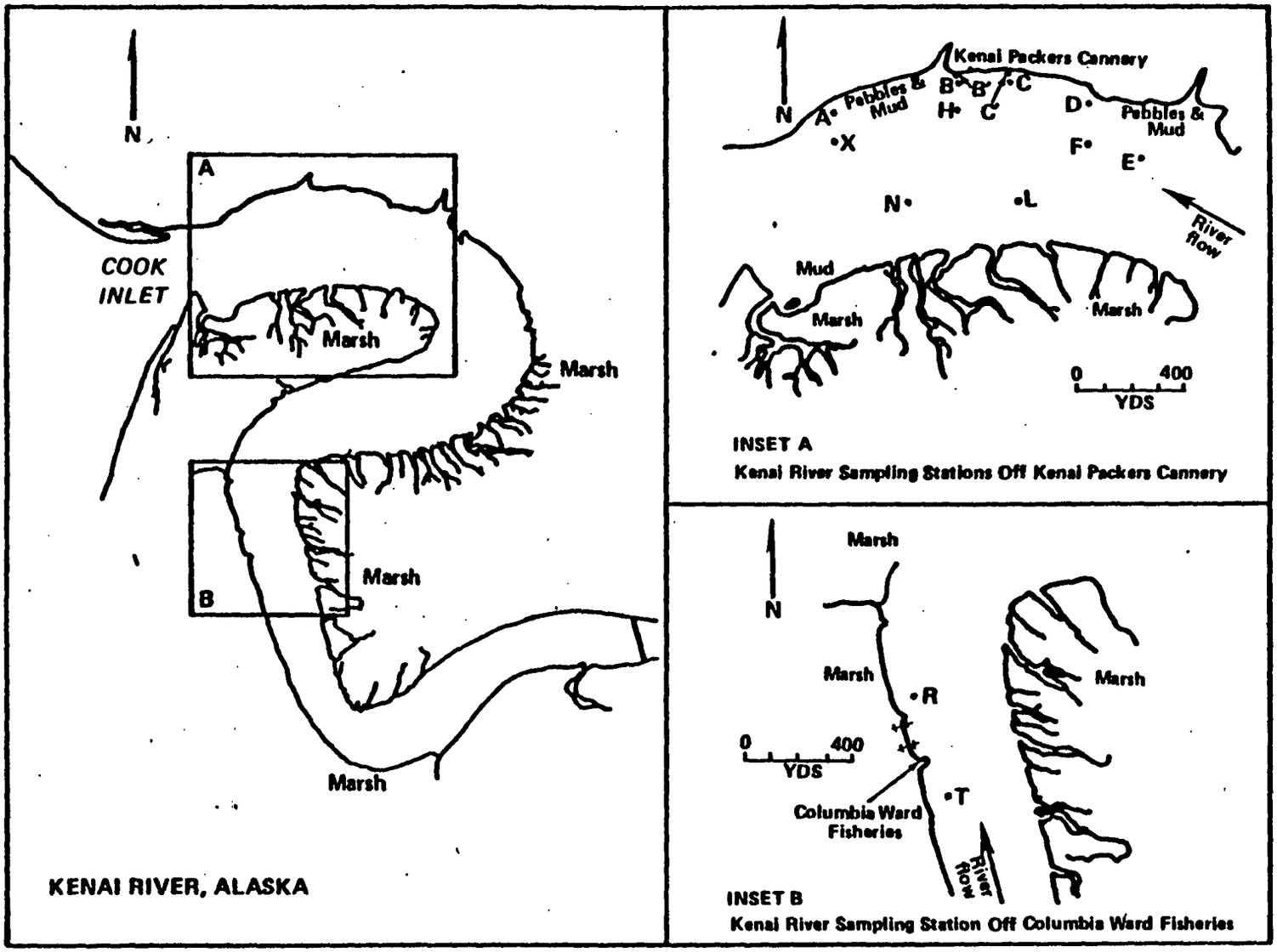
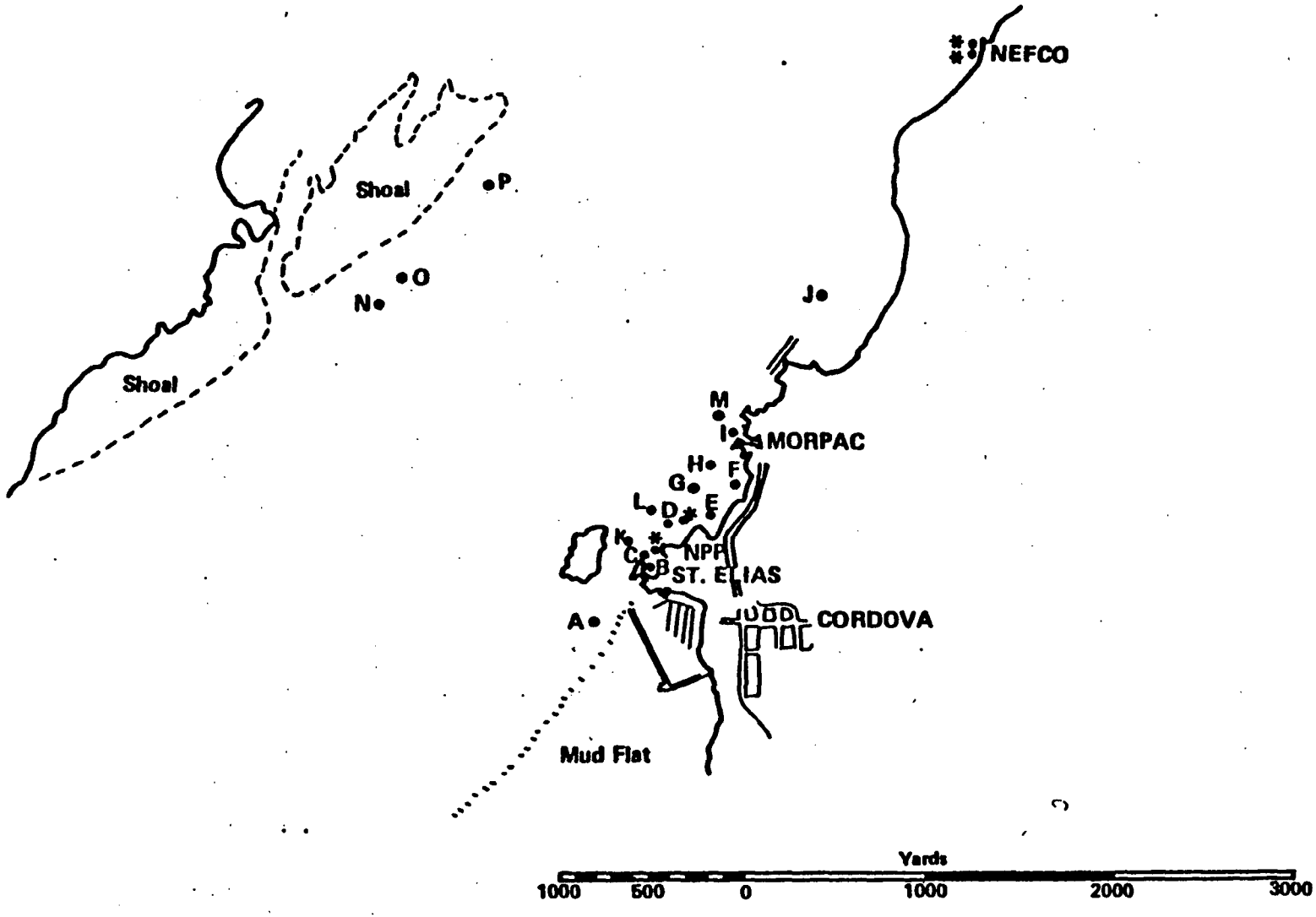


Figure 2. Sampling sites in the vicinity of the Kenai River, Alaska.



*End of outfall at St. Elias, NPP and Nefco canneries.

Figure 3. Sampling sites in the vicinity of Cordova, Alaska.

ENTEROBACTERIACEAE ENRICHMENT

Enrichment for enteric pathogens was accomplished by suspending 10 g of sediment into 100 ml of Selenite F Medium (Difco), followed by streak plate isolation after 48 hours at 37°C, on Bismuth Sulfite, Hektoen, and MacConkey's agars (all Difco). Suspect colonies were streaked for purity on Hektoen and MacConkey's.

BIOCHEMICAL IDENTIFICATION

All biochemical profiles were determined with API-20E (Analytab Products) culture systems, following the manufacturer's recommendations, except that all TCBS isolates were suspended in 3.5% saline (instead of 0.9%) for the API inoculations. In addition, identification of *Vibrio* was confirmed by sensitivity to Novobiocin (Difco discs) and to 2,4-diamino-6-7-diisopropyl pteridine (Vibriostatic Agent 0/129, Calbiochem, San Diego, Ca.).

CULTURES AND CONTROLS

Positive controls were made by adding *Vibrio parahemolyticus* (ATCC: 17802) to some sample replicates, and in every case, the organism was recovered and correctly identified. *Vibrio parahemolyticus* (ATCC: 17802) was kindly supplied by Ms. Lee Anne McGonagle, Department of Laboratory Medicine, University of Washington School of Medicine, and Dr. Roger Grischkowsky, Fish Pathology Laboratory, Alaska Department of Fish and Game, supplied a culture of *V. anguillarum*. All cultures, including environmental isolates, were maintained on Sea Water Stock Culture Agar (SWSC) stabs, consisting of Stock Culture Agar (Difco) in artificial sea water, at pH 8.0.

IN VITRO EXPERIMENTS

For experimental purposes, organisms were grown on SWPC agar for 24 to 48 hours, after which sufficient colonies were picked and suspended into 3.5% saline to give a moderately heavy suspension (about 10^5 cells/ml). One milliliter aliquots of this suspension were used as inocula for growth experiments in 100 ml of the experimental growth media, in 250 ml flasks. Depending upon experimental requirements, growth media consisted of combinations of artificial sea water (ASW), natural sea water (NSW), 1.0% commercial crab meal (CM), kindly donated by Dr. Fred Husby, University of Alaska Experimental Farm from Seward Fisheries, Inc. (Lot No. CO-355), and 10 g of marine sediment (SED). APM was used for comparative growth determinations. All media were sterilized by autoclaving at 121°C for 15 minutes.

Growth at 37° and 25°C was measured by standard pour plate count procedures in 3.5% saline plate count agar (Difco) and by standard spread plate techniques on TCBS when growth was at 10° and 5°C. In all cases, culture purity was verified with check plates on TCBS. *Vibrio parahemolyticus* colonies were counted after 48 hours at 37°C, and colonies of *V. anguillarum* were counted after 72 hours at 25°C.

SECTION 5

RESULTS

FIELD SAMPLES

Dutch Harbor

Nineteen samples were obtained for analysis for *Vibrio* spp., pH, and total heterotrophic counts of selected sub-samples. These results are summarized in Table 1. Six samples had populations of *Vibrio*-like isolates that were lower than could be counted with a three tube MPN series, and three of these were also negative when the initial 1:10 enrichment was plated. Conversely, five samples had populations exceeding the resolution of the three tube set. The results of the *Vibrio* MPN tests correlated well with physical appearance and odor of the samples and with total heterotrophic counts, which showed that those samples with highest *Vibrio*-like colonies had more than 100 times as many colonies by plate count enumeration. Analysis for coliforms (MPN-3 tube-Brilliant Green Bile Lactose), however, showed all samples to be free of significant coliform contamination.

Kenai

Fifteen sediment samples were obtained (S.C.S. Engineers, Long Beach, Ca.) from areas adjacent to the Kenai processing facilities (see Fig. 2A, B,C), for qualitative analysis for *Vibrio parahemolyticus* and pathogenic coliforms. Although seven samples produced green colonies on TCBS after enrichment, only one proved to be oxidase positive after sub-culture and was identified as being of the *Pseudomonas fluorescens* group by API analysis. *Vibrio parahemolyticus* was not detected in any sample. Six samples produced suspect colonies on Bismuth Sulfite Agar, but further analysis with Hektoen Agar, and API analysis identified them as *Citrobacter freundii* and *Pseudomonas fluorescens*. These results are shown in Table 2.

Cordova

Sixteen samples were obtained (S.C.S. Engineers, Long Beach, Ca.) from areas adjacent to Cordova processing facilities and subjected to qualitative analysis for *V. parahemolyticus* and pathogenic Enterobacteriaceae. Three samples produced suspect colonies on TCBS, but were subsequently identified as *P. putrefaciens* and *P. fluorescens*. Seven samples produced suspect colonies on Bismuth Surfite, MacConkeys, or Hektoen and were identified as shown in Table 3. *Vibrio alginolyticus* was isolated from one sample (CE). Reisolation and reidentification confirmed the original findings.

TABLE 1. ANALYSIS OF DUTCH HARBOR SEDIMENT FOR pH, *VIBRIO*, TOTAL COLIFORMS, AND TOTAL HETEROTROPHIC COUNTS

Sampling Dates 6/11/78-6/12/78

Sample No.	pH*	*Vibrio*; MPN/100 ml (of a 1:10 susp.)	Coliform MPN/100 ml	Total CFU/ml (Lg10 #)	Mean Total CPU/ml (Lg10 #)
HEL 3AG	7.3	240			
HEL 3	7.5	460			
HEL 3BF	7.09	150			
HEL 1A	7.04	9			
HEL 3H	7.38	75			
HEL 3D	7.12	460			
HEL 3A	7.09	1,100			
HEL 3C	7.77	150			
HEL 3DE	6.64	<3.0*			
DUT 02A	7.01	93			
HEL 3E	7.14	<3.0†	23	3.39	
DUT 01A	7.40	<3.0†	9	2.35	2.85 ± 0.58
DUT 02	7.50	<3.0†	23	2.30	
DUT 00	7.30	<3.0†	9	3.25	
HEL 3F	7.08	>1100	23	5.25	
HEL 3G	7.06	>1100	9	4.82	5.07 ± 0.19
HEL 3I	7.03	>1100	9	5.18	
HEL 3B	7.10	>1100	4	5.03	

*pH taken at 72 hrs after sampling.

†Of those samples showing less than 3.0 *Vibrio*/100 ml, three (DUT 02, DUT 00, DUT 101) yielded no growth of *Vibrio*-like colonies on TCBS streaks of the original 1:10 suspension. All others were positive at 1:10.

TABLE 2. ANALYSIS OF KENAI SEDIMENT SAMPLES

Sampling Dates 7/25-26/78

Sample No.	*VIBRIO* SCREEN TCBS Plates	*VIBRIO* SCREEN Final API Analysis	COLIFORM SCREEN Bismuth Sulfide Screen	COLIFORM SCREEN Mac/Hek* Screen	Final API Analysis
A	-		-		
B	-		-		
B_1	+	Oxidase Negative	+	Non-LF†	*Pseudomonas fluorescens*
C	-		-		
C_1	+	Oxidase Negative	-	LF	*Citrobacter fruendii*
D	+	Oxidase Negative			
E	+	*Pseudomonas fluorescens*	+	Non-LF + LF	*Ps. fluorescens* and *Cit. fruendii*
F	-		-		
H	-		-		
L	-		+	LF	*Citrobacter fruendii*
N	+	Oxidase Negative	+	LF	ND
R	-		-		
T	-		+	Non-LF	*Ps. fluorescens*
X	-		-		

*MAC = MacConkey's AGAR; HEK = Hektoen AGAR

†LF = Lactose Fermenter

TABLE 3. ANALYSIS OF CORDOVA SEDIMENT SAMPLES

Sampling Dates 7/28-8/2/78

Sample No.	Temp.* Celsius	Depth* Meters	*VIBRIO* SCREEN TCBS Plates	*VIBRIO* SCREEN API Analysis	COLIFORM SCREEN Bismuth Sulfide MAC/HEK†	COLIFORM SCREEN API Analysis
CA	11.6	65	-		-	
CC	11.7	125	-		-	
CD	11.9	8.7	-		-	
CE	na	na	-		+	*V. alginolyticus*
CG	na	na	-		-	
CH	11.9	6.75	+	*Ps. putrefaciens*	+	LF†
CI	11.4	7.5	-		-	
CJ	11.1	10.2	-		-	
CK	11.6	8.5	-		+	*Achromobacter* sp.
CL	11.9	8.0	+	*Ps. putrefacieus*	+	LF
CM	11.8	18	+	*Ps. fluorescens*	-	
CN	11.4	9.5	-		-	
CO	11.7	8	-		-	
CP	na	na	-		+	*Ps. putrefacieus*
NPP	na	na	-		+	*Ps. putrefacieus*
St. Elias	na	na	-		+	*Ps. fluorescens*

*Data supplied by S. C. S. Engineers.

†Abbreviations as in Table 2.

IN VITRO EXPERIMENTS

Tolerance of Reduced Salt Concentration by *Vibrio parahemolyticus*

Viability of *V. parahemolyticus* was tested in artificial seawater, 3.5% NaCl, 0.85% NaCl, and distilled water by both qualitative (Table 4) and quantitative (Table 5) determination of viable colony forming units. No difference could be detected between sea water, 3.5% NaCl or 0.85% NaCl as a suspending medium, but suspension in distilled water resulted in a rapid loss of viability. However, when 3.5% NaCl and 0.85% NaCl were used as the suspending medium for API analysis, abnormal biochemical profiles (Table 6) were observed with 0.85% saline, but not with 3.5% saline. In this experiment, four cultures of *V. parahemolyticus* in 0.85% NaCl, resulted in abnormal API profiles at 24 hours, resembling that commonly observed with some pseudomonads. All tests remained negative at 48 hours.

TABLE 4. EFFECT OF SALINE CONCENTRATION OF SUSPENDING MEDIUM ON SURVIVAL OF *VIBRIO PARAHEMOLYTICUS* - QUALITATIVE ASSAY

	Time, min.					
Suspension	0	5	10	30	60	90
Distilled Water	4+	1+	-	-	-	-
Artificial Seawater	4+	4+	4+	4+	4+	4+
3.5% Saline	4+	4+	4+	4+	4+	4+

TABLE 5. EFFECT OF SALINE CONCENTRATION OF SUSPENDING MEDIUM ON SURVIVAL OF *VIBRIO PARAHEMOLYTICUS* - QUANTITATIVE ASSAY

	Time, min.			
Suspension	0	20	60	120
Distilled Water	4.80*	1.50	1.30	0
0.85% Saline	5.10	5.40	5.20	5.40
3.50% Saline	5.20	4.90	5.30	5.30

*Numbers are $\log_{10}$ numbers of cells, determined by pour plate technique.

Bacterial Content of Crab Meal

The crab meal used in this project was analyzed for bacterial content and was found to produce 3.1 x 10^6 CFU/ml by total count, 2.0 x 10^1 CFU/ml on Bismuth Sulfite Agar and 1.75 x 10^5 *Vibrio*-colonies on TCBS agar. *Vibrio parahemolyticus* was not detected. The suspect colonies on Bismuth Sulfite were identified as *Enterobacter cloacae* by API, but the yellow colonies produced on TCBS did not key out, although they were Gram negative, oxidase positive rods. No further analysis of the crab meal was attempted and when used in subsequent experiments, it was sterilized by autoclaving.

TABLE 6. BIOCHEMICAL PROFILE ON API-20E OF SELECTED ISOLATES FROM ORIGINAL CULTURE OF *VIBRIO PARAHEMOLYTICUS*

Culture Reisolate	API Inoculum Diluet	API Profile Identification
Vp-01	0.85% Saline	All tests negative at 24 and 48 hrs
	3.50% Saline	*V. parahemolyticus* (profile No. 4356106)
Vp-02	0.85% Saline	All tests negative at 24 and 48 hrs
	3.50% Saline	*V. parahemolyticus* (Profile No. 4356106)
Vp-A	0.85% Saline	All tests negative at 24 and 48 hrs
	3.50% Saline	*V. parahemolyticus* (Profile No. 4356106)
Vp-37I	0.85% Saline	All tests negative at 24 and 48 hrs
	3.50% Saline	*V. parahemolyticus* (Profile No. 4356106)

Growth of *V. parahemolyticus* in Sea Water and Crab Meal Based Media

The data in Table 7 and Figure 4 show that *V. parahemolyticus* is quite able to utilize commercially available crab meal as a nutrient source. In these experiments, the crab meal was not treated in any way (other than during preparation by the manufacturer) except that the test media (sea water + 1% Crab Meal) were sterilized by autoclaving prior to use. The apparent increase in number of colony-forming-units in non-supplemented sea water is unexplained, although it suggests the *V. parahemolyticus* is an efficient saprophyte, quite able to scavange the small amounts of nutrients present in sea water. Nevertheless, growth in 1% crab meal was dramatic, resulting in up to a five-log (100,000x) increase in cell number in 96 hours. Also, it can be seen that little or no difference can be observed between the growths obtained in natural or artificial sea water. It would also appear that the crab meal was a better nutrient than alkaline peptone medium, although the reasons for this were not pursued in this project.

Growth of *V. parahemolyticus* at 5, 10 and 25°C

Tables 8 through 10 and Figure 5 show the growth of *V. parahemolyticus* at temperatures related to *in situ* temperatures of Alaskan waters. Although this strain of *Vibrio* could grow quite well at 25°C (Table 10), no growth was observed, at 5°C (Table 8) and 10°C (Table 9), for up to 96 hours. However, our data show that *V. parahemolyticus* in sea water media is also able to survive for up to 96 hours, with no appreciable loss of viability at 25°C and at 10°C, and with only moderate loss at 5°C.

TABLE 7. GROWTH OF *VIBRIO PARAHEMOLYTICUS* AT 37°C IN ARTIFICIAL AND NATURAL SEAWATER-BASED MEDIA

Medium	Time, Hrs						
	3.0	6.0	8.5	24	48	72	96
ASW*	3.23†	3.49	3.21	4.56	4.89	4.84	4.83
ASW + CM	3.51	4.75	5.49	nd	6.72	7.84	7.45
NSW	3.18	3.59	3.54	3.48	4.51	4.46	4.05
NSW + CM	3.53	4.76	5.57	nd	7.43	7.61	7.40
APM	3.53	4.53	5.31	nd	5.82	4.67	4.51
	Count at Ø hrs = 3.18						

*Abbreviations: ASW = Artificial Seawater; CM = Crab Meal; NSW = Natural Seawater; APM = Alkaline Peptone Medium.

†Numbers are $\log_{10}$ number of colony forming units/ml.

TABLE 8. GROWTH OF *V. PARAHEMOLYTICUS* AT 5°C IN ARTIFICIAL SEAWATER AND CRAB MEAL MEDIUM

Time, hrs	Artificial Seawater	Artificial Seawater & Crab Meal
0	4.03*	4.03
1.5	4.10	4.19
3.0	4.10	4.25
7.0	4.08	3.93
24.0	2.88	3.78
48.0	3.72	2.70
72.0	3.70	3.00

*Numbers are $\log_{10}$ number of colony-forming-units/ml.

TABLE 9. GROWTH OF *V. PARAHEMOLYTICUS* AT 10°C IN ARTIFICIAL SEAWATER AND ARTIFICIAL SEAWATER AND CRAB MEAL MEDIUM

Time, hrs	Artificial Seawater	Artificial Seawater and Crab Meal
0	6.10*	6.10
6	6.10	6.40
24	6.90	7.10
45	5.90	6.20
69	6.40	5.70
96	6.80	6.00

*Numbers are $\log_{10}$ number of colony-forming-units/ml.

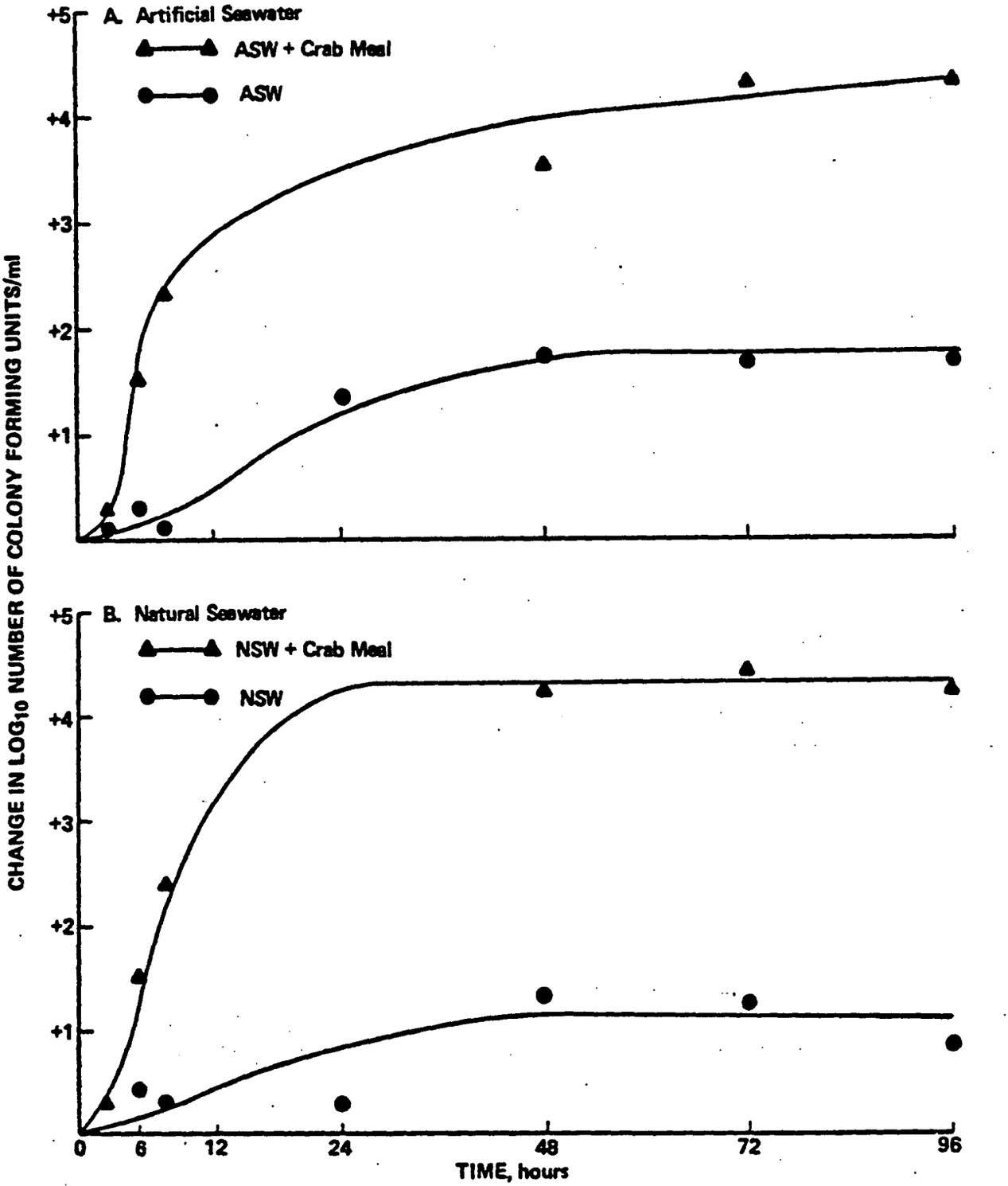


Figure 4. Growth of *Vibrio parahemolyticus* at 37°C in crab meal supplemented artificial and natural seawater.

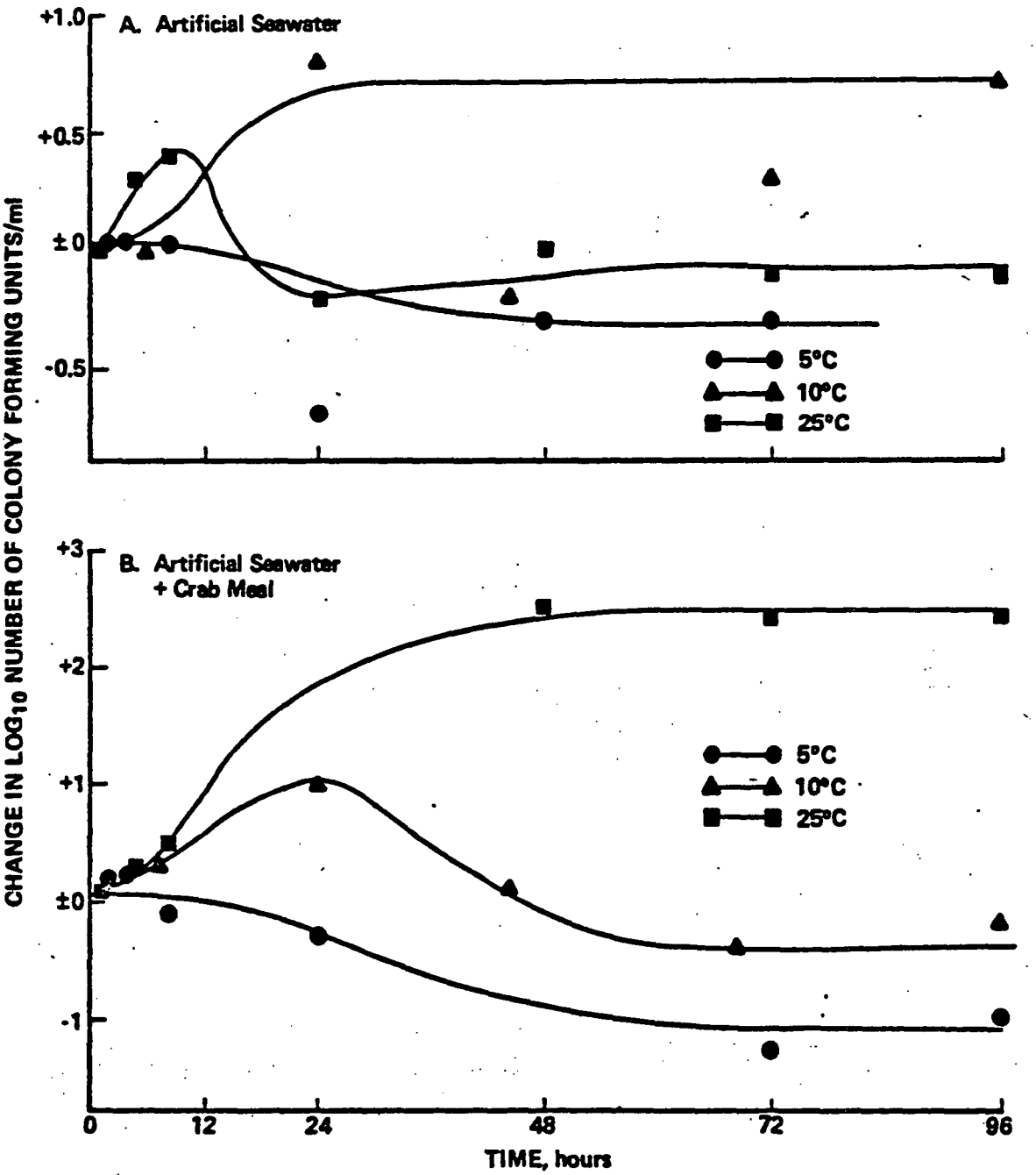


Figure 5. Growth of *Vibrio parahemolyticus* at 5°, 10°, and 25°C in artificial seawater and artificial seawater and crab meal.

TABLE 10. GROWTH OF *V. PARAHEMOLYTICUS* AT 25°C IN ARTIFICIAL SEAWATER AND ARTIFICIAL SEAWATER PLUS CRAB MEAL MEDIUM

Time, hrs	Artificial Seawater	Artificial Seawater Plus Crab Meal
0	5.14*	5.14
1	5.26	5.20
4	5.43	5.47
7	5.49	5.67
24	4.99	na
48	5.10	7.61
72	5.00	7.57
96	4.96	7.59

*Numbers are $\log_{10}$ number of colony-forming-units/ml.

Growth of *V. anguillarum* at 25°C and 5°C in Sea Water and Crab Meal

The data in Tables 11, 12, and Figure 6 show that *V. anguillarum* grew well in the crab meal medium and, although some lag was observed, showed good growth at 5°C. This is consistent with *V. anguillarum* lower optimal temperature and temperature range characteristics (as compared with *V. parahemolyticus*) and suggests that this organism, or other cold-adapted saprophytes would be expected to proliferate where conditions similar to these prevail.

TABLE 11. GROWTH OF *VIBRIO ANGUILLARUM* IN SEVERAL MEDIA AT 5°C

Medium	Time, hrs					
	4	6	8.5	24	48	72
ASW*	4.15†	4.30	5.10	4.48	4.64	4.69
NSW	3.36	3.92	3.98	3.23	4.15	4.16
ASW+CM	4.11	4.00	4.34	4.76	5.62	6.71
NSW+CM	4.19	4.30	4.32	4.48	5.17	6.72
APM	4.43	4.46	4.15	4.70	5.59	6.99
Count at Ø time = 4.22						

*Abbreviations as shown in Table 7.

†Numbers are $\log_{10}$ number of colony-forming-units/ml.

TABLE 12. GROWTH OF *VIBRIO ANGUILLARUM* IN SEVERAL MEDIA AT 25°C

Medium	Time, hrs					
	3	6	9	24	48	72
ASW*	4.28†	4.43	nd	4.26	4.38	nd
NSW	4.15	4.08	nd	4.36	4.20	4.11
ASW+CM	4.56	4.49	5.72	6.41	6.40	6.04
NSW+CM	4.32	5.19	5.83	6.85	6.04	6.63
APM	4.54	5.26	6.53	7.33	6.88	7.09
Count at Ø time = 3.98						

*Abbreviations as shown in Table 7.

†Numbers are $\log_{10}$ number of colony-forming-units/ml.

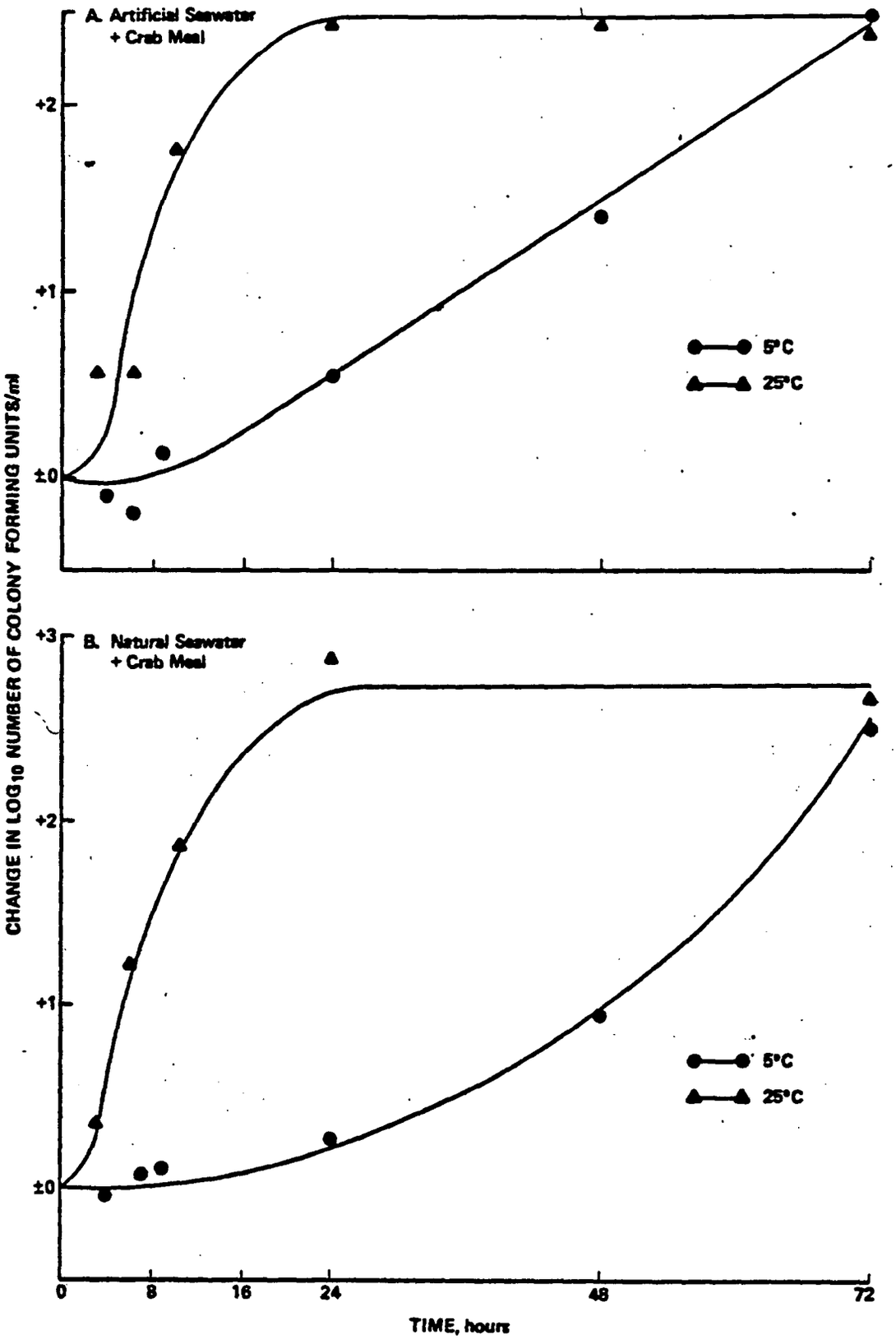


Figure 6. Growth of *Vibrio anguillarum* in natural and artificial seawater media, with crab meal, at 5° and 25°C.

SECTION 6

DISCUSSION OF RESULTS

FIELD SAMPLES

Vibrio parahemolyticus was not isolated from any of forty-six sediment samples obtained from three locations associated with seafood processing wastes at Dutch Harbor, Kenai, and Cordova, Alaska. However, the isolation of *V. alginolyticus* from a single Cordova sample deserves careful attention. *Vibrio alginolyticus* is considered a biotype of *V. parahemolyticus* differing from *parahemolyticus* in salt tolerance, the reactions in MR-VP medium (12), and sucrose fermentation. Since fermentation of sucrose is at least partly responsible for the differences in colony colors on TCBS, the possibility that some of the yellow colonies observed in these samples were, in fact, *V. alginolyticus*, must be considered. That is, the organism may be more common than appears to be the case, because the screening used in this project selected for *V. parahemolyticus*-like green colonies and disregarded yellow colonies. Similar considerations apply to *V. anguillarum*, which also forms yellow colonies on TCBS. Thus, while *V. parahemolyticus* could not be detected in any sample, the techniques used here did allow for easy recovery of other *Vibrio*, especially *V. anguillarum* and *V. alginolyticus*. Considering the nature of the added nutrients, the enrichment of the microbial population for chitinolytic bacteria, such as *Vibrio* is to be expected (6,7) and in fact, was observed. However, the growth of *V. parahemolyticus* and *V. alginolyticus* should be restricted to areas where the temperature remained above 10°C (8) for significant periods of time. Organisms such as *V. anguillarum* which are able to grow at 5°C, must be considered as possible inhabitants of sediment and waters in which seafood wastes have been allowed to accumulate. (See section on *in vitro* studies for further discussion.) These studies indicate that current practices of sea-food waste disposal have not, of yet, created a health hazard to humans, at least, under present criteria. There was no successful isolation of *V. parahemolyticus* (although "added-in" controls produced positive isolates) or significantly increased enteric populations at the sites. However, the severe pollution reported previously (2,3) was confirmed by markedly increased heterotrophic bacterial counts (Table 4) and increased numbers of *Vibrio*-like organisms (Table 4). Dramatic changes in environmental conditions occurred wherever disposal practices resulted in accumulation of wastes.

PHYSIOLOGICAL ECOLOGY OF *VIBRIO* SPP.

One major objective of this project was to determine if *Vibrio parahemolyticus* or *Vibrio anguillarum* could grow under conditions similar to those occurring at the disposal sites. The genus *Vibrio* is characterized, in part, as being chitinolytic and associated with invertebrate exoskeleton material

(5,6). Furthermore, *V. parahemolyticus* has been reported to be mesophilic while other *Vibrio* are psychrophylic to varying degrees. It is generally believed that ambient water temperature at the disposal site will determine which species of *Vibrio* will predominate and that seasonal fluctuations in temperatures have been associated with seasonal appearances of *V. parahemolyticus* (7) and associated cases of enteritis (9,10).

The results obtained in this project confirm the previous reports that *V. parahemolyticus* was unable to replicate at either 5° or 10°C, but grew very well at 25° and 37°C in a sea water-crab meal medium (Figs. 4 and 5). *Vibrio anguillarum*, however, was able to replicate at 5°C and presumably could do so *in situ*. The isolation of *V. alginolyticus* from Cordova sediment may or may not indicate that *V. parahemolyticus* can grow at that location. The two organisms have different salt tolerances and different temperature tolerances (13).

These studies also indicate that *V. parahemolyticus* can very effectively use crab processing wastes in sea water as nutrients when the ambient temperature exceeds the minimum growth temperature. Although our data show that when the temperature does not exceed 10°C, *V. parahemolyticus* will not grow, we were unable to determine the exact minimum growth temperature for this organism, but caution that it may not be very much higher than 10°C.

There is little doubt, however, that the fish pathogen (9,10) *V. anguillarum*, can grow at 5°C and that the accumulation of sea food wastes could result in establishing a focus source of this organism, with resulting risk to local populations of marine organisms.

This project also demonstrated some of the problems that arise when studying marine organisms. Reports of osmotic and temperature damage and (14,15, 16) the prevention of, or compensation for, such damage have recently appeared. Our data suggest (Table 7) that although suspension of *V. parahemolyticus* in 0.9% NaCl has little observable effect on viability as measured by plate counts on osmotically suitable media (in this case TCBS and alkaline peptone-sea water agar), viability may be seriously affected when other more restrictive media are used or when diagnostic systems are used with 0.9% NaCl. The critical nature of the medium used subsequent to osmotic or temperature shock, as observed here, deserves careful consideration when developing diagnostic systems. In our laboratory, diagnosis of *Vibrio parahemolyticus* by API on 0.9% NaCl was simply not reliable. The necessity of using inocula containing cells in logrithemic growth, presumably to ensure good continued activity in the API system has also reported by Murray (17).

GENERAL ECOLOGICAL CONDITIONS

These studies, like all such studies that use pure cultures and laboratory conditions, can be applied to *in situ* situations in only a very limited way. For example, although our data show that *V. anguillarum* can replicate at 5°C, on crab wastes, the data do not measure the relative competitiveness of this organism *in situ*. It would be desirable to know its growth rate relative to other saprophytic bacteria occupying the same or a similar niche.

Although these studies suggest that *Vibrio parahemolyticus* will not grow at 10°C or lower, the data do not necessarily support a converse conclusion - that is, that *V. parahemolyticus* will necessarily appear if the water temperature exceeds 10°C. Again, knowledge of relative growth rate and competitiveness in a mixed population is necessary before such speculation would have any value. The data reported here only indicate that so long as the temperature remains at, or below, 10°C, it is unlikely that *V. parahemolyticus* will grow.

Finally, of course, growth will occur only where sufficient and appropriate nutrients are supplied. These data suggest, as hopefully other studies will prove, that dispersal of wastes by current flow will very effectively prevent the development of large bacterial populations and the problems associated with such a condition.

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