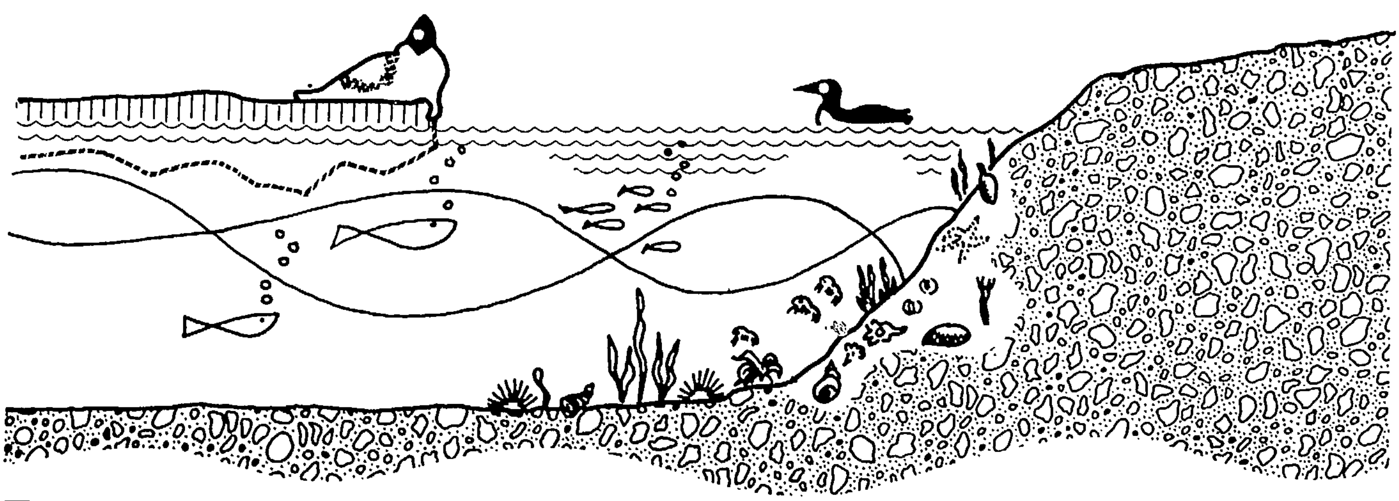
MACROBENTHOS



Baffin Island Oil Spill Project

WORKING REPORT SERIES

BIOS CAPE HATT

1982 STUDY RESULTS

The Baffin Island Oil Spill Project

OBJECTIVES

The Baffin Island Oil Spill (BIOS) Project is a program of research into arctic marine oil spill countermeasures. It consists of two main experiments or studies. The first of these, referred to as the Nearshore Study, was designed to determine if the use of dispersants in the nearshore environment would decrease or increase the impact of spilled oil. The second of the two experiments in the BIOS Project is referred to as the Shoreline Study. It was designed to determine the relative effectiveness of shoreline cleanup countermeasures on arctic beaches.

The project was designed to be four years in length and commenced in 1980.

FUNDING

The BIOS Project is funded and supported by the Canadian Government (Environment Canada: Canadian Coast Guard; Indian and Northern Affairs; Energy, Mines & Resources; and Fisheries & Oceans), by the U.S. Government (Outer Continental Shelf Environmental Assessment Program and U.S. Coast Guard), by the Norwegian Government and by the Petroleum Industry (Canadian Offshore Oil Spill Research Association; BP International [London] and Petro-Canada).

WORKING REPORT SERIES

This report is the result of work performed under the Baffin Island Oil Spill Project. It is undergoing a limited distribution prior to Project completion in order to transfer the information to people working in related research. The report has not undergone rigorous technical review by the BIOS management or technical committees and does not necessarily reflect the views or policies of these groups.

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EFFECTS OF OIL AND DISPERSED OIL ON NEARSHORE MACROBENTHOS AT CAPE HATT, NORTHERN BAFFIN ISLAND

III. RESULTS OF 1980, 1981 and 1982 PRE- AND POST-SPILL STUDIES

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EXECUTIVE SUMMARY

Effects of experimental releases of oil and dispersed oil on nearshore macrobenthos were studied in four small bays at Cape Hatt, Baffin Island. Lagomedio crude oil was applied to the surface of one bay on 19 August 1981, and dispersed oil (10 Lagomedio : 1 Corexit 9527) was released underwater in another bay on 27 August 1981. The latter release also resulted in relatively heavy contamination of the third study bay, and low levels of contamination in the surface oil release bay and in the fourth (reference) bay.

Systematic sampling was carried out in three bays during September 1980 and in four bays during August 1981 (pre-spill), September 1981 (two to four weeks post-spill) and August and September 1982 (one year post-spill). Three transects at each of 2 depths (3 m, 7 m) were sampled in each bay and sampling period. The work on each transect during each study period included (1) collection of eight samples, each covering 0.0625 m2, using a diver-operated airlift sampler, (2) collection of 8-12 photographs, each covering 0.25 m2, and (3) in situ counts of large organisms within five areas, each 1 x 10 m in dimensions. All fauna $\geq$1 mm in length were sorted from airlift samples, identified to species where possible, counted and weighed. All bivalves and holothurians were measured, and wet and dry weights were obtained for a subsample of four dominant bivalve species from each bay and period. Photographs and in situ counts were used to provide a permanent visual record of the study area and to enumerate large and widely distributed organisms.

In addition to the sampling during the five systematic survey periods, photographs and direct counts of animals at the surface along the standard transects were obtained within five days of the dispersed oil release. These data provided information about short-term responses.

Spatial and temporal variability in the benthic community were examined and tested using (1) three-factor (periods, bays, transects) fixed-effects analyses of variance, with transects nested within periods and bays, (2) factor analysis and discriminant analysis of community structure, (3) multivariate analyses of variance to test for changes in community structure, and (4) analysis of covariance to examine weight-length relationships. Depths were treated separately in all analyses. To test for effects of oil or dispersed oil, we looked for (1) pre- to post-spill changes that occurred in oiled bays but not in the reference bay and (2) pre- to post-spill changes that were not consistent between dispersed and untreated oil bays. The period x bay interaction term in the analyses provided a test of significance of oil effects. Variables examined included density and biomass of dominant infaunal taxa, biomass of four infaunal feeding guilds and of dominant macroalgal species, density of epibenthic echinoderms and crustaceans, infaunal community structure, and size and weight-length relationships in common bivalve species.

Most of the systematic variability identified by these analyses was spatial and temporal. Nearly all variables differed significantly on small and large spatial scales (among-transects and among-bays, respectively). Significant temporal differences were less common and most often were annual rather than seasonal.

Oil and dispersed oil released at Cape Hatt caused some detectable effects on selected species, but did not cause large scale immediate mortality of benthic animals or any significant change in benthic infaunal community composition. This was probably because hydrocarbon levels in the sediments were rather low, similar to those in 'lightly oiled' areas reported elsewhere. Significant oil effects were found in only 16 of 212 analyses performed, and results were similar using a less conservative analysis design. Within the framework of published literature, our results are consistent with the low quantities of oil to which the animals were exposed.

The observed oil effects at Cape Hatt were associated with both untreated and chemically dispersed oil. These effects fall under three categories: sublethal effects, decreased abundance in some organisms, and enhancement of growth or recruitment in others. Some of these effects appear to have been transitory, including immediate post-spill stress in a variety of benthic animals, temporary relocation of urchins, and changes in the abundance of amphipods, polychaetes and juvenile bivalves. Other effects detected one year post-spill (1982) may persist or become more evident in subsequent years. These include changes in weight-length relationships in two bivalve species and changes in the biomass of macrophytic algae.

Oil effects were visually apparent on the first and second days following both oil releases in 1981. Only intertidal amphipods and some larval fish were obviously affected by the surface oil release; immediate and one year post-spill effects on intertidal amphipods are reported by Cross (1982) and Cross and Martin (1983). The dispersed oil release, however, produced marked immediate effects on benthos at both 3 and 7 m depths in both the release bay and the adjacent bay (difference of approximately an order of magnitude in dispersed oil levels). In these bays, a variety of large infaunal and epibenthic invertebrates, particularly *Serripes groenlandicus*, emerged from the substrate and/or assumed unnatural postures. Sea urchins (*Strongylocentrotus droebachiensis*) apparently moved away in response to the dispersed oil release. Recovery in both urchins and *Serripes groenlandicus* had apparently begun shortly after the release (Cross and Thomson 1982), and analysis of data collected in 1982 indicated that further recovery towards pre-spill conditions had occurred.

Other immediate post-spill changes related to oil were a decrease in densities of juvenile bivalves (*Macoma*) in the dispersed oil release bay, and a decrease in polychaete density in the surface oil release bay. Both of these taxa appear to have recovered (densities increased) one year following the oil releases. In contrast, two groups of amphipods (the genus *Anonyx* and the family Calliopiidae) increased in abundance in the surface oil release bay after the release, and then decreased before the next sampling periods. Juvenile bivalves (*Astarte*) showed a similar increase in the two dispersed oil bays, and a similar decrease in the following period. Again, these effects appear to be transitory; in two cases (*Anonyx* and *Astarte*), densities in September 1982 were similar to pre-spill (September 1980) densities.

Effects that may persist for longer periods were found with both untreated and dispersed oil. The surface oil release appears to have stimulated growth of the filamentous brown alga *Pilayella littoralis* in the month following the oil release. Decreased growth occurred in the following summer. Tissue weight in the deposit-feeding bivalve *Macoma calcarea* decreased between August and September of 1981 and 1982 in all three oiled bays, in contrast to the reference bay, where weight increased during both summers. This seasonal increase is necessary to meet metabolic requirements in the winter. The lack of such an increase in oiled bays was likely attributable to oil effects on feeding, gonadal development or metabolic processes. The filter-feeding bivalve Serripes groenlandicus showed a progressive decrease in body weight relative to length only in the reference bay, which received very low amounts of dispersed oil. This is difficult to explain, but may be related to the higher body burdens of hydrocarbons in this bay than in other bays (Boehm 1983).

An important objective of the BIOS project is to compare oil effects in the dispersed oil release bay with those in the surface release bay and to make inferences about the effects of dispersing oil with chemical agents. To this end, it is possible to say that the effects of dispersed oil have occurred and that they were minor. Immediate post-spill effects were obvious but only short-lived, and appear to have had no permanent effect. Medium term effects did not change community composition and affected only a few species. It is too early to be certain, but it appears that there will be little or no long-term effect of dispersed oil.

Oil levels in the sediment of the bay where there was a surface oil release have not yet reached maximum levels (Boehm 1983) and resultant effects on the benthic community (if any) have yet to be manifested. The increasing concentrations of oil recorded in the sediment of the surface oil release bay may be sufficient to cause a change in the condition, reproductive status and mortality rates of benthic animals in the next year or two.

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SECTION ONE

INTRODUCTION

The pace of exploration and development of hydrocarbon resources in arctic and subarctic marine areas is likely to increase in the future. Already, exploratory drilling is occurring in the Canadian Beaufort Sea, Sverdrup Basin, Davis Strait and the Labrador Sea, and plans call for offshore drilling in the Alaskan Beaufort Sea, Lancaster Sound and Baffin Bay in the near future. Plans for major offshore oil production are being developed for the Canadian Beaufort Sea, and the Federal Environmental Assessment Review Office is presently evaluating the plans. Year-round transport of oil through the Northwest Passage, Baffin Bay and Davis Strait is now a distinct possibility.

Clearly, as the amount of activity increases, the possibility of an accidental release of oil also increases. If oil is released there may be substantial pressure to use chemical dispersants to try to keep the oil from accumulating on the surface of the water or on shorelines.

With or without the use of chemical dispersants, released oil will enter the water column and, especially in nearshore locations, impinge upon the bottom. The initial biological effects will occur among planktonic and benthic invertebrates, although effects at higher levels of the food web may result from the mortality of (or accumulation of oil in) important food species. The use of chemical dispersants may increase biological effects because of dispersant toxicity, increased dissolution of toxic oil fractions, or increased opportunity for the accumulation of oil in sediments.

Recently, considerable attention has been given to the effects of oil and dispersants on individual species of arctic marine flora and fauna under experimental conditions (Percy and Mullin 1975, 1977; Percy 1976, 1977, 1978; Busdosh and Atlas 1977; Malins 1977; Atlas et al. 1978; Foy 1978, 1979; Hsiao et al. 1978), but to date the potential effects on whole communities are unknown. During the recent oil spill investigations following the grounding of the tanker TSESIS in the Baltic Sea, a comparison of approaches towards detecting biological effects supported the 'ecosystem approach' advocated by Mann and Clark (1978): data on reproductive abnormalities in a sensitive species only confirmed effects that were already obvious at the community level (Elmgren et al. 1980). In temperate waters community studies have been carried out for up to 10 years after a spill (e.g. Sanders et al. 1980), but most of these studies have been after the fact; hence they lack adequate 'control' data on pre-spill conditions, on naturally occurring changes that would have occurred in the absence of the spill, or on both (National Academy of Sciences 1975; cf. Bowman 1978). Another shortcoming of many spill studies has been the lack of supporting data on oceanographic and atmospheric conditions, and on hydrocarbon concentrations in the impacted environment (National Academy of Sciences 1975).

To date, no major oil spill has occurred in Canadian arctic waters. In 1978-1979 the Arctic Marine Oil Spill Program (AMOP) examined the need for research associated with experimental oilspills in cold Canadian waters, and thereafter instigated the Baffin Island Oil Spill (BIOS) project to study a controlled introduction of oil and dispersed oil onto shorelines and into nearshore arctic waters. The objectives of this project were to assess the environmental impact of chemical dispersants and the relative effectiveness and impact of other shoreline protection and clean-up techniques. The BIOS project is an internationally funded, multidisciplinary study being carried out by engineers, meteorologists, physical oceanographers, geologists, chemists and biologists from various government departments, industry and research organizations. The nearshore component of the BIOS project includes studies of microbiology and benthic macrobiology, atmospheric and oceanographic conditions, and chemical properties of the water column and surface sediments, with special emphasis on concentrations of petroleum hydrocarbons.

The objectives of the macrobiological component of the BIOS project are to assess the effects of oil and dispersed oil on the macrophytic algae, the relatively immobile benthic infauna (e.g. bivalves, polychaetes), and the motile epibenthos (e.g. amphipods, urchins) in shallow arctic waters. Variables to be examined include total abundance, total biomass and structure of these communities, as well as the abundance, biomass, population age structure and length-weight relationships of dominant species in these communities. The statistical design of the study is 'optimal' for impact assessment (in the sense of Green 1979) in that it includes both temporal (pre-spill) and spatial (unoiled bay) controls.

Cross and Thomson (1981) provided baseline data from three bays at Cape Hatt, Baffin Island (Bays 9, 10 and 11; Fig. 1), during the first of two pre-spill sampling periods (September 1980). In anticipation of the possibility of cross-contamination of the original control bay, a fourth bay remote from the spill site was added to the study design. All four bays were sampled during the second pre-spill sampling period (August 1981). In late August 1981, 15 m^3 of untreated Lagomedio oil was released within booms on the surface of Bay 11, and an additional 15 m^3 of the same oil treated with the dispersant Corexit 9527 (10 oil : 1 Corexit) was released underwater in Bay 9 (Fig. 1). Currents carried the dispersed oil into Bay 10, which had originally been designated as the control bay. This resulted in a relatively high level of contamination of Bay 10 -- approximately one order of magnitude lower than that in the oil/dispersant release bay. For several days following the dispersed oil release, low levels of oil (average maximum of 50 ppb) were also found in the new control bay--Bay 7--and also throughout Ragged Channel (Fig. 1). The first post-spill sampling was carried out in September 1981 in all four bays.

Cross and Thomson (1982) reported observations and quantitative data on immediate post-spill effects. They also provided an analysis of the effects of oil and dispersed oil based on 2 pre-spill sampling periods (September 1980 and August 1981) and one post-spill sampling period (September 1981). The 1980 data are presented in detail in Cross and Thomson (1981).

The present report includes new data from 1982 (August and September sampling periods, approximately one year following the oil release). It provides an analysis of the effects of oil and dispersed oil based on the two pre-spill and three post-spill sampling periods to date.

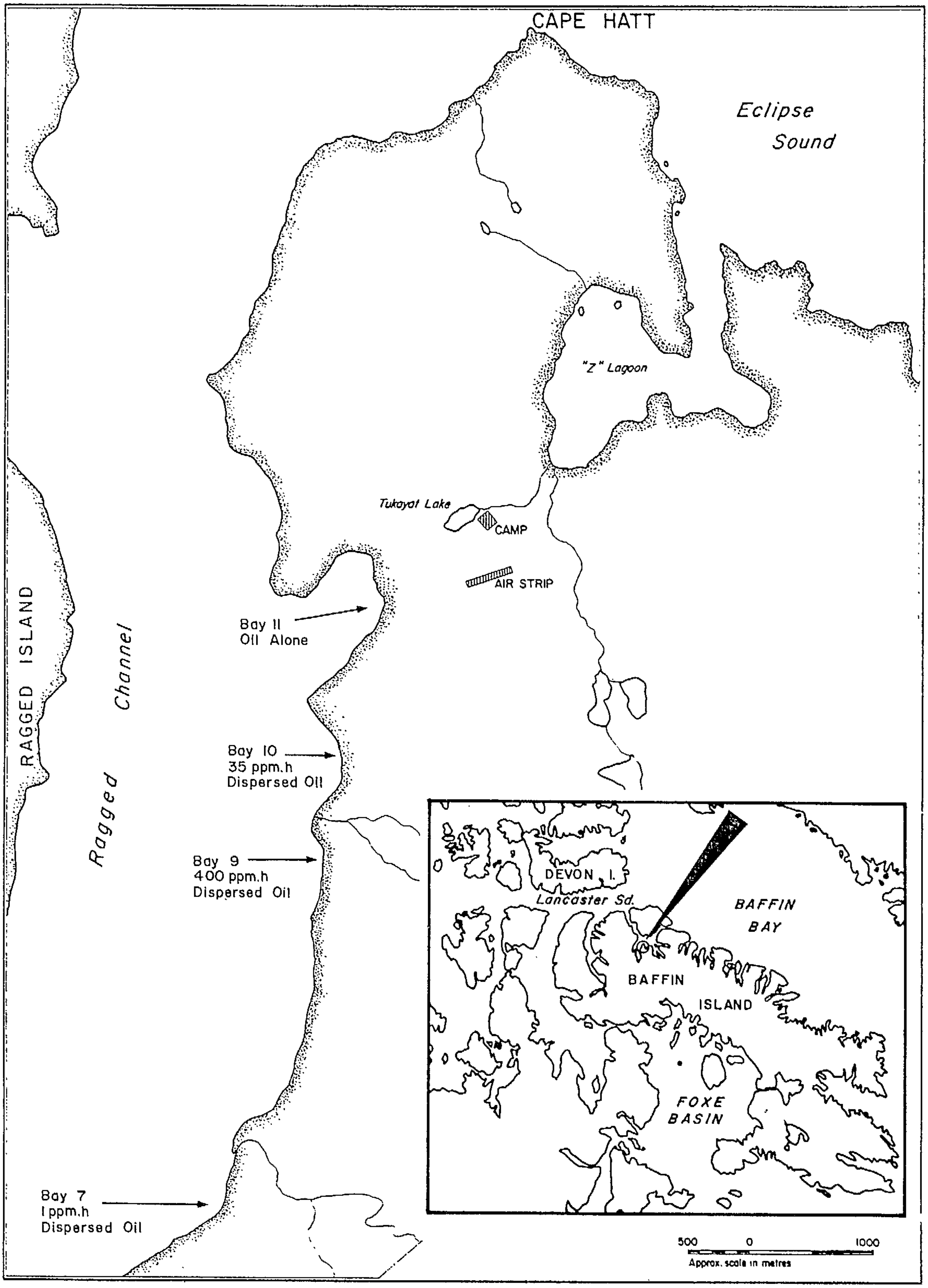


Figure 1. BIOS site at Cape Hatt, Baffin Island, showing the locations of study bays and oil treatments applied in August 1981. Dispersed oil concentrations are maximum estimated exposures in ppm × hours.

SECTION TWO

METHODS

2.1 Study Area

The study area for the nearshore component of the Baffin Island Oil Spill Project consisted of four shallow embayments in Ragged Channel, some 5-8 km SSE of Cape Hatt, Eclipse Sound (72°27'N, 79°51'W). Bays 9 and 10 (heavy and light dispersed oil release bays, respectively) are shallow indentations in the coastline, each about 500 m in length, separated by the delta of a small stream and a distance of somewhat less than 500 m. Bay 7 (reference bay) is similar in size and configuration, located about 6 km to the south, and just south of another small stream. Bay 11 (surface oil release bay) has been designated as the lower half (and Bay 12 as the upper half) of a deeper embayment approximately 1 km x 1 km in dimensions, located approximately 1 km north of Bay 10 (Fig. 1).

2.2 Field Procedures

Observations were made using SCUBA in the study bays during 7 August to 17 September 1980, 5 August to 20 September 1981 and 30 July to 13 September 1982. Divers monitored each oil release in 1982 and the condition of each bay on the first day following the dispersed oil release. Systematic sampling was carried out during 29 August-17 September 1980, 6-17 August 1981, 29 August-10 September 1981, 8-15 August 1982 and 3-12 September 1982 from the BIOS project camp located at Cape Hatt, Baffin Island (Fig. 1).

Additional sampling for other studies continued between the two periods in 1981 and 1982 and until 20 September 1981 and 13 September 1982. All sampling was carried out by divers working from inflatable boats (Zodiacs). Processing and preservation of samples were performed in tents erected on the beach in Bay 12. During September 1980, systematic sampling was carried out in Bays 9, 10, and 11, and during August and September 1981 and 1982 systematic sampling was carried out in Bays 7, 9, 10 and 11 (Fig. 1).

2.2.1 Sampling Locations

Three contiguous 50 m transects were set parallel to the shoreline at each of two depths in each of the study bays (Fig. 2). A depth of 7 m was selected as the primary sampling depth because of substrate characteristics and time/depth limitations for divers. Transect locations at 7 m depth were chosen in each bay using as criteria (1) similarity in substrate characteristics and infaunal community composition among transects and bays (as determined during preliminary surveys in August 1980 and, for Bay 7, 1981), and (2) facility of sampling (soft substrate with as little surface rock as possible). The second set of three transects in each bay was located immediately inshore of the 7 m transects at a depth of 3 m, where a relatively even cover of algae occurred in each bay.

Transect locations at 3 and 7 m depths were marked underwater during Pre-spill Period 1 (September 1980) by driving steel rods approximately 1 m into the substrate at 50 m intervals along a 150 m line. In each bay, sighting lines at the ends of the transects were established on the shore by placing pairs of markers on the beach. Transects were relocated in subsequent periods using the surface and underwater markers.

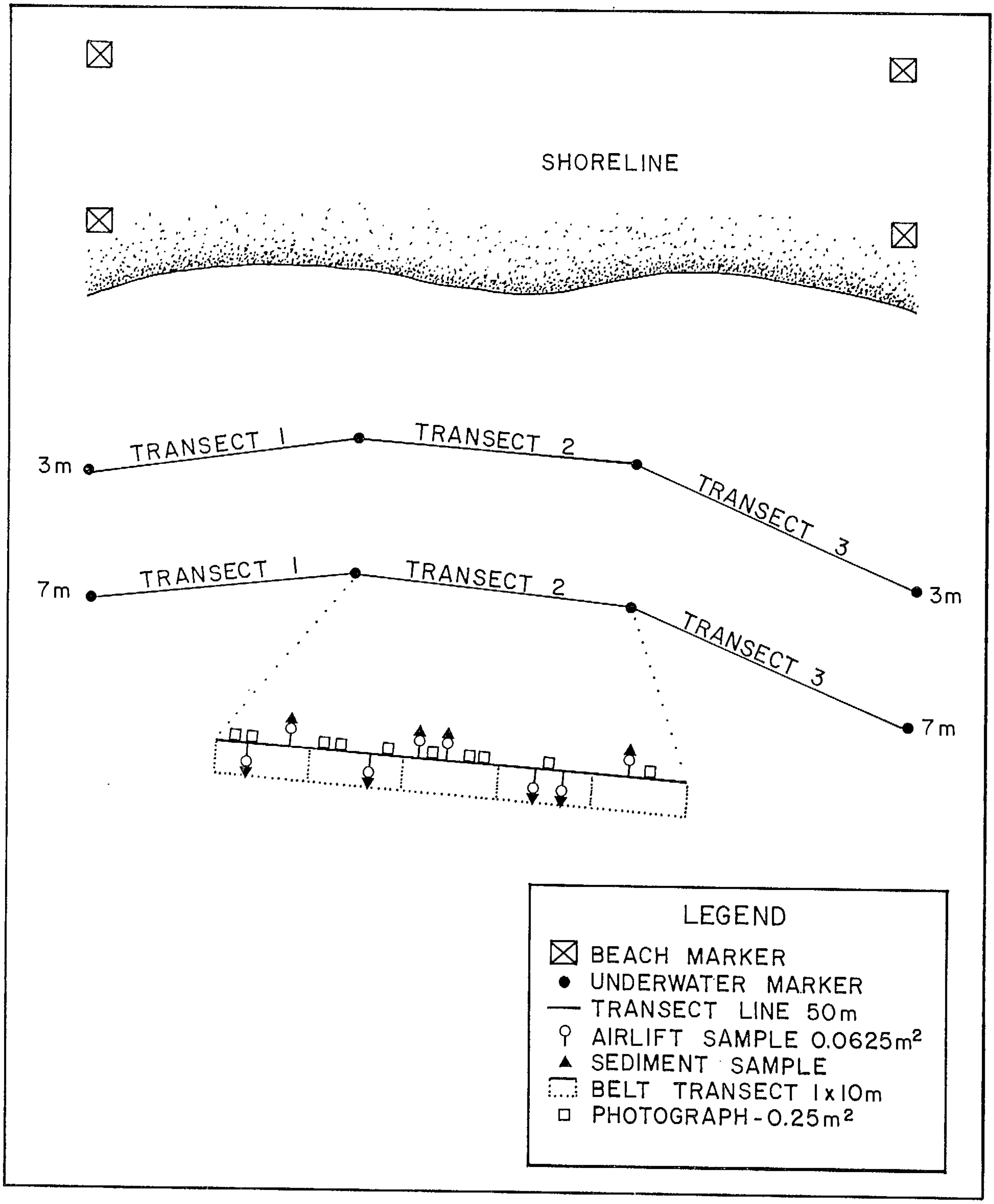


Figure 2. Schematic representation of sampling design for BIOS benthic study. Configuration of transects shown was repeated in each bay, and types and numbers of samples shown for one transect were repeated on each transect at each depth in each bay and period.

A 150 m transect rope marked at 1 m intervals was set between the permanent stakes before (and removed after) sampling at each bay/depth/period combination in 1980 and 1981. Transect lines were left in place in 1982. Airlift sampling locations 1 m^2 in area, immediately seaward or shoreward of the line, were selected using a random numbers table, and the exact location of the 0.0625 m^2 sample within each of these 1 m^2 areas was selected to avoid large rocks on the surface of the sediment. Photograph locations along each transect were also randomly selected, and were indicated on a list attached to the camera. Sample locations for airlifts and photographs were re-randomized for each transect and period; on any given transect, randomly selected airlift locations were rejected if they had been used during a previous period. *In situ* counts and supporting collections were made within 1 x 10 m belts along each transect line.

2.2.2 Airlift Sampling

Infauna were sampled by means of a self-contained diver-operated airlift. Eight replicate samples were obtained on each of three transects at each of two depths in each of three bays in 1980 (total of 144 samples), and in each of four bays in each of two periods in 1981 and 1982 (total of 384 samples in each year).

The airlift consisted of a weighted 2 m length of pipe 8 cm in diameter fitted at the top with a 1 mm mesh net which retained the sample and could be removed quickly and capped. Air was supplied from a 20 MPa air cylinder fitted with the first stage of a diving regulator, which reduced air pressure to approximately 860 kPa above ambient. Areas to be sampled were demarcated by a ring containing an area of 0.0625 m^2.

The ring was placed on the bottom and pushed as far as possible into the substrate to contain shallow infauna. The airlift was inserted into the ring, the air was turned on, and the mouth of the airlift was moved around to thoroughly cover the area within the ring. The air was turned off when all visible organisms had been collected, the net on the airlift was then removed, capped and replaced, and the depth of penetration of the airlift into the substrate was measured to the nearest cm. A sample of surface sediment was taken immediately beside the excavated area during September 1980 in Bays 9, 10 and 11, and during August 1981 in Bay 7. After three or four samples had been taken they were raised to the boat and rinsed in the collecting bags from the side of the boat in order to remove fine sediments. Immediately after each dive all samples were returned to the field laboratory.

2.2.3 Quantitative Photography

A photographic record of each transect during each period was obtained on colour slide film using a Nikonos camera with a 15 mm lens, paired Vivitar electronic flashes and a fixed focus framer covering a bottom area of approximately 0.25 m^2. Ten photographs were taken at randomly located intervals along each 50-m transect line during each period. In addition to providing a permanent visual record of each study area, photographs were used to estimate densities of visible surface fauna that were too sparsely distributed to be represented adequately in airlift samples. In order to obtain quantitative information on effects that were apparent immediately after the dispersed oil release, an additional six randomly located photographs were taken on each transect in Bays 9 and 10 on the second day following the release. Photographs were also taken in Bays 7 and 11 on the fourth and fifth days following the release. (No immediate effects were apparent in these bays.)

2.2.4 In Situ Counts

Macrophytes and those invertebrates too large and sparsely distributed to be representatively sampled by airlift or camera were counted *in situ*. On each transect during each period, counts of urchins, starfish and individual kelp plants were made within five 1 x 10 m strips parallel to and immediately adjacent to the transect line. Collections of representative plants and animals were also made for species identification. Additional counts of urchins and starfish were made after the dispersed oil release in 1981 using both *in situ* and photographic techniques (see above).

2.3 Laboratory Analysis Procedures

All samples were processed in the field within 12 h of collection. Samples were emptied into large plastic trays, and nets were carefully rinsed and picked clean. Entire samples (minus large rocks and gravel) were labeled and preserved in 10% seawater-formalin. Macrophytic algae other than those in airlift samples were pressed on herbarium paper and dried at room temperature.

Detailed laboratory processing and analysis of the 908 samples was carried out within six months of collection. Samples were initially rinsed to remove formalin and sediment, and then separated into five fractions. The first fraction, consisting of all material passing through a 1 mm mesh screen and retained on a 0.45 mm mesh screen, was preserved in alcohol for future reference. The second fraction, separated by rinsing, contained algae, detritus and most soft bodied animals. This fraction was examined under a binocular microscope and animals $\geq$1 mm in length were sorted into major taxonomic groups; the remaining algae and detritus was blotted dry and weighed on a Mettler PT 200 balance. In 45 samples that contained large volumes of algae (>500 mL), large and conspicuous organisms were picked from the entire sample but only a subsample of known weight was examined microscopically.

Fractions three to five were obtained by using nested sieves to separate the balance of the sample into three different size fractions (1-2.8 mm; 2.8-5.6 mm; $\geq$5.6 mm) containing sand, gravel, bivalves and some soft bodied animals. The large fraction was sorted in a glass tray into major taxonomic groups. Shell fragments and entire bivalve shells were separated, labeled and stored for future reference.

The two smaller size fractions from 1980 and 1981 samples were routinely sorted under a binocular microscope. Careful checking of a number of these samples indicated that approximately 10% of the smaller organisms remained in the sand and gravel, and were excluded from analysis. Hence a more efficient method using differential specific gravity (Sellmer 1956) was used in 1982. The 1 mm and 2.8 mm sieves were placed on paper towelling to remove excess moisture, and the contents were then emptied into a plastic pail containing a 70% solution (by weight) of $ZnCl_2$ (s.g. = 2.0). The mixture was gently stirred and organisms that floated to the surface were removed with a 1 mm mesh net. The procedure was repeated a minimum of two times. The specific gravity of the solution was measured before each sample was processed, and kept relatively constant (s.g. = 1.8-2.0) by adding $ZnCl_2$ as necessary.

The combined net contents were sorted into major taxonomic groups, and entire bivalve shells were separated and stored in labeled whirlpaks for future reference.

This change in technique was instituted in the interests of precision and accuracy, and on the understanding that the new technique would be retroactively applied to the previous years' samples. Results of the present report should be interpreted in consideration of this bias; densities of smaller organisms in 1980 and 1981 are underestimated by approximately 10%. It is doubtful, however, that a difference of this magnitude would affect the analyses. In particular, results concerning oil effects should not be affected because the change in technique involved samples from all bays. The experimental design separates oil effects from year-to-year effects (including any effect of the altered methodology).

During 1981, several unsorted samples were inadvertently mixed during laboratory analysis. In one case, two samples from different depths (3 m and 7 m, Bay 10, Pre-spill Period 2) were mixed; these were not analyzed. In two cases, two samples from the same transect were mixed: 3 m and 7 m in Bay 11 during Post-spill Period 1. In these two cases the two samples were combined, processed, and the results divided by two to provide data on one 'composite' sample. The resultant loss in data was, therefore, one of eight replicates at each of 3 m and 7 m in Bay 10 during Pre-spill Period 2, and at each of 3 m and 7 m in Bay 11 during Post-spill Period 1.

All animals were identified to species level whenever possible; unidentified or tentatively identified species were sent to appropriate authorities for identification or verification (see Acknowledgements). In cases where (1) verifications indicated that additional taxonomic effort was required on previous years' samples, or (2) it is generally recognized that additional species descriptions or revision of higher taxonomic levels are required, questionable species or genera were pooled at the next highest taxonomic level prior to analysis. For each taxon identified, individuals were counted, gently blotted dry, and weighed together to the nearest milligram on a Mettler PT 200 or PC 220 balance. Unless otherwise specified (see below), all weights presented in this report are preserved (10% formalin) wet weights, including mollusc shells but excluding polychaete tubes. Lengths of individuals of all bivalve species, and diameters of the calcareous oral rings of the holothurian Myriotrochus rinkii, were measured to the nearest mm. After laboratory examination, all taxa were stored in 75% ethanol; a solution of 3% propylene glycol in 75% ethanol was used for crustaceans.

For each of four common bivalve species (Mya truncata, Astarte borealis, Macoma calcarea, and Serripes groenlandicus), the relationships between length, wet weight and dry weight were derived as follows: For each bay and period, approximately fifty undamaged individuals of each species were selected (where possible) from airlift samples taken along the middle transect at 7 m depth; Serripes groenlandicus was selected only from 1981 and 1982 samples. If necessary to obtain a sample size of 50 per bay, animals from the inner ends of the outer two 7 m transects were also used. For each individual the length, wet weight including shell, wet meat weight, and dry (constant) meat weight were determined. Constant dry weight was obtained by drying at 60°C in a Fisher Isotemp Oven Model 301 and weighing at daily intervals until constant weight was found.

Airlift samples of algae and detritus from 3 m depths were weighed (see below), and 452 of the 454 samples from 3 m were analyzed in detail. Large and conspicuous species were sorted from each of these samples and weighed; in 26 cases (samples that had been subsampled for invertebrate sorting), only the subsample was examined. A subsample of approximately 2 g wet weight was separated from the balance of the sample, and sorted completely into the following categories: Stictyosiphon tortilis, Dictyosiphon foeniculaceus, Sphacelaria spp., a mixture of Pilayella littoralis and tubular diatoms, other species, and detritus (non-algal material). An appropriate subsample factor was then applied to extrapolate these results to the unsorted portion of the sample. Formalin wet weights were determined by rinsing in water, removing water by vacuum filtration in a Buchner funnel using Whatman #1 Qualitative filter paper until drops were 30 seconds apart, and weighing immediately to the nearest milligram on a Mettler PC 220 balance.

2.4 Data Processing and Analysis

All quantitative data collected in the field and all results from laboratory analyses were coded for computer processing. Computer programs developed by LGL were used to generate the sample by sample, transect by transect, and bay by bay tabulations that were used to select species and taxa for further analyses. Other LGL programs were used to organize the data into a format acceptable to packaged statistical programs. Prior to analyses, a logarithmic transformation (log [x+1]) was applied to density and biomass data in order to reduce the skewness inherent in such data. Many of the analyses conducted on 1980 data (Cross and Thomson 1981) showed significant bay by depth interactions, so separate analyses were run on data from each depth.

Three-factor (periods, bays and transects) fixed-effects analyses of variance, with transects nested within periods and bays, were used to examine and test spatial and temporal variability in the benthic community. Period (temporal) effects included both seasonal (August/September) and yearly (1980/1981/1982) components. Because of the nested design, the transect term rather than the residual error term was used to test the significance of main effects (periods, bays) and of the interaction between the main effects. When interaction terms involving transects were non-significant ($P>0.05$), they were pooled with the transect term before we tested for main effects. When interactions involving transects were significant ($P\leq0.05$), they were not pooled with the transect term. Analyses of variance were performed separately for each depth by the GLM procedure of the SAS computer program package (Helwig and Council 1979; Freund and Littell 1981).

The unbalanced design that resulted from the addition of the fourth bay in 1981 necessitated the use of two separate types of analysis to test for oil effects whenever analysis of variance or multivariate analysis of variance (see below) were used. One analysis, hereafter referred to as 3 bay/5 period, included data from all five periods and only the three bays sampled in all periods (Bays 9, 10 and 11). The other analysis, hereafter referred to as 4 bay/4 period, included data from all four bays and only the four periods during which all bays were sampled (Pre-spill 2 and Post-spill 1, 2 and 3).

Factor analysis (BMDP4M; Dixon and Brown 1981) was used to identify recurring groups of species. The principal components method was used to extract initial factors from the correlation matrix of log-transformed species abundance data. Final factors were generated by varimax rotation. Separate factor analyses were performed for 3 m and 7 m depth. The scoring coefficients produced by the two analyses were applied to log-transformed species abundances to produce factor scores for all samples collected during all sampling periods.

These factor scores were used as dependent variables in multivariate analyses of variance (SAS general linear models program; Helwig and Council 1979). Depths were treated separately and the three-way design (periods, bays, transects nested within bays and periods) employed in univariate analyses of variance was used. Transect effects were used to test main effects, as above. An a priori decision was made to use Pillai's trace as the test of significance in multivariate analyses of variance. The elements of the vectors produced for each test of main effects in these analyses were applied to the factor scores to derive discriminant functions. Group centroids were plotted against the discriminant functions for each test of main effects and interaction.

The functional relationships between lengths and weights of dominant bivalve species were identified by analysis of (1) scatter plots of the 1980 data, and (2) plots of residuals generated by regression analyses (Cross and Thomson 1981). The type of relationship determined the type of transformation used in subsequent analyses. Analyses of covariance with the corresponding function of length as the covariate were used to test for differences in dry meat weight among periods and bays, using data from all three years. Analyses of covariance were carried out using the SAS GLM procedure (Helwig and Council 1979).

The mean lengths of selected bivalve species were calculated for each sample and analyses of variance were used to test whether mean lengths of these species differed among bays or periods.

SECTION 3

RESULTS

The benthos in the study bays at Cape Hatt consists of a wide variety of animals which, for the purposes of the present study, have been classified into two groups according to their relative mobility. The term infauna will be used to refer to those animals that are either incapable of motion or are able to move only slowly in the sediment or on the sediment surface. This group includes bivalves, polychaetes, gastropods, priapulids, nemerteans and some echinoderms. The term epibenthos will be used for those animals capable of relatively rapid motion, including amphipods, cumaceans and ostracods, and large echinoderms capable of moving relatively large distances on the sediment surface (urchins and starfish). Both of these groups (infauna and epibenthos) are included in the infauna as defined by Thorson (1957).

The infauna and epibenthos (as defined above) will be treated separately in the present study. Most analysis and discussion will concern infauna, primarily because their relative immobility will expose them to the full impact of oil or dispersed oil and facilitate the interpretation of results. With mobile epibenthos, it is often impossible to distinguish between mortality and emigration as the cause of disappearance following an oilspill (e.g. Elmgren et al. 1980). Infauna are also of interest because of their dominance of total benthic biomass (99.4% in the study bays at Cape Hatt), and because of their long life spans in the Arctic (Curtis 1977; Petersen 1978). The latter further facilitates interpretation of results because it is indicative of comparatively reduced seasonal and annual variability.

The design of this study incorporates several potential sources of variability besides any effects of oil or dispersed oil. These include water depth, spatial variability on three scales (within transects, among transects within bays, among bays), and temporal variability between seasons and years. It is important to examine the effects of each of these sources of potential variability in order to differentiate their effects from those of oil or dispersed oil.

The effect of depth (3 m vs. 7 m) was assessed in the first year of studies (Cross and Thomson 1981). Significant between-depth differences in infaunal communities were found. Furthermore, these differences between depths were not consistent among the three bays studied. The latter effect (an interaction effect in statistical terms) was itself indicative of a depth effect, but for statistical reasons the significant interaction precluded unambiguous interpretation of depth or bay effects themselves. The addition of a temporal effect after the second year of studies increases the number of possible interactions involving depth (depth x bay; depth x period; depth x period x bay), thereby rendering interpretation of any effect practically impossible. Thus, separate analyses were used for data from each depth throughout the present report, thereby eliminating the depth term and all of the interaction terms involving depth from the analyses.

Spatial variability is fundamental to the study design. The smallest-scale variability, that among replicate samples within transects, is used as a basis of comparison for variation among transects. Among-transect variation, in turn, is used to determine the significance of variation among bays. This among-bay variation is one of the main effects we are testing;

differences among bays, however, could be attributable either to natural factors or to the different oil treatments applied in the different bays. An additional factor (time) is required in order to differentiate between oil effects and natural spatial variability.

The temporal variability assessed in the BIOS project, termed the period effect, includes both seasonal and year-to-year components. Sampling is being carried out in both August and September, and in different years. At the end of the four year study it will be possible to separate the period effect into its seasonal and annual components in the analyses of variance; this will be possible because, at the end of the study, a balanced design will have been achieved (3 August samplings, in 1981, 1982, 1983; and 3 September samplings in 1980, 1981 and 1982). At present, there have been three sampling periods in September (1980, 1981, 1982) but only two in August (1981, 1982). Thus, we currently have only one temporal factor representing the five sampling periods to date.

Oil effects will be determined by comparing (1) temporal changes in the experimental (oil release) bays with temporal changes in the reference bay and (2) temporal changes in the surface oil release bay with those in the dispersed oil bays. In statistical terms, a significant interaction between bay and period effects will indicate an oil effect. Another interpretation of interaction effects that must be considered is that these were random occurrences unrelated to the oil releases. In statistical terms, this would be a type I error--(rejection of the null or 'no effect' hypothesis when it is true). A few errors of this type are likely to occur when a large number of analyses are done, as is the case here. Type I errors are discussed further in Section 4.

At the end of the experiment these tests will be based on data from sampling periods ranging from one year pre-spill to two years post-spill. The analyses outlined in the present interim report include data collected between September 1980 (1 year pre-spill) and September 1982 (1 year post-spill).

3.1 Infauna

3.1.1 Sampling Efficiency

Cross and Thomson (1981) reported that the penetration depth and the total area sampled by the airlift in each of Bays 9, 10 and 11 appeared to be sufficient to yield samples that adequately represent the types and quantities of animals present. This was based on *in situ* inspection of the sampling plots, and on species-area curves derived from 1980 data at each depth in each bay. Particular care was taken during sampling to collect all individuals of the deeply burrowing bivalve *Mya truncata*.

3.1.2 Group and Species Composition

Group composition of the infauna collected in the study area at Cape Hatt in the five sampling periods (bays and depths combined) is shown in Table 1. Bivalves accounted for most of the biomass (91.4-94.0%); bivalves and polychaetes, in approximately equal proportions, accounted for most of the numbers of animals collected (82.0-86.3%).

The most common animals taken from samples at Cape Hatt in each period are shown in Tables 2 and 3, and a complete species list is included in

Table 1. Group composition of infauna collected in the four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Based on 908 airlift samples, each covering 0.0625 m^2, from 3 and 7 m depths.

Variable	Taxon	Sept 1980	Aug 1981	Sept 1981	Aug 1981	Sept 1982
Density (%)	Bivalvia	45.70	41.91	40.97	37.35	36.67
	Polychaeta	40.56	42.88	42.27	44.64	47.55
	Gastropoda	8.33	10.15	10.97	12.47	11.31
	Holothuroidea	4.05	3.27	3.56	3.53	2.86
	Ophiuroidea	0.06	0.14	0.12	0.06	0.05
	Ascidiacea	0.08	0.02	<0.01	0.01	<0.01
	Other	1.22	1.63	2.10	1.94	1.55
Biomass (%)	Bivalvia	94.00	91.40	92.66	93.41	93.01
	Polychaeta	3.77	5.14	3.94	3.56	3.58
	Gastropoda	1.15	1.31	1.43	1.66	1.13
	Holothuroidea	0.36	0.46	0.53	0.40	0.29
	Ophiuroidea	0.15	0.54	0.29	0.18	0.12
	Ascidiacea	0.03	<0.01	<0.01	<0.01	<0.01
	Other	0.54	1.14	1.14	0.78	1.86
Density (no./m^2)	Total	2883.6	2338.1	2559.3	3440.6	3543.0
Biomass (g/m^2)	Total	1163.3	779.8	833.3	891.4	972.2

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

Table 2. Percent contribution to total infaunal biomass (wet weight) by dominant species in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Based on 908 airlift samples, each covering 0.0625 m^2, from 3 and 7 m depths.

Dominant species	Pre-spill 1	Pre-spill 2	Post-spill 1	Post-spill 2	Post-spill 3
Mya truncata (B)	51.24	41.34	45.98	43.12	49.15
Astarte borealis (B)	18.53	19.63	19.47	19.55	17.69
Serripes groenlandicus (B)	8.49	10.45	7.00	11.92	8.67
Astarte montagui (B)	4.44	5.56	5.88	5.07	4.92
Hiatella arctica (B)	2.89	2.64	1.79	2.40	2.10
Macoma calcarea (B)	2.89	4.50	4.24	5.76	5.09
Pectinaria granulata (P)	1.11	1.48	1.16	1.11	1.01
Musculus niger (B)	0.92	0.83	1.04	0.82	0.72
Musculus discors (B)	0.88	0.77	0.90	1.20	1.09
Macoma moesta (B)	0.84	1.13	1.22	0.56	0.57
Trichotropis borealis (G)	0.64	0.71	0.79	0.84	0.68
Total % contribution	92.87	89.04	89.47	92.35	91.69
Biomass of all infauna (g/m^2)	1163.3	779.8	833.3	891.4	972.2

B = bivalve, P = polychaete, G = gastropod.

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

Table 3. Percent contribution to total infaunal numbers by dominant taxa in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Based on 908 airlift samples, each covering 0.0625 m^2, from 3 and 7 m depths.

Dominant species	Pre-spill 1	Pre-spill 2	Post-spill 1	Post-spill 2	Post-spill 3
Pholoe minuta (P)[3]	11.93	15.43	15.83	13.70	13.42
Thyasiridae sp. (B)	8.36	8.88	8.90	9.05	9.15
Astarte borealis (B)	8.19	9.14	8.55	6.37	5.94
Nereimyra punctata (P)	6.91	6.44	5.04	4.41	4.04
Mya truncata (B)	6.18	4.87	4.33	3.19	3.40
Astarte montagui (B)	5.14	5.80	6.10	4.06	3.99
Astarte juveniles (B)	4.27	1.13	1.11	3.64	2.99
Myriotrochus rinkii (H)	4.05	3.27	3.56	3.53	2.86
Euchone analis (P)	3.84	2.90	3.80	3.80	4.81
Cingula castanea (G)	2.23	3.73	4.17	5.20	4.78
Macoma calcarea (B)	2.22	3.40	3.18	2.76	2.65
Eteone longa (P)	1.88	2.15	2.36	1.59	1.71
Total % contribution	65.20	67.14	66.93	61.30	59.74
Density of all infauna (no./m^2)	2883.6	2338.1	2559.3	3440.6	3543.0

B = bivalve, P = polychaete, G = gastropod, H = holothurian.

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

3 Includes Pholoe longa.

Appendix B. Eleven species accounted for 89.0-92.9% of the infaunal biomass (Table 2), and a partially overlapping list of 12 taxa accounted for 59.5-66.1% of the numbers of animals collected (Table 3). Only four species were dominant (i.e. among the top 12 species) in terms of both biomass and density: the bivalves *Mya truncata*, *Astarte borealis*, *Astarte montagui* and *Macoma calcarea*.

In general, the benthos of the study area at Cape Hatt appears to be typical of that in other nearshore high arctic areas. Several of the dominant infaunal species, including several of those contributing most to biomass (*Mya truncata*, *Macoma calcarea*, *M. moesta*, *Astarte borealis*, *A. montagui*, *Serripes groenlandicus*, and *Pectinaria granulata*), belong to the arctic *Macoma* community (Thorson 1957; Ockelmann 1958; Ellis 1960; Thomson 1982). This community is a widespread and common feature of nearshore high arctic areas and is displaced only under local circumstances (e.g. under estuarine influences). A quantitative analysis of community structure in the study bays is presented in a following section.

3.1.3 Biomass

Average infaunal biomass in the study area at Cape Hatt (all bays and depths considered) varied from 818 to 1175 g/m^2, depending on period (Table 2). At 3 m depth, mean biomass was 78-984 g/m^2; at 7 m it was 1037-2860 g/m^2. These values are considerably higher than mean depth-integrated (5 to 50 m) biomass in other arctic areas:

Location*	Sample size	Mean biomass (g/m2)	Source
Alaskan Beaufort Sea	131	41	Carey (1977)
Bridport Inlet, Melville Is.	78	94	Buchanan et al. (1977)
Brentford Bay, Boothia Pen.	21	188	Thomson et al. (1978)
Lancaster Sound	110	319	Thomson and Cross (1980)
Pond Inlet and Arctic Bay	51	200-438	Ellis (1960)

* Relatively high biomass (up to 1482 g/m^2 at one location, n = 7) has also been reported in West Greenland (Vibe 1939).

The apparently high infaunal biomass at Cape Hatt relative to that in other arctic locations is likely due largely to the effectiveness of our sampler. About half of the biomass found at 7 m depth at Cape Hatt represented Mya truncata. Cross and Thomson (1981) found that this deeply burrowing species was only sampled effectively if the sediment was excavated to a depth of 15 cm. Buchanan et al. (1977) compared results of quantitative underwater photographs with those of shallow penetrating samplers and found that their shallow samples underestimated infaunal biomass by as much as 960 g/m^2. Many of the other low values previously reported may also be biased by inadequate sampling.

In most high arctic areas a barren zone extends from the shoreline to depths of 2-10 m. This zone is devoid of infauna except for the tunicate Rhizomolgula globularis, and is populated almost exclusively by motile amphipods. At Cape Hatt, however, a relatively high infaunal biomass consisting mainly of bivalves was found at 3 m depth. Here and elsewhere in Eclipse Sound the barren zone occurs only at shallower depths, likely due to the relatively protected location (Thomson and Cross 1980).

3.1.4 Factors Affecting Abundance and Biomass

3.1.4a Spatial Effects

Mean density (no./m^2) and biomass (g/m^2) of bivalves, polychaetes, total infauna and species that are dominant either in terms of density or biomass are given in Tables 4 and 5 and Figures 3 and 4. The smallest scale of variability apparent in our data is that among replicate samples within transects. Cross and Thomson (1981) reported relatively high variability on this scale for most groups and dominant species. Distributions of these species ranged from relatively even to relatively patchy, and even greater extremes of variability were observed for the many uncommon species in the study area. The extent of this within-transect variability was used to test the significance of differences among transects within bays (hereafter termed transect variability). The latter, in turn, was used to test the significance of differences among bays.

There was considerable transect variability for the species and groups examined. This variability was greater at the 3 m depth (40 of 42 tests showed significant variation among transects) than at the 7 m depth (significant in 32 of 50 tests). The results of statistical analyses for dominant groups and taxa examined in previous years are given in Tables 6 and 7, and those for additional species are given in Tables 8 and 9.

The greatest variability in infaunal distribution was that among bays (78 of 86 tests were significant). At both depths, the highest total biomass and density of infauna were found in Bay 9, both before and after the

Table 4. Mean density (no./m²) of major taxa and selected species of infauna in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Data are expressed as mean ± standard deviation and are based on 8 replicate 0.0625 m² airlift samples on each of three transects for each depth, period and bay.

Taxon	Period[2]	3 m Depth Bay 7	3 m Depth Bay 9	3 m Depth Bay 10	3 m Depth Bay 11	7 m Depth Bay 7	7 m Depth Bay 9	7 m Depth Bay 10	7 m Depth Bay 11
Total infauna[3]	Pre-spill 1	-	3765.3 ± 1005.1	3014.0 ± 1024.6	1486.0 ± 860.4	-	3586.7 ± 1315.0	2840.7 ± 852.1	2751.3 ± 630.8
	Pre-spill 2	1596.7 ± 816.8	3690.0 ± 1649.6	2274.4 ± 782.6	1091.0 ± 504.6	2291.3 ± 749.8	3092.0 ± 959.7	2177.4 ± 554.6	2532.7 ± 809.0
	Post-spill 1	1838.0 ± 912.5	4326.7 ± 2093.4	2444.0 ± 809.9	1396.9 ± 701.5	2472.0 ± 597.6	2996.0 ± 762.7	2594.3 ± 681.8	2393.0 ± 946.7
	Post-spill 2	2994.8 ± 849.4	4946.0 ± 1918.3	3236.3 ± 1216.3	1563.0 ± 623.3	2950.4 ± 1154.7	4387.3 ± 1389.4	3583.7 ± 1360.8	3379.8 ± 1273.2
	Post-spill 3	3072.0 ± 984.2	5341.3 ± 1895.3	2889.5 ± 1133.6	1695.8 ± 1113.8	3392.7 ± 1461.8	4585.3 ± 1521.0	3306.3 ± 974.8	4108.0 ± 1259.8
Polychaeta	Pre-spill 1	-	1879.3 ± 568.7	1598.7 ± 541.7	877.3 ± 501.6	-	880.0 ± 329.7	940.0 ± 326.6	842.7 ± 271.7
	Pre-spill 2	800.7 ± 487.7	1818.7 ± 834.0	1424.1 ± 526.2	727.7 ± 356.7	732.0 ± 295.9	922.7 ± 371.9	742.3 ± 280.3	859.3 ± 318.1
	Post-spill 1	992.0 ± 593.1	1888.0 ± 793.0	1412.7 ± 542.1	860.7 ± 472.3	758.0 ± 275.1	953.3 ± 288.0	1112.8 ± 519.2	649.0 ± 252.8
	Post-spill 2	1634.3 ± 502.3	2307.3 ± 896.3	1853.6 ± 593.0	1109.3 ± 495.6	866.4 ± 375.9	1378.0 ± 567.2	1503.4 ± 620.4	1105.7 ± 407.3
	Post-spill 3	1867.3 ± 594.1	2876.7 ± 1153.0	1654.3 ± 806.3	1273.2 ± 864.2	1156.0 ± 529.6	1569.3 ± 586.2	1356.0 ± 536.9	1725.3 ± 994.6
Bivalvia	Pre-spill 1	-	1103.3 ± 604.4	907.3 ± 568.9	303.3 ± 284.1	-	2284.0 ± 808.4	1726.7 ± 686.9	1582.0 ± 498.8
	Pre-spill 2	254.7 ± 194.8	1126.7 ± 777.8	535.3 ± 224.3	152.2 ± 203.0	1216.7 ± 640.3	1896.7 ± 622.8	1261.9 ± 550.0	1388.0 ± 505.4
	Post-spill 1	238.7 ± 190.5	1384.0 ± 960.0	579.3 ± 294.2	227.5 ± 250.4	1408.0 ± 554.9	1797.3 ± 568.4	1302.7 ± 531.5	1432.0 ± 641.0
	Post-spill 2	346.0 ± 224.4	1339.3 ± 806.7	704.3 ± 418.8	169.3 ± 192.5	1648.0 ± 930.0	2570.0 ± 859.6	1748.0 ± 942.2	1754.7 ± 590.5
	Post-spill 3	266.0 ± 210.0	1359.3 ± 730.6	619.2 ± 365.9	182.4 ± 360.4	1776.7 ± 1037.5	2655.3 ± 957.1	1679.4 ± 682.1	1856.0 ± 572.4
Mya truncata	Pre-spill 1	-	282.7 ± 159.1	225.3 ± 211.9	57.3 ± 57.8	-	176.0 ± 83.3	152.7 ± 97.2	176.0 ± 87.8
	Pre-spill 2	52.0 ± 45.6	241.3 ± 149.2	119.0 ± 75.8	25.3 ± 43.7	96.0 ± 58.4	109.3 ± 67.2	98.8 ± 131.3	168.7 ± 99.9
	Post-spill 1	66.0 ± 55.1	266.7 ± 181.2	108.7 ± 64.3	27.8 ± 49.5	101.3 ± 57.5	86.7 ± 48.6	89.3 ± 43.5	137.7 ± 70.2
	Post-spill 2	82.7 ± 65.8	221.3 ± 186.5	89.3 ± 62.0	17.3 ± 29.1	98.0 ± 56.1	113.3 ± 68.7	94.7 ± 78.8	162.7 ± 88.5
	Post-spill 3	56.7 ± 44.8	242.7 ± 206.0	108.0 ± 86.1	31.8 ± 78.5	120.0 ± 74.3	126.7 ± 84.3	114.0 ± 97.0	163.3 ± 78.5
Astarte borealis	Pre-spill 1	-	193.3 ± 154.0	57.3 ± 90.9	20.0 ± 30.3	-	424.0 ± 266.6	353.3 ± 223.2	369.3 ± 198.0
	Pre-spill 2	66.7 ± 66.7	306.0 ± 281.3	81.9 ± 78.9	32.0 ± 66.2	160.0 ± 126.2	320.7 ± 177.6	329.0 ± 184.7	412.0 ± 188.5
	Post-spill 1	64.7 ± 83.3	298.0 ± 235.0	141.3 ± 122.1	9.7 ± 13.4	202.7 ± 116.6	336.0 ± 205.3	292.0 ± 135.9	404.5 ± 237.5
	Post-spill 2	89.3 ± 115.6	289.3 ± 219.3	85.3 ± 92.7	11.3 ± 19.2	181.3 ± 138.4	374.7 ± 245.5	358.0 ± 359.8	364.0 ± 161.3
	Post-spill 3	67.3 ± 81.7	284.7 ± 197.5	59.3 ± 61.4	8.7 ± 22.6	184.7 ± 211.5	408.0 ± 246.2	262.0 ± 171.1	407.3 ± 207.9
Astarte montagui	Pre-spill 1	-	136.7 ± 173.8	5.3 ± 23.0	2.0 ± 7.2	-	178.7 ± 153.4	140.7 ± 101.4	426.0 ± 261.0
	Pre-spill 2	15.3 ± 37.6	222.7 ± 207.6	23.7 ± 42.6	9.3 ± 42.0	43.3 ± 47.8	141.3 ± 99.3	174.6 ± 146.4	451.3 ± 223.1
	Post-spill 1	13.3 ± 28.6	308.0 ± 303.8	27.3 ± 48.7	2.1 ± 7.3	45.3 ± 39.1	146.0 ± 103.3	219.3 ± 180.6	495.7 ± 312.5
	Post-spill 2	14.7 ± 32.3	204.7 ± 202.8	10.0 ± 22.0	1.3 ± 4.5	34.7 ± 41.8	148.0 ± 100.1	200.0 ± 179.0	505.3 ± 230.7
	Post-spill 3	8.7 ± 18.9	250.7 ± 239.5	9.3 ± 16.3	0	31.3 ± 45.6	164.0 ± 119.6	180.0 ± 186.9	486.0 ± 243.2
Thyasiridae	Pre-spill 1	-	220.7 ± 241.1	124.7 ± 99.9	8.0 ± 20.6	-	590.0 ± 235.3	433.3 ± 238.8	69.3 ± 79.2
	Pre-spill 2	18.0 ± 29.2	178.0 ± 157.4	77.8 ± 62.4	1.3 ± 4.5	345.3 ± 233.1	612.7 ± 226.0	365.9 ± 228.4	62.7 ± 59.9
	Post-spill 1	30.0 ± 39.0	253.3 ± 363.2	110.0 ± 74.5	9.7 ± 30.8	414.7 ± 219.9	541.3 ± 201.5	368.0 ± 225.0	80.0 ± 144.4
	Post-spill 2	42.7 ± 55.2	207.3 ± 151.2	139.3 ± 129.9	0.7 ± 3.3	507.3 ± 355.0	924.7 ± 318.1	582.0 ± 344.0	87.3 ± 73.4
	Post-spill 3	17.3 ± 20.5	272.0 ± 206.3	106.0 ± 118.4	0.7 ± 3.3	588.7 ± 416.1	974.0 ± 412.9	547.1 ± 245.2	88.0 ± 69.2
Euchone analis	Pre-spill 1	-	428.0 ± 491.0	139.3 ± 135.9	79.3 ± 95.7	-	4.0 ± 13.6	6.0 ± 14.8	8.0 ± 21.6
	Pre-spill 2	58.0 ± 61.8	319.3 ± 264.0	105.7 ± 73.3	22.0 ± 42.2	6.7 ± 15.6	9.3 ± 17.0	14.6 ± 27.7	6.7 ± 11.5
	Post-spill 1	140.7 ± 177.5	412.7 ± 304.6	164.0 ± 161.3	20.2 ± 31.3	6.7 ± 10.5	18.7 ± 29.0	7.3 ± 16.3	0.7 ± 3.3
	Post-spill 2	162.2 ± 146.9	563.3 ± 622.1	181.5 ± 121.6	41.3 ± 54.6	44.9 ± 109.7	28.7 ± 31.3	16.7 ± 23.3	8.7 ± 21.1
	Post-spill 3	208.7 ± 213.9	770.7 ± 808.5	201.0 ± 257.3	53.1 ± 91.3	39.3 ± 84.0	32.7 ± 46.3	35.3 ± 123.9	23.3 ± 47.6
Myriotrochus rinkii	Pre-spill 1	-	350.0 ± 175.5	142.0 ± 139.4	92.0 ± 79.4	-	90.7 ± 100.5	0.7 ± 3.3	26.0 ± 65.9
	Pre-spill 2	102.0 ± 104.6	273.3 ± 158.3	77.1 ± 57.6	90.7 ± 81.8	24.0 ± 55.6	30.7 ± 40.3	7.7 ± 26.8	4.0 ± 14.3
	Post-spill 1	110.7 ± 103.0	266.7 ± 133.8	131.3 ± 114.5	139.7 ± 172.5	4.7 ± 17.3	62.7 ± 82.7	1.3 ± 4.5	11.1 ± 31.1
	Post-spill 2	248.2 ± 152.1	354.7 ± 272.1	148.2 ± 178.3	109.7 ± 91.0	17.3 ± 41.9	82.0 ± 92.6	1.3 ± 4.5	11.7 ± 38.2
	Post-spill 3	182.0 ± 147.2	268.7 ± 107.3	156.7 ± 250.2	116.6 ± 150.9	12.7 ± 29.5	65.3 ± 95.2	0.7 ± 3.3	9.3 ± 18.8
Capitella capitata	Pre-spill 1	-	54.0 ± 157.4	39.3 ± 37.4	20.0 ± 26.8	-	14.0 ± 23.3	27.3 ± 52.6	11.3 ± 14.5
	Pre-spill 2	29.3 ± 37.9	33.3 ± 56.6	54.9 ± 70.0	17.6 ± 27.2	20.0 ± 29.2	14.7 ± 36.8	9.0 ± 11.6	19.3 ± 32.7
	Post-spill 1	20.7 ± 30.8	17.3 ± 32.0	41.3 ± 74.1	9.0 ± 12.6	10.0 ± 14.8	8.7 ± 12.5	16.7 ± 22.4	7.0 ± 10.6
	Post-spill 2	48.0 ± 99.6	28.0 ± 51.7	77.5 ± 81.3	36.7 ± 75.1	18.0 ± 34.6	22.0 ± 27.0	49.6 ± 144.2	18.7 ± 23.9
	Post-spill 3	56.0 ± 79.9	20.0 ± 28.4	61.0 ± 69.5	128.5 ± 366.4	28.7 ± 27.1	41.3 ± 50.8	20.6 ± 33.0	33.3 ± 35.9
Serripes groenlandicus	Pre-spill 1	-	23.3 ± 47.6	0.7 ± 3.3	0.7 ± 3.3	-	77.3 ± 56.2	32.7 ± 34.8	12.0 ± 21.2
	Pre-spill 2	0	28.0 ± 50.7	0	2.7 ± 10.2	35.3 ± 26.7	50.0 ± 42.3	25.7 ± 24.9	16.7 ± 21.4
	Post-spill 1	0	15.3 ± 19.2	0.7 ± 3.3	0	33.3 ± 34.0	45.3 ± 37.3	20.7 ± 20.3	12.5 ± 24.6
	Post-spill 2	7.3 ± 29.5	18.7 ± 18.1	0.7 ± 3.3	4.0 ± 10.8	51.3 ± 49.5	54.7 ± 45.5	23.3 ± 25.4	8.7 ± 14.1
	Post-spill 3	5.3 ± 13.9	30.0 ± 42.8	0.7 ± 3.3	0.7 ± 3.3	50.7 ± 43.7	48.7 ± 32.9	24.7 ± 23.1	10.0 ± 13.2

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
[3] All taxa but ostracods, cumaceans and amphipods.

Table 5. Mean biomass (g/m²) of major taxa and dominant species of infauna in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Data are expressed as mean ± standard deviation and are based on 10% formalin wet weight in 8 replicate 0.0625 m² airlift samples on each of three transects for each depth, period and bay.

Taxon	Period[2]	3 m Depth				7 m Depth			
		Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Total infauna[3]	Pre-spill 1	-	595.9 ± 414.2	304.3 ± 222.3	83.3 ± 109.8	-	2860.4 ± 1124.5	1602.2 ± 767.2	1606.1 ± 853.3
	Pre-spill 2	176.9 ± 176.6	675.9 ± 483.9	341.1 ± 270.8	83.3 ± 134.3	1037.4 ± 671.0	1567.0 ± 1040.3	1281.6 ± 654.1	1380.9 ± 797.0
	Post-spill 1	236.2 ± 199.9	899.5 ± 700.7	491.8 ± 378.1	85.5 ± 93.4	1312.5 ± 653.2	1351.2 ± 620.9	1212.1 ± 612.8	1237.1 ± 753.8
	Post-spill 2	258.7 ± 256.6	942.2 ± 622.9	477.1 ± 475.9	92.8 ± 97.4	1300.4 ± 1027.5	1630.4 ± 816.1	1318.5 ± 905.6	1265.5 ± 516.7
	Post-spill 3	226.2 ± 218.3	984.6 ± 682.5	430.6 ± 331.8	78.1 ± 88.2	1430.8 ± 968.5	2014.1 ± 927.1	1382.5 ± 881.3	1464.4 ± 850.8
Bivalvia	Pre-spill 1	-	535.5 ± 406.8	261.4 ± 208.8	54.5 ± 88.3	-	2739.0 ± 1125.2	1507.2 ± 770.2	1463.4 ± 831.5
	Pre-spill 2	143.2 ± 164.9	607.5 ± 469.1	299.5 ± 261.3	60.1 ± 133.0	866.3 ± 689.3	1330.7 ± 833.5	1121.7 ± 676.1	1272.9 ± 776.7
	Post-spill 1	199.2 ± 195.4	824.7 ± 688.5	420.3 ± 379.0	48.9 ± 85.0	1145.5 ± 636.3	1238.5 ± 585.3	1117.8 ± 595.3	1168.7 ± 743.3
	Post-spill 2	215.2 ± 238.5	873.2 ± 609.2	418.4 ± 433.5	69.2 ± 95.7	1158.9 ± 1047.3	1529.1 ± 797.2	1216.1 ± 912.0	1181.7 ± 521.9
	Post-spill 3	175.1 ± 190.7	904.1 ± 675.8	370.6 ± 313.9	45.7 ± 73.9	1261.5 ± 1013.4	1862.1 ± 976.4	1227.8 ± 896.8	1386.8 ± 839.8
Polychaeta	Pre-spill 1	-	39.5 ± 14.4	33.1 ± 21.4	18.5 ± 14.0	-	54.8 ± 36.9	63.8 ± 42.5	53.5 ± 28.7
	Pre-spill 2	15.3 ± 12.4	42.8 ± 21.4	24.3 ± 14.3	13.7 ± 7.5	32.8 ± 27.0	43.2 ± 63.7	37.1 ± 19.6	44.4 ± 30.1
	Post-spill 1	16.5 ± 9.0	42.7 ± 21.4	34.6 ± 21.4	23.0 ± 21.3	30.8 ± 20.1	34.5 ± 15.9	45.9 ± 29.9	33.8 ± 23.4
	Post-spill 2	18.2 ± 14.3	42.1 ± 36.1	28.6 ± 21.1	18.1 ± 9.8	30.8 ± 18.0	33.2 ± 26.8	42.5 ± 24.7	39.8 ± 19.7
	Post-spill 3	18.2 ± 12.4	53.2 ± 25.3	22.3 ± 10.8	14.4 ± 10.9	34.8 ± 16.8	39.7 ± 23.1	50.1 ± 30.4	45.8 ± 22.8
Mya truncata	Pre-spill 1	-	245.2 ± 178.6	143.4 ± 172.8	17.6 ± 48.2	-	1664.2 ± 908.5	725.8 ± 616.2	780.1 ± 638.9
	Pre-spill 2	61.0 ± 99.0	248.2 ± 215.8	190.0 ± 177.2	21.3 ± 48.8	415.0 ± 443.7	550.2 ± 481.9	533.7 ± 410.7	562.9 ± 562.0
	Post-spill 1	102.7 ± 114.3	404.5 ± 318.3	165.7 ± 158.8	27.4 ± 64.1	701.5 ± 489.3	554.0 ± 377.6	548.3 ± 455.1	553.5 ± 505.2
	Post-spill 2	116.9 ± 150.8	478.6 ± 465.0	224.4 ± 296.9	13.6 ± 30.8	673.4 ± 853.4	562.6 ± 336.1	529.2 ± 594.1	476.1 ± 360.6
	Post-spill 3	88.0 ± 123.6	450.8 ± 428.9	249.3 ± 270.4	10.1 ± 25.4	855.0 ± 888.9	906.9 ± 731.5	636.8 ± 533.9	625.3 ± 539.2
Astarte borealis	Pre-spill 1	-	172.6 ± 182.5	32.9 ± 67.0	11.6 ± 27.4	-	319.4 ± 291.4	360.4 ± 314.4	396.5 ± 458.6
	Pre-spill 2	40.6 ± 48.8	213.2 ± 241.8	48.9 ± 94.6	26.7 ± 112.1	52.2 ± 58.4	220.9 ± 164.1	225.7 ± 215.9	395.3 ± 207.4
	Post-spill 1	53.2 ± 88.9	230.9 ± 256.6	155.9 ± 211.0	3.9 ± 10.6	82.8 ± 77.0	191.5 ± 145.1	290.1 ± 244.2	288.0 ± 231.9
	Post-spill 2	57.7 ± 112.3	201.6 ± 222.2	96.7 ± 182.3	9.5 ± 25.4	77.4 ± 72.7	284.8 ± 197.3	268.9 ± 276.6	397.5 ± 245.2
	Post-spill 3	57.4 ± 70.0	246.2 ± 260.4	58.7 ± 119.3	10.5 ± 30.4	80.3 ± 69.0	291.4 ± 200.5	251.6 ± 331.2	379.8 ± 293.5
Astarte montagui	Pre-spill 1	-	49.9 ± 65.7	3.1 ± 11.5	0.1 ± 0.4	-	58.2 ± 59.5	51.4 ± 43.4	147.3 ± 94.5
	Pre-spill 2	3.1 ± 8.2	74.7 ± 76.1	2.7 ± 5.9	3.6 ± 14.5	9.6 ± 10.9	37.2 ± 22.9	59.8 ± 65.4	155.1 ± 92.4
	Post-spill 1	1.7 ± 5.1	103.1 ± 93.4	8.6 ± 18.4	<0.01	13.4 ± 14.6	46.5 ± 47.3	59.9 ± 57.5	161.7 ± 94.9
	Post-spill 2	7.3 ± 19.7	66.6 ± 75.1	4.8 ± 13.0	0.7 ± 2.3	8.6 ± 11.3	40.4 ± 27.2	69.6 ± 51.8	163.4 ± 73.7
	Post-spill 3	2.6 ± 8.5	91.6 ± 103.7	2.5 ± 5.1	0	8.9 ± 12.7	50.4 ± 41.5	51.6 ± 52.9	175.2 ± 97.5
Serripes groenlandicus	Pre-spill 1	-	13.6 ± 26.3	1.2 ± 5.7	2.2 ± 10.8	-	360.5 ± 367.3	186.6 ± 206.8	28.4 ± 61.1
	Pre-spill 2	0	26.8 ± 48.2	0	0.1 ± 0.6	128.0 ± 147.6	281.6 ± 288.6	157.5 ± 183.7	57.8 ± 113.5
	Post-spill 1	0	21.8 ± 57.6	0.2 ± 0.9	0	111.5 ± 149.7	197.1 ± 178.4	80.5 ± 118.8	52.5 ± 134.5
	Post-spill 2	0.2 ± 0.7	43.3 ± 78.8	<0.01	28.6 ± 89.2	207.8 ± 280.2	369.3 ± 314.8	167.2 ± 211.0	33.4 ± 63.8
	Post-spill 3	0.5 ± 1.0	40.0 ± 69.9	<0.01	1.3 ± 6.4	122.9 ± 160.9	345.6 ± 259.4	118.2 ± 174.2	45.6 ± 103.7
Hiatella arctica	Pre-spill 1	-	34.0 ± 51.5	23.4 ± 62.6	3.3 ± 12.3	-	126.7 ± 194.2	6.4 ± 16.9	7.8 ± 24.9
	Pre-spill 2	19.4 ± 40.0	17.1 ± 31.2	18.4 ± 47.6	0	69.1 ± 324.4	20.6 ± 39.6	3.4 ± 9.4	16.2 ± 43.1
	Post-spill 1	28.2 ± 51.1	25.4 ± 43.6	30.1 ± 73.4	0.5 ± 1.9	3.3 ± 15.6	20.1 ± 42.8	0.2 ± 0.7	11.0 ± 30.6
	Post-spill 2	17.2 ± 29.2	56.8 ± 69.3	32.9 ± 52.9	4.8 ± 15.6	<0.01	45.1 ± 101.9	2.1 ± 8.4	12.6 ± 31.2
	Post-spill 3	9.6 ± 21.5	37.9 ± 50.7	9.3 ± 19.5	4.1 ± 12.1	6.4 ± 21.9	31.7 ± 86.5	15.5 ± 41.5	48.6 ± 97.6
Macoma calcarea	Pre-spill 1	-	9.0 ± 16.0	4.6 ± 6.9	2.4 ± 6.6	-	73.1 ± 41.1	67.0 ± 41.4	45.4 ± 37.7
	Pre-spill 2	2.9 ± 7.4	16.6 ± 21.3	3.1 ± 7.7	0	90.2 ± 63.0	67.6 ± 37.8	65.7 ± 65.3	34.5 ± 41.1
	Post-spill 1	6.1 ± 11.2	11.7 ± 21.0	4.1 ± 8.1	2.5 ± 8.3	98.4 ± 67.4	64.9 ± 38.7	55.6 ± 37.1	38.4 ± 32.4
	Post-spill 2	3.7 ± 8.0	11.9 ± 16.1	12.6 ± 15.1	0.4 ± 1.4	129.3 ± 74.4	102.3 ± 50.6	99.0 ± 65.0	51.5 ± 45.4
	Post-spill 3	6.3 ± 10.3	17.9 ± 22.7	6.3 ± 13.7	1.1 ± 3.9	128.3 ± 84.7	93.9 ± 39.6	79.4 ± 46.0	62.4 ± 48.0

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
[3] All taxa but ostracods, cumaceans and amphipods.

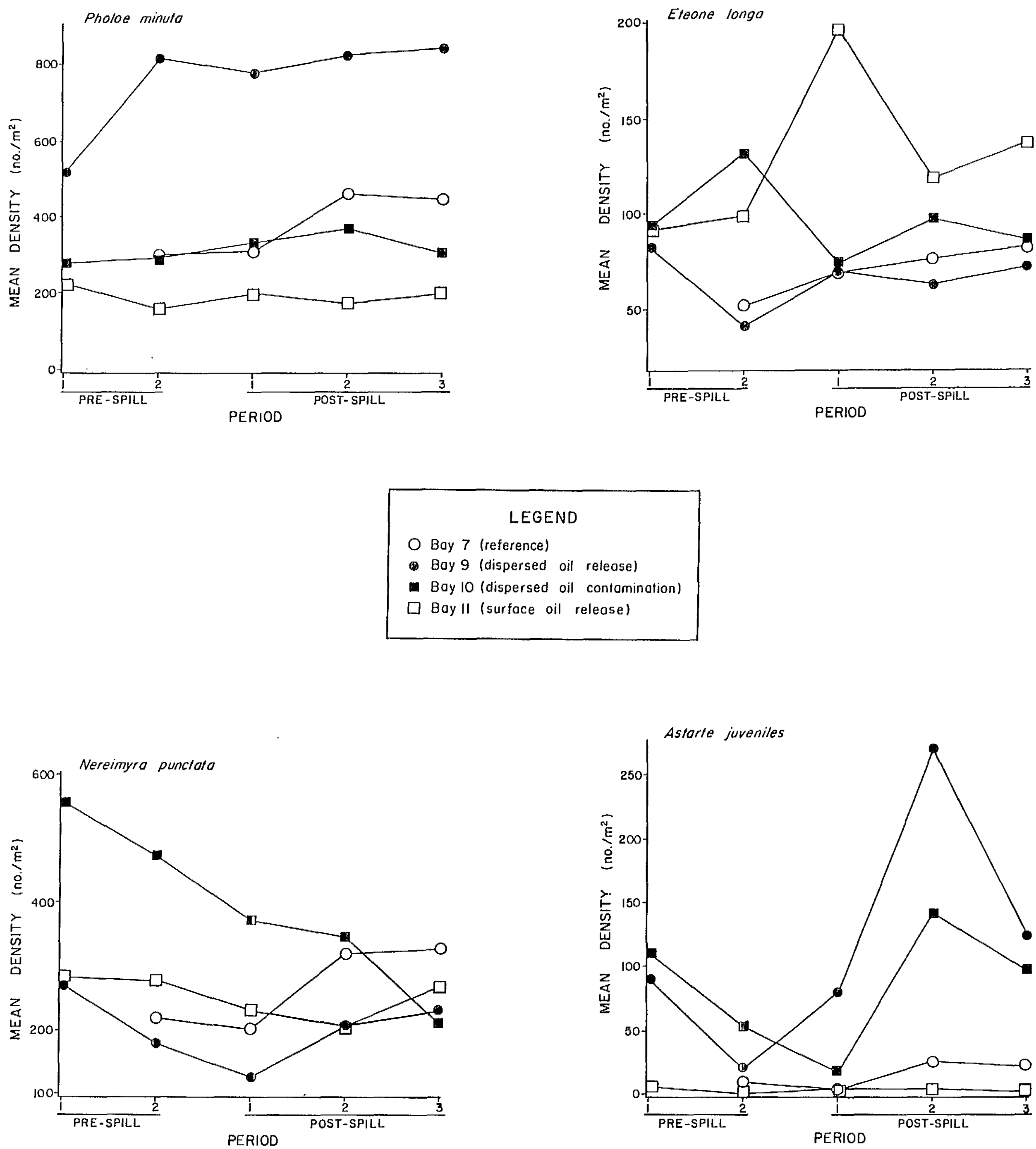


FIGURE 3. Mean density (no./m2) of selected species of infauna at 3 m depth in four bays at Cape Hatt, northern Baffin Island, during pre-spill sampling in September 1980 and August 1981 and during post-spill sampling in September 1981 and August and September 1982. Data are expressed as the mean of 24 replicate 0.0625 m2 airlift samples taken in each experimental bay during each sampling period.

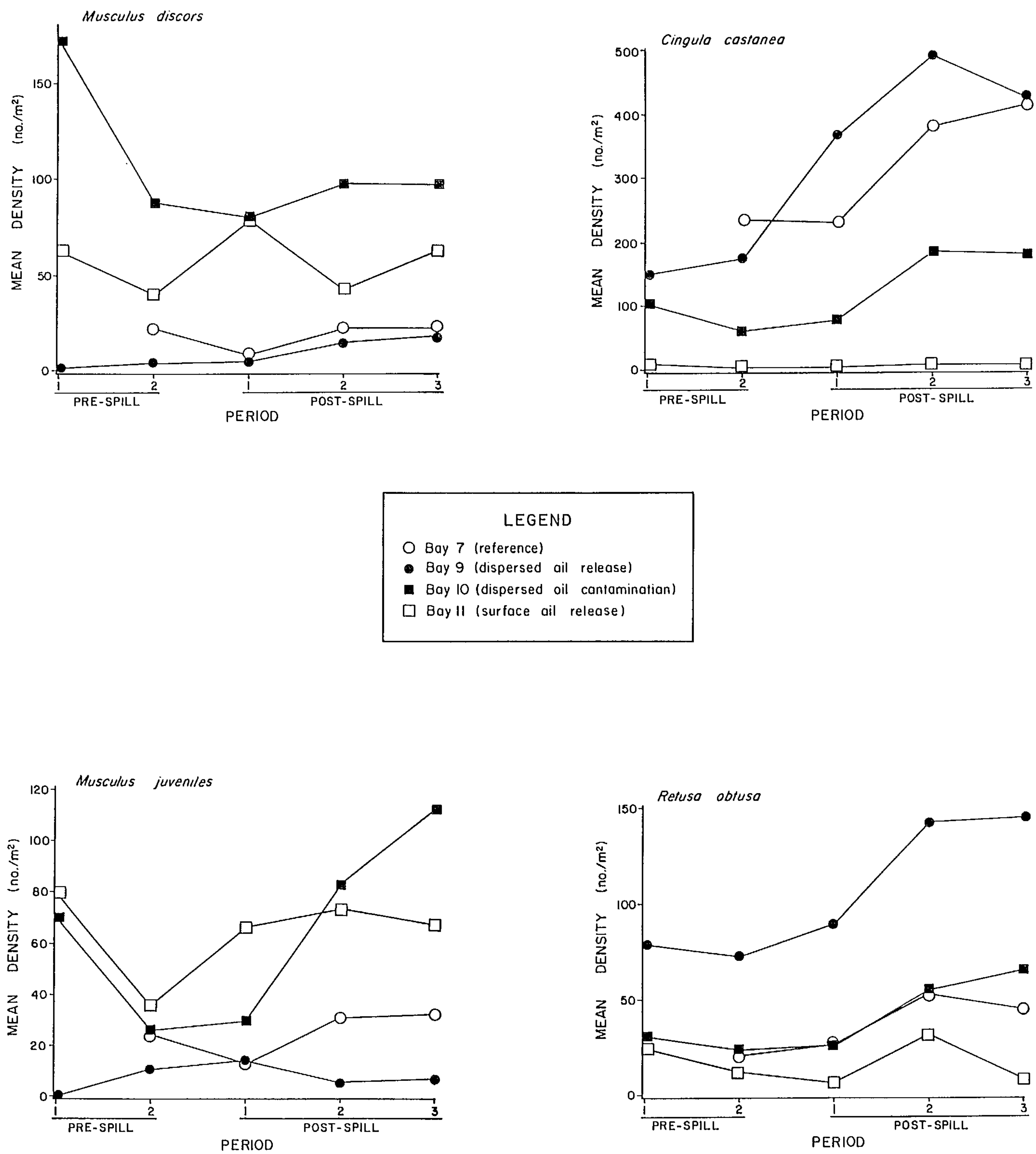


FIGURE 3. Continued

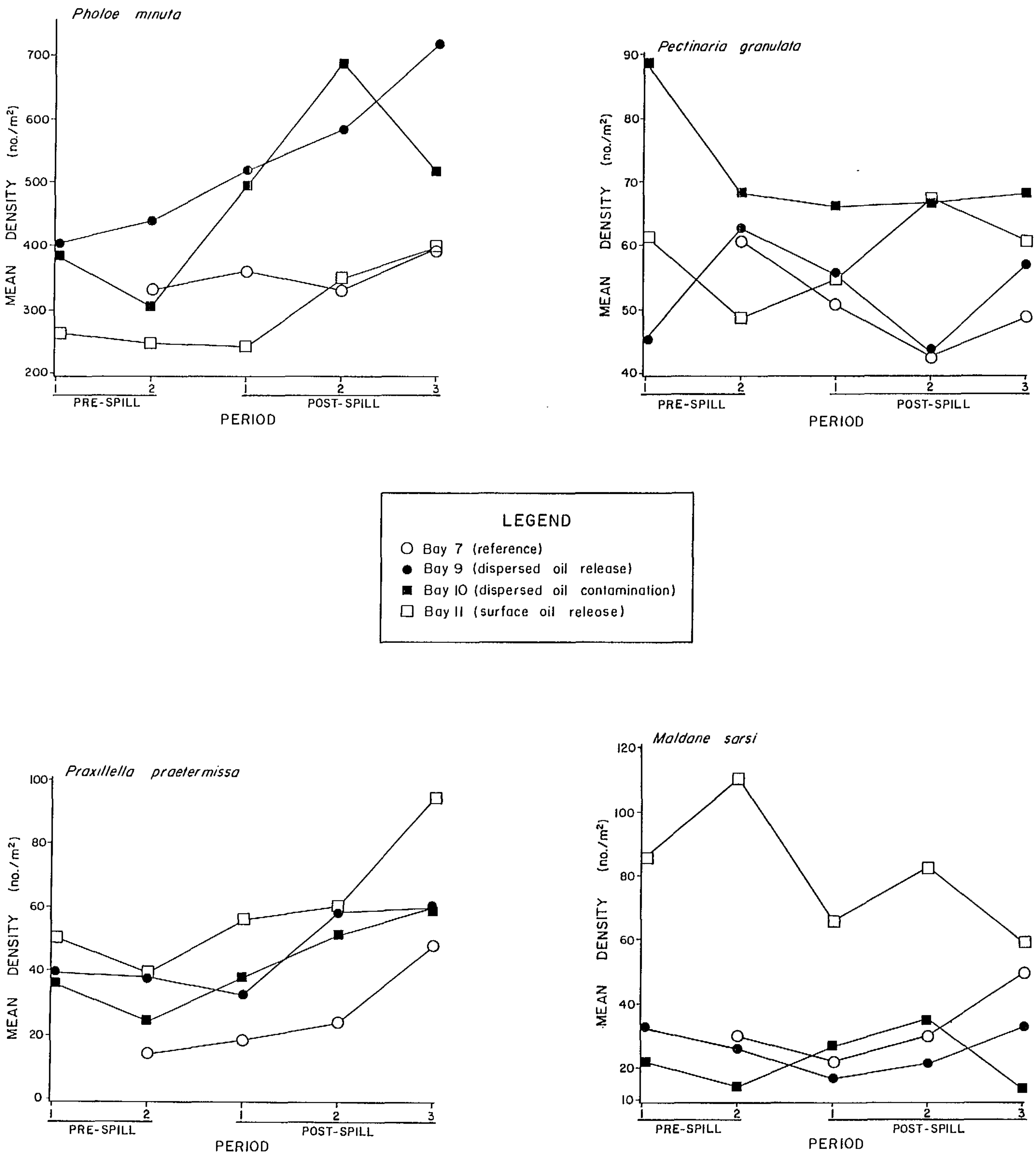


FIGURE 4. Mean density (no./m2) of selected species of infauna at 7 m depth in four bays at Cape Hatt, northern Baffin Island, during pre-spill sampling in September 1980 and August 1981 and during post-spill sampling in September 1981 and August and September 1982. Data are expressed as the mean of 24 replicate 0.0625 m2 airlift samples taken in each experimental bay during each sampling period.

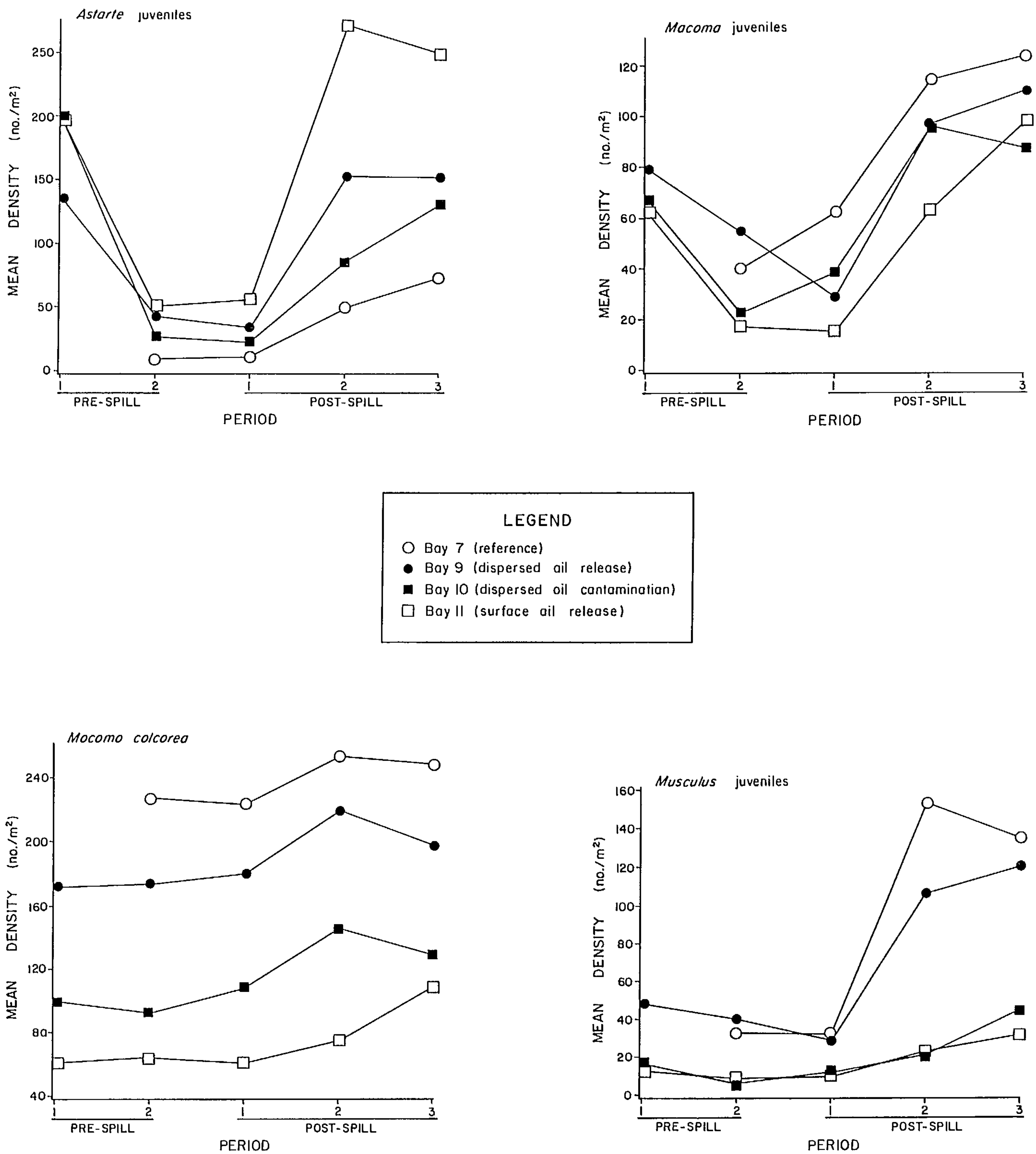


FIGURE 4. Continued

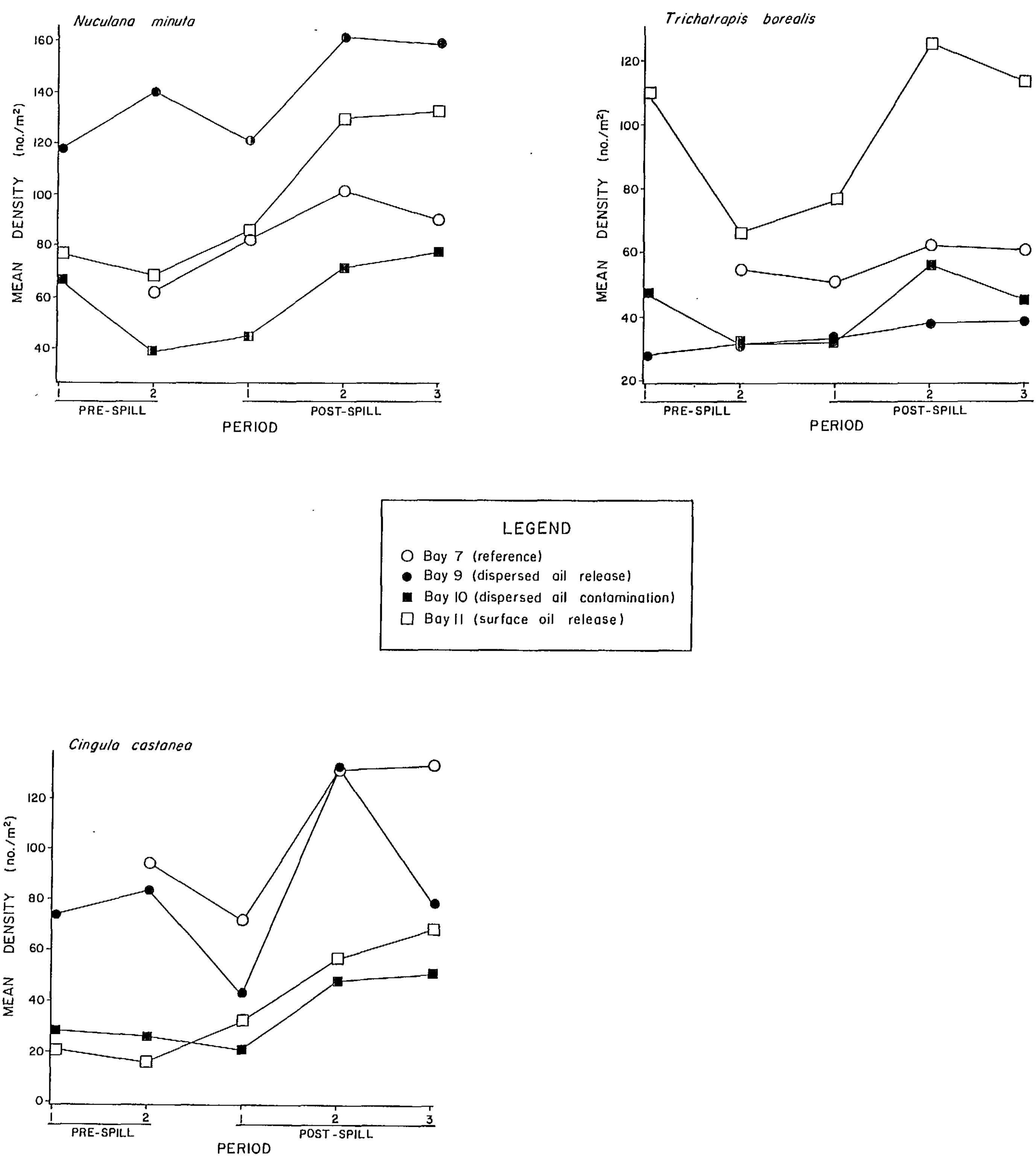


FIGURE 4. Concluded

Table 6. Three-factor analyses of variance for the biomasses and densities of major taxa and dominant species in three bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05, ** P≤0.01, *** P≤0.001).

			Source of Variation and df[3]				
			Period 4,6 or 30	Bay 2,6 or 30	Period x Bay[4] 8,6 or 30	Transect (Bay) 6,313	Per x Trans (Bay) 24,313
3 m	Biomass (g/m^2)	Total infauna	0.56 ns	64.61 ***	0.16 ns	12.97 ***	0.82 ns
		Polychaeta	0.63 ns	32.52 ***	0.66 ns	7.28 ***	1.35 ns
		Bivalvia	0.58 ns	84.09 ***	0.39 ns	8.88 ***	0.84 ns
	Density ($no./m^2$)	Total infauna	2.95 *	76.88 ***	0.27 ns	7.75 ***	1.28 ns
		Polychaeta	4.34 **	53.16 ***	0.55 ns	3.74 **	1.54 ns
		Bivalvia	1.72 ns	68.74 ***	1.20 ns	9.76 ***	0.59 ns
		Mya truncata	6.56 ***	176.24 ***	1.30 ns	2.83 *	0.51 ns
		Astarte borealis	0.72 ns	38.78 ***	0.68 ns	13.71 ***	0.68 ns
		Astarte montagui	0.41 ns	30.79 ***	0.13 ns	40.42 ***	1.02 ns
		Thyasiridae spp.	0.18 ns	85.49 ***	0.29 ns	14.47 ***	1.00 ns
		Euchone analis	1.09 ns	54.12 ***	0.88 ns	9.42 ***	1.26 ns
		Myriotrochus rinkii	0.52 ns	23.49 **	0.37 ns	1.83 ns	1.80 *
		Capitella capitata	0.77 ns	4.68 *	0.08 ns	14.49 ***	1.12 ns
7 m	Biomass (g/m^2)	Total infauna	4.51 **	8.60 **	0.86 ns	1.68 ns	1.17 ns
		Polychaeta	3.64 *	0.75 ns	1.00 ns	3.09 **	0.99 ns
		Bivalvia	3.45 *	6.81 **	0.89 ns	1.77 ns	1.27 ns
	Density ($no./m^2$)	Total infauna	20.66 ***	14.25 ***	0.87 ns	1.39 ns	1.26 ns
		Polychaeta	–	–	3.06 *	2.55 *	0.98 ns
		Bivalvia	3.71 ns	13.90 **	0.23 ns	1.91 ns	1.79 *
		Mya truncata	3.34 *	6.87 **	0.61 ns	2.77 *	1.20 ns
		Astarte borealis	0.33 ns	1.94 ns	0.38 ns	4.18 ***	1.46 ns
		Astarte montagui	0.11 ns	25.59 ***	0.73 ns	3.87 ***	1.31 ns
		Thyasiridae spp.	5.38 **	226.94 ***	0.49 ns	2.24 *	0.82 ns
		Euchone analis	3.81 *	4.65 *	1.41 ns	0.66 ns	1.35 ns
		Myriotrochus rinkii	0.65 ns	46.83 ***	0.64 ns	9.51 ***	0.80 ns
		Capitella capitata	3.37 *	0.03 ns	1.00 ns	4.46 ***	0.84 ns

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.
[4] The Period x Bay term is the test of oil effects.

Table 7. Three-factor analyses of variance for the biomasses and densities of major taxa and dominant species in four bays[1] at Cape Hatt, northern Baffin Island, during August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P<0.05, ** P<0.01, *** P<0.001).

			Source of Variation and df[3]				
			Period 3,8 or 30	Bay 3,8 or 30	Period x Bay[4] 9,8 or 30	Trans (Bay) 8,313	Per x Trans (Bay) 24,313
3 m	Biomass (g/m^2)	Total infauna	0.58 ns	33.67 ***	0.10 ns	10.04 ***	1.01 ns
		Polychaeta	0.51 ns	12.10 **	0.31 ns	4.88 ***	1.89 **
		Bivalvia	0.60 ns	43.24 ***	0.21 ns	6.84 ***	0.80 ns
	Density ($no./m^2$)	Total infauna	3.53 ns	17.90 ***	0.25 ns	6.22 ***	1.62 *
		Polychaeta	9.57 **	20.65 ***	0.95 ns	2.79 **	1.97 **
		Bivalvia	1.26 ns	47.62 ***	0.88 ns	6.87 ***	0.51 ns
		Mya truncata	1.63 ns	107.44 ***	0.59 ns	2.82 **	0.31 ns
		Astarte borealis	0.33 ns	25.51 ***	0.49 ns	8.09 ***	1.11 ns
		Astarte montagui	0.16 ns	23.31 ***	0.05 ns	21.25 ***	1.11 ns
		Thyasiridae spp.	0.78 ns	68.35 ***	0.38 ns	7.02 ***	0.81 ns
		Euchone analis	1.50 ns	37.37 ***	0.47 ns	6.15 ***	1.27 ns
		Myriotrochus rinkii	1.87 ns	14.28 ***	0.95 ns	2.65 **	1.14 ns
		Capitella capitata	1.47 ns	2.47 ns	0.10 ns	11.87 ***	1.05 ns
7 m	Biomass (g/m^2)	Total infauna	1.02 ns	3.53 *	0.52 ns	2.86 **	0.78 ns
		Polychaeta	1.23 ns	3.61 *	0.96 ns	2.31 *	0.88 ns
		Bivalvia	0.75 ns	3.69 *	0.55 ns	3.49 ***	0.93 ns
	Density ($no./m^2$)	Total infauna	31.13 ***	12.44 ***	1.22 ns	1.72 ns	1.02 ns
		Polychaeta	-	-	2.76 *	2.61 **	1.03 ns
		Bivalvia	5.21 **	9.46 ***	0.27 ns	2.66 **	1.42 ns
		Mya truncata	0.33 ns	5.01 **	0.40 ns	2.46 *	1.01 ns
		Astarte borealis	0.43 ns	21.28 ***	0.78 ns	2.26 *	0.83 ns
		Astarte montagui	0.13 ns	50.40 ***	0.70 ns	3.99 ***	1.31 ns
		Thyasiridae spp.	3.66 *	50.75 ***	0.26 ns	5.18 ***	0.84 ns
		Euchone analis	3.54 *	3.96 *	0.82 ns	1.30 ns	1.25 ns
		Myriotrochus rinkii	0.54 ns	25.43 ***	0.87 ns	7.04 ***	0.81 ns
		Capitella capitata	6.24 **	0.13 ns	0.81 ns	2.32 *	1.09 ns

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
2 Pre-spill Period 2 (August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
3 Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P<0.05), Transect (Bay) alone was used to test main effects.
4 The Period x Bay term is the test of oil effects.

Table 8. Three-factor analyses of variance for the densities of additional species of infauna in three bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = $P>0.05$; * $P\leq0.05$; ** $P\leq0.01$, *** $P\leq0.001$).

		Source of Variation and df[3]				
Depth	Species	Period 4,6 or 30	Bay 2,6 or 30	Period x Bay[4] 8,6 or 30	Transect (Bay) 6,313	Per x Trans (Bay) 24,313
3 m	Pholoe minuta[6]	0.29 ns	20.64 **	0.22 ns	3.87 ***	1.55 *
	Nereimyra punctata	0.27 ns	5.54 **	0.45 ns	19.43 ***	1.20 ns
	Eteone longa	1.06 ns	4.09 *	0.58 ns	6.34 ***	1.21 ns
	Astarte juveniles	[5]	[5]	4.18 **	3.78 **	0.65 ns
	Musculus discors	0.15 ns	16.84 ***	1.04 ns	10.18 ***	0.98 ns
	Musculus juveniles	2.23 ns	24.69 ***	0.80 ns	6.73 ***	0.83 ns
	Cingula castanea	2.79 *	183.31 ***	0.74 ns	6.90 ***	0.86 ns
	Retusa obtusa	2.85 *	48.94 ***	1.06 ns	3.65 **	1.30 ns
7 m	Pholoe minuta[6]	9.75 ***	24.47 ***	0.88 ns	1.78 ns	0.79 ns
	Praxillella praetermissa	4.73 **	1.80 ns	0.28 ns	1.57 ns	0.76 ns
	Pectinaria granulata	0.49 ns	1.78 ns	0.86 ns	4.59 ***	1.34 ns
	Maldane sarsi	0.11 ns	13.81 ***	0.61 ns	7.33 ***	1.28 ns
	Astarte juveniles	62.19 ***	9.73 ***	0.45 ns	1.00 ns	0.84 ns
	Macoma calcarea	1.91 ns	28.25 ***	0.52 ns	2.09 ns	1.92 **
	Macoma juveniles	[5]	[5]	2.49 *	1.32 ns	1.25 ns
	Musculus juveniles	12.48 ***	25.13 ***	0.44 ns	5.20 ***	0.63 ns
	Nuculana minuta	2.44 ns	25.15 ***	0.60 ns	5.56 ***	0.76 ns
	Serripes groenlandicus	0.57 ns	33.92 ***	0.37 ns	2.79 *	1.55 ns
	Cingula castanea	5.88 **	17.33 ***	1.84 ns	1.68 ns	1.29 ns
	Trichotropis borealis	2.05 ns	17.22 ***	0.54 ns	1.78 ns	0.69 ns

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant ($P\leq0.05$), Transect (Bay) alone was used to test main effects.

[4] The Period x Bay term is the test of oil effects.

[5] Interpretation of main effects confounded by significant interaction of Period x Bay term.

[6] Includes Pholoe longa.

Table 9. Three-factor analyses of variance for the densities of additional species of infauna in four bays[1] at Cape Hatt, northern Baffin Island, during August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01, *** P≤0.001).

Depth	Species	Source of Variation and df[3]				
		Period 3,8 or 32	Bay 3,8 or 32	Period x Bay[4] 9,8 or 32	Transect (Bay) 8,334	Per x Trans (Bay) 24,334
3 m[6]	Pholoe minuta[6]	1.17 ns	24.05 ***	0.17 ns	4.09 ***	1.21 ns
	Nereimyra punctata	1.37 ns	3.25 *	0.74 ns	12.55 ***	0.96 ns
	Eteone longa	1.88 ns	6.72 **	0.88 ns	2.91 **	0.99 ns
	Astarte juveniles	[5]	[5]	3.82 **	3.44 ***	0.59 ns
	Musculus discors	0.31 ns	9.94 ***	1.12 ns	6.94 ***	0.60 ns
	Musculus juveniles	1.80 ns	11.33 ***	0.93 ns	5.73 ***	1.15 ns
	Cingula castanea	5.19 **	138.62 ***	0.38 ns	5.77 ***	0.73 ns
	Retusa obtusa	7.28 ***	41.41 ***	0.72 ns	1.52 ns	1.16 ns
7 m	Pholoe minuta[6]	7.11 ***	15.64 ***	1.62 ns	1.45 ns	0.91 ns
	Praxillella praetermissa	10.99 ***	9.25 ***	0.69 ns	1.33 ns	0.94 ns
	Pectinaria granulata	0.60 ns	0.91 ns	0.44 ns	5.60 ***	1.40 ns
	Maldane sarsi	0.04 ns	9.76 ***	0.69 ns	5.68 ***	0.96 ns
	Astarte juveniles	94.45 ***	21.25 ***	0.65 ns	0.59 ns	0.84 ns
	Macoma calcarea	1.88 ns	18.38 ***	0.51 ns	3.31 **	1.35 ns
	Macoma juveniles	[5]	[5]	2.25 *	1.38 ns	1.05 ns
	Musculus juveniles	20.80 ***	16.56 ***	0.41 ns	3.81 ***	0.55 ns
	Nuculana minuta	4.05 *	19.43 ***	0.67 ns	2.51 *	0.88 ns
	Serripes groenlandicus	0.82 ns	18.33 ***	0.43 ns	2.26 *	1.41 ns
	Cingula castanea	8.71 ***	18.42 ***	2.04 ns	2.20 *	0.90 ns
	Trichotropis borealis	2.38 ns	8.98 ***	0.41 ns	2.33 *	0.69 ns

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Period 2 (August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.
[4] The Period x Bay term is the test of oil effects.
[5] Interpretation of main effects confounded by significant interaction of Period x Bay term.
[6] Includes Pholoe longa.

dispersed oil release in late August 1981 (Tables 4 and 5). At 7 m depth, total biomass and density were similar in the other three bays; at 3 m depth, total density and biomass of infauna were consistently lower in Bay 11 (surface release bay) than in the other three bays (Tables 4 and 5).

In shallow water (3 m depth), bay differences were consistent for all dominant groups and species studied in previous years. The ranking of bays was $9>10\geq7\geq11$ in all 12 cases where bay variability was significant. In each sampling period, densities or biomasses were highest in Bay 9 for all these taxa, and lowest in Bay 11 in 10 of 12 cases. Densities or biomasses were greater in Bay 10 than in Bay 7 in only half of the cases, and similar in the other half.

At 7 m depth, bay differences were much less consistent. For 8 of 21 groups or species where bay effects were significant (Tables 7 and 9), density or biomass were highest in Bay 9 during each sampling period. None of the taxa examined were least abundant in this bay. In Bay 11, six taxa were more abundant during all periods than in any other bay. Only three species (the bivalves *Serripes groenlandicus*, *Macoma calcarea* and Thyasiridae sp.) were least abundant in Bay 11, in contrast to results from the shallower depth. Bays 7 and 10 (reference and dispersed oil contaminated bays) ranked second or third for most groups or species (Tables 4 and 5; Fig. 4; Appendices C and D).

3.1.4b Temporal Effects

Temporal effects were greater at 7 m depth than at 3 m depth (Tables 6-9). In shallow water there were significant differences among sampling periods in only 8 of 40 tests. In most of these instances (four of five groups or species), density was higher during the 1982 sampling periods than in the other three sampling periods in 1980 and 1981 (Tables 4 and 5; Fig. 3).

At 7 m depth, differences among sampling periods were significant in 23 of 46 tests (Tables 6-9). Density was generally higher in the two sampling periods in 1982 than in 1980 or 1981 (Tables 4 and 5; Fig. 4). However, biomass of bivalves, total infaunal biomass and the density of *Mya truncata* were higher during September 1980 than during August and September 1981 and 1982.

Cross and Thomson (1981) reported that differences among sampling periods were attributable to annual rather than seasonal effects. When all sampling periods have been completed and a balanced design has been achieved, a further analysis of seasonal *vs.* annual effects will be undertaken.

3.1.4c Oil Effects

A temporal change (pre-spill to post-spill) that occurred in one or more of the treatment bays but not in the reference bay would constitute evidence for an oil effect. A temporal change that is not consistent among bays, either in direction or magnitude, would be detectable statistically as a significant interaction between period and bay effects.

The bay x period interaction was significant in both the 3 bay/5 period and 4 bay/4 period analyses for 2 of 24 taxa tested at the 7 m depth and 1 of

21 taxa tested at the 3 m depth. Each of these interactions could be interpreted as an oil effect, although in two cases the interactions are complex.

At 7 m depth the density of juveniles of the bivalve genus *Macoma* decreased in Bay 9 (dispersed oil release bay) between the second pre-spill and first post-spill sampling periods, whereas densities in the other three bays increased or remained constant between these periods (Fig. 4). A similar decrease between the second pre-spill and first post-spill sampling periods occurred in the density of polychaetes in Bay 11 (surface oil release bay), whereas densities increased or remained relatively constant in the other three bays (Fig. 5). In both cases, however, another possible source of the interaction is the decrease in Bay 10 (dispersed oil contaminated bay) between the second and third post-spill sampling periods and a concomitant increase in the other three bays. The pre- to post-spill decreases may have been caused by direct mortality resulting from the experimental oil releases, but the decrease in Bay 10 between the second and third post-spill periods cannot reasonably be attributed to oil effects.

The third significant period x bay interaction is more easily interpreted. At 3 m depth, density of juvenile *Astarte* bivalves in Bays 9 and 10, each of which received dispersed oil, increased dramatically between the first and second post-spill sampling periods (Fig. 3). Densities remained relatively constant at this time in Bays 7 and 11, the reference and surface oil release bays (Fig. 3). This increase in the density of *Astarte* juveniles may have resulted from an increase in settlement of juvenile bivalves during or after the dispersed oil release.

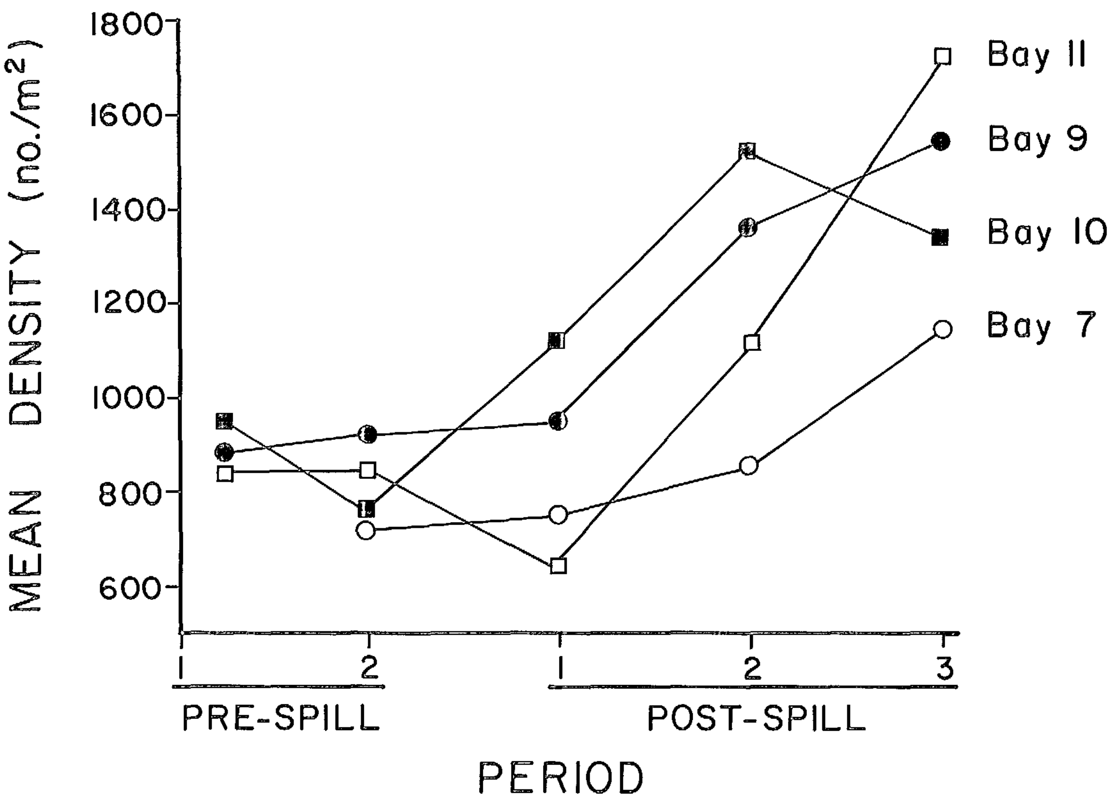


FIGURE 5. Mean density (no./m2) of polychaetes at 7 m depth in four bays at Cape Hatt, northern Baffin Island, during pre-spill sampling in September 1980 and August 1981 and during post-spill sampling in September 1981 and August and September 1982. Data are expressed as the mean of 24 replicate 0.0.625 m^2 airlift samples taken in each experimental bay during each sampling period.

3.1.5 Capitella capitata

The polychaete worm Capitella capitata is an opportunistic species that is often used as an indicator of pollution (Grassle and Grassle 1977; Pearson and Rosenberg 1978). After an oil spill in Buzzards Bay, Massachusetts, Capitella capitata 'monopolized the biologically denuded substrata at the heavily oiled stations for the first eleven months after the spill' (Sanders et al. 1980).

At Cape Hatt, mean densities of Capitella capitata ranged from 27.7 ± SD 71.5 to 48.7 ± 139.3 individuals/m2 over the study period. Mean densities for each period, bay and depth are given in Table 4.

Three-factor, nested analyses of variance showed that the density of this species differed significantly among transects at 3 m depth and at 7 m depth in both types of analysis, indicating a patchy distribution within bays. Differences among bays, however, were significant only at 3 m depth and only in one type of analysis (Table 6). Period differences were evident only at 7 m depth and in both types of analyses (Tables 6 and 7); densities of Capitella capitata were generally higher in 1982 than in 1980 or 1981 (Table 4).

Interaction effects (test for oil effects) were not significant at either depth in either analysis type. Mean density at 3 m depth increased markedly from the fourth to fifth post-spill periods only in Bay 11 (Table 4), but this was due to the presence of large numbers of Capitella capitata in only 1 of 24 samples. Thus there was no evidence of an oil effect.

3.1.6 Size-Frequency Distribution

Exposure to oil may cause size-selective mortality of benthic animals in a variety of ways. Not all life stages of marine animals are equally susceptible to the effects of oil (Rice et al. 1975; Linden 1978). Larval stages are generally more susceptible than are adults (Wells and Sprague 1976). Dow (1978) has demonstrated, on the other hand, an instance of selective mortality of large individuals of a bivalve species. The juveniles inhabited clean surface sediments, but as they grew they tended to burrow deeper into the substrate and died when they reached an oil-contaminated layer.

Mean lengths of five bivalve species and oral ring diameters of a holothurian are shown in Table 10. Mean lengths (log transformed) of individuals in each sample were compared among bays, periods and transects, using three-factor nested analyses of variance (Table 11). The test of significance of the period x bay interaction term is the test for any oil or oil plus dispersant effect. For one of these species, the bivalve Serripes groenlandicus, mean sizes of the populations are underestimated because damaged individuals were not measured, and broken shells were more common among the larger individuals in our samples. There is no reason to expect any systematic differences among bays or periods in the sizes of damaged animals, however, so the analyses presented below are still valid.

Small-scale patchiness (transect variability) in the mean sizes of the animals tested was evident for all three species at 3 m depth, but for only one of four species (Mya truncata) at 7 m depth; results of both types of

Table 10. Mean lengths (mm) of six species of infaunal benthic animals from four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Data are expressed as mean ± standard deviation; numbers in parentheses are number of individuals collected and measured.

		3 m Depth				7 m Depth			
Taxon	Period	Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Mya truncata	Pre-1	-	12.6 ± 7.5 (296)	9.9 ± 7.8 (296)	8.9 ± 5.4 (79)	-	28.0 ± 13.9 (222)	19.3 ± 13.6 (178)	17.6 ± 13.0 (224)
	Pre-2	14.1 ± 7.9 (51)	15.0 ± 7.1 (277)	15.8 ± 8.9 (132)	10.8 ± 6.2 (28)	19.5 ± 12.2 (101)	20.0 ± 12.4 (126)	17.9 ± 14.4 (112)	17.0 ± 12.0 (213)
	Post-1	17.5 ± 7.2 (66)	16.5 ± 7.8 (338)	14.1 ± 9.2 (124)	10.4 ± 7.3 (36)	22.2 ± 13.4 (110)	22.5 ± 12.9 (94)	23.0 ± 12.2 (103)	19.2 ± 10.9 (170)
	Post-2	12.6 ± 9.5 (109)	19.4 ± 8.3 (275)	16.6 ± 10.7 (120)	13.6 ± 7.2 (23)	21.7 ± 13.7 (129)	23.6 ± 11.4 (147)	22.4 ± 12.7 (131)	17.2 ± 10.8 (205)
	Post-3	14.1 ± 9.3 (67)	18.4 ± 7.2 (315)	16.8 ± 10.1 (131)	11.3 ± 6.0 (32)	22.2 ± 14.0 (148)	23.8 ± 12.3 (167)	23.9 ± 10.6 (127)	18.3 ± 11.1 (214)
Macoma calcarea	Pre-1	-	14.4 ± 3.7 (30)	12.8 ± 3.8 (21)	19.4 ± 3.8 (5)	-	14.0 ± 5.0 (225)	16.5 ± 6.0 (130)	16.6 ± 6.1 (78)
	Pre-2	16.3 ± 3.3 (8)	13.7 ± 5.0 (9)	16.1 ± 5.0 (9)	0	14.1 ± 4.8 (260)	14.3 ± 4.5 (205)	16.5 ± 6.4 (103)	15.6 ± 6.4 (70)
	Post-1	14.9 ± 5.7 (16)	13.0 ± 4.9 (46)	12.2 ± 5.0 (20)	23.0 (1)	14.5 ± 4.9 (271)	13.7 ± 4.7 (210)	15.7 ± 6.1 (117)	16.7 ± 6.8 (68)
	Post-2	14.5 ± 4.2 (12)	14.0 ± 4.6 (43)	16.4 ± 5.5 (28)	12.0 ± 4.2 (2)	14.5 ± 4.8 (336)	14.6 ± 4.2 (299)	16.4 ± 5.7 (187)	16.2 ± 6.4 (89)
	Post-3	14.4 ± 5.3 (15)	14.0 ± 4.8 (60)	16.1 ± 5.4 (13)	16.7 ± 3.8 (3)	14.7 ± 4.5 (318)	14.6 ± 4.5 (259)	15.9 ± 5.4 (159)	15.0 ± 6.1 (136)
Astarte borealis	Pre-1	-	15.2 ± 6.9 (225)	18.4 ± 8.5 (28)	14.8 ± 6.2 (18)	-	15.2 ± 6.3 (478)	16.5 ± 7.9 (378)	16.3 ± 8.0 (420)
	Pre-2	14.6 ± 6.8 (62)	14.9 ± 7.0 (296)	17.5 ± 7.7 (42)	14.5 ± 6.4 (15)	12.6 ± 5.8 (152)	15.6 ± 7.0 (294)	16.2 ± 7.3 (277)	17.0 ± 7.9 (414)
	Post-1	15.9 ± 7.0 (68)	16.0 ± 7.0 (288)	21.2 ± 8.1 (91)	14.0 ± 5.8 (9)	12.6 ± 5.9 (196)	14.8 ± 6.2 (319)	16.6 ± 8.1 (295)	15.9 ± 7.6 (341)
	Post-2	13.7 ± 7.3 (89)	14.7 ± 6.1 (324)	19.1 ± 7.6 (78)	18.2 ± 9.7 (6)	13.1 ± 5.7 (169)	15.6 ± 6.4 (412)	15.5 ± 7.0 (384)	17.3 ± 8.3 (385)
	Post-3	14.8 ± 7.1 (81)	15.8 ± 6.7 (305)	18.3 ± 7.7 (51)	18.6 ± 9.8 (9)	12.1 ± 6.1 (187)	15.0 ± 6.4 (448)	15.9 ± 7.9 (275)	16.2 ± 7.9 (429)
Astarte montagui	Pre-1	-	11.6 ± 2.2 (191)	12.6 ± 2.7 (8)	9.0 (1)	-	11.0 ± 2.9 (211)	11.9 ± 2.9 (153)	11.4 ± 2.9 (496)
	Pre-2	11.3 ± 3.0 (16)	11.5 ± 2.4 (273)	11.5 ± 2.9 (10)	13.0 ± 4.6 (3)	10.9 ± 3.1 (39)	11.4 ± 3.4 (126)	12.8 ± 3.6 (178)	11.8 ± 2.9 (491)
	Post-1	11.1 ± 3.5 (7)	11.6 ± 2.7 (365)	11.6 ± 2.4 (30)	0	11.5 ± 3.0 (51)	11.4 ± 3.0 (144)	11.5 ± 3.0 (212)	11.8 ± 2.9 (506)
	Post-2	13.5 ± 3.0 (19)	11.4 ± 2.3 (275)	12.2 ± 2.7 (14)	14.0 ± 1.4 (2)	11.2 ± 3.1 (33)	11.0 ± 3.0 (153)	11.9 ± 2.9 (227)	11.5 ± 2.9 (531)
	Post-3	11.8 ± 3.5 (9)	11.4 ± 2.3 (346)	11.2 ± 3.1 (9)	0	11.2 ± 3.4 (33)	11.0 ± 3.0 (190)	11.2 ± 2.8 (185)	11.9 ± 2.9 (541)
Serripes groenlandicus	Pre-1	-	13.5 ± 5.6 (26)	22.0 (1)	26.0 (1)	-	25.6 ± 15.2 (80)	29.0 ± 12.2 (34)	21.4 ± 8.4 (15)
	Pre-2	0	16.2 ± 4.7 (29)	0	6.3 ± 3.9 (4)	17.8 ± 11.4 (29)	24.8 ± 13.6 (35)	29.0 ± 14.5 (21)	20.6 ± 10.4 (18)
	Post-1	0	14.9 ± 11.4 (17)	10.0 (1)	0	20.3 ± 12.5 (31)	24.4 ± 12.3 (39)	20.0 ± 10.7 (16)	26.4 ± 12.4 (9)
	Post-2	4.7 ± 1.6 (10)	17.7 ± 12.8 (22)	1.0 (1)	28.8 ± 17.7 (5)	16.4 ± 14.3 (61)	30.9 ± 12.3 (53)	22.6 ± 17.5 (24)	22.3 ± 14.6 (9)
	Post-3	10.0 (1)	15.7 ± 10.8 (38)	0	23.0 (1)	16.2 ± 12.6 (53)	26.0 ± 14.8 (48)	15.8 ± 16.3 (23)	19.0 ± 13.0 (8)
Myriotrochus rinkii[3]	Pre-1	-	2.3 ± 1.1 (517)	2.7 ± 1.1 (210)	2.7 ± 1.0 (137)	-	3.2 ± 1.0 (136)	4.0 (1)	3.6 ± 0.8 (39)
	Pre-2	2.6 ± 0.9 (153)	2.3 ± 0.8 (410)	3.0 ± 0.9 (104)	2.8 ± 1.1 (136)	3.1 ± 0.9 (29)	3.2 ± 0.9 (46)	3.5 ± 0.7 (11)	3.7 ± 0.5 (6)
	Post-1	2.4 ± 0.9 (166)	2.3 ± 0.8 (400)	2.8 ± 1.0 (196)	2.6 ± 1.0 (134)	3.1 ± 0.9 (7)	2.9 ± 0.8 (91)	3.5 ± 2.1 (2)	2.8 ± 0.9 (16)
	Post-2	2.5 ± 1.0 (358)	2.5 ± 0.9 (523)	2.8 ± 0.9 (207)	2.9 ± 1.0 (139)	3.7 ± 0.9 (25)	3.1 ± 0.9 (119)	3.4 ± 0.3 (2)	3.5 ± 1.3 (7)
	Post-3	2.3 ± 1.1 (263)	2.6 ± 0.8 (388)	2.6 ± 0.9 (223)	2.9 ± 1.1 (117)	3.5 ± 0.9 (18)	3.3 ± 0.8 (95)	3.9 (1)	2.9 ± 1.2 (11)

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
3 Diameter of calcareous oral ring.

Table 11. Results of analyses of variance on mean lengths (in each sample) of four bivalve species, and mean oral ring diameter of the holothurian Myriotrochus rinkii, in four bays[1] at Cape Hatt, northern Baffin Island during September 1980 and during August and September 1981 and 1982[2]. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01, *** P≤0.001).

			Source of Variation and numerator df[4]						
Analysis[3]	Depth	Species	Period 4 (3)	Bay 2 (3)	Period x Bay[5] 8 (9)	Transect (Bay) 6 (8)	Per x Tran (Bay) 24 (24)	Residual df	No. of samples
3 bay/5 period	3 m	Myriotrochus rinkii	3.28 *	14.66 ***	0.27 ns	4.27 ***	1.17 ns	282	327
		Astarte borealis	0.25 ns	2.36 ns	0.36 ns	3.60 **	1.82 *	161	205
		Mya truncata	5.58 **	15.25 ***	0.56 ns	6.14 ***	0.60 ns	242	287
	7 m	Astarte montagui	0.75 ns	7.92 **	1.70 ns	0.62 ns	0.83 ns	296	341
		Astarte borealis	1.08 ns	5.36 *	0.88 ns	1.56 ns	0.99 ns	308	353
		Mya truncata	0.38 ns	12.23 ***	2.20 ns	2.85 **	0.96 ns	303	348
		Macoma calcarea	0.66 ns	6.04 **	1.05 ns	0.84 ns	0.80 ns	302	347
4 bay/4 period	3 m	Myriotrochus rinkii	3.16 *	10.32 ***	0.64 ns	3.27 **	1.15 ns	304	352
		Astarte borealis	0.60 ns	1.44 ns	0.49 ns	3.11 **	1.74 *	178	225
		Mya truncata	1.71 ns	9.83 ***	1.95 ns	3.19 **	0.46 ns	252	300
	7 m	Astarte montagui	0.33 ns	4.07 *	1.34 ns	0.48 ns	0.85 ns	284	331
		Astarte borealis	0.83 ns	23.06 ***	0.77 ns	0.80 ns	1.06 ns	316	364
		Mya truncata	0.96 ns	4.11 *	0.97 ns	3.28 **	1.11 ns	321	369
		Macoma calcarea	0.74 ns	4.68 **	1.03 ns	0.98 ns	0.77 ns	320	368

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

3 3 bays/5 period analysis excludes Bay 7; 4 bay/4 period analysis excludes Pre-spill Period 1.

4 Numerator df are shown for 3 bay/5 period analysis, followed by 4 bay/4 period analysis (in parentheses). Denominator df are residual df for transect effects. Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period effects and Period x Bay effects; denominator df are 30 (3/5 analysis) or 32 (4/4 analysis). Where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test Period, Bay and Period x Bay effects; denominator df are 6 (3/5 analysis) or 8 (4/4 analysis).

5 The Period x Bay term is the test of oil effects.

analyses were consistent (Table 11). These transect effects at 3 m depth may be the result of patchy settlement patterns in juvenile bivalves or of periodic mortality due to ice scour or variations in temperature and salinity. Each of these physical factors (particularly ice scour) may vary on a small scale, and any resultant mortality would cause a shift towards smaller (newly settled) bivalves in those areas.

At 3 m depth, differences in mean lengths among bays were evident only for Mya truncata and Myriotrochus rinkii (Table 11). Mya truncata was generally largest in Bay 9 (dispersed oil release bay) and smallest in Bay 11 (surface oil release bay). Myriotrochus rinkii, on the other hand, was consistently larger in Bays 10 (dispersed oil contaminated bay) and 11, and smaller in Bays 7 (reference bay) and 9.

At 7 m depth, mean lengths of all four bivalve species differed among bays (Table 11). Mya truncata showed the same bay differences (9>10, 7>11) as at the 3 m depth. Astarte borealis was smaller in Bay 7 than in the other three bays, and Astarte montagui and Macoma calcarea were somewhat smaller in Bays 7 and 9 than in the other two bays (Table 10); this trend is similar to that shown by the holothurian Myriotrochus rinkii at 3 m depth.

Differences among periods were significant only for Myriotrochus rinkii and Mya truncata at 3 m depth (Table 11). The variation in the size of the oral ring diameter of Myriotrochus rinkii at 3 m depth was apparently seasonal. In five of eight cases (August-September comparisons in two years in four bays), mean sizes were smaller in September than in August (Table 10). This may have been the result of mortality in large individuals or recruitment of juveniles. In the case of Mya truncata, size differences were apparent at the 3 m depth only in one of two analysis types, when the first sampling period was included (Table 11). In each of the three bays sampled in 1980, mean sizes were lower in September 1980 than in any other sampling period.

The period x bay interaction (test of oil effects) was not significant for any of the species tested at either depth in either type of analysis (a total of 14 tests; Table 11). Most of the systematic variation in the mean sizes of the infaunal species examined was attributable to spatial effects. This spatial variability was evident on both small (transect) and relatively large (bay) scales, and occurred in all of the species tested. There was no evidence of any oil-related change in size structure of the populations.

3.1.7 Weight-Length Relationships of Bivalves

Exposure to crude oil may cause physiological changes in marine invertebrates. In bivalves these changes may be reflected in the dry weight-length relationship (Stekoll et al. 1980). The dry weight-length relationship of four bivalve species is being used as an indicator of sublethal effects of oil in the experimental bays at Cape Hatt.

For three species of bivalves (Mya truncata, Macoma calcarea and Astarte borealis), we measured and weighed approximately 50 individuals from the middle transect at 7 m depth in each of the three bays sampled in September 1980. Analysis of scatter plots of the original data and of residuals produced by regression analyses indicated that the weight-length relationship of these animals was best expressed by a power curve (y = axb) rather than by exponential (y = aex), linear (y = a + bx) or logarithmic (y = a log x) functions (Cross and Thomson 1981). This type of weight-length relationship was expected *a priori* and is typical of most animals.

Weight-length analyses in the present report include a fourth species, *Serripes groenlandicus*, a fourth bay (Bay 7), and all five sampling periods. Analyses of covariance were used to assess among-bay and among-period variations in the slopes of the regression lines and in dry weights adjusted for length (Table 12). The slope is the power to which length must be raised in order to estimate weight (b in the expression $y = ax^b$). The first part of the analysis of covariance is a test of equality of slopes. If the slopes for different bays and periods are similar, then the rate of gain in weight with increasing length is consistent. If slopes are significantly different among bays or periods, interpretation of the remainder of the analysis for that effect or interaction is ambiguous. The second part of the analysis compares weights in different bays and periods after adjustment for any differences in length. If adjusted weights (i.e. weight at a standard length) are significantly different, then at any given length animals are heavier in some bays or periods than in others.

When three bays (9, 10 and 11) and five periods were considered, slopes of the weight-length regression lines varied significantly only in one instance (Table 12); *Astarte borealis* showed significant temporal differences in slopes. Large individuals collected during the first pre-spill sampling period (September 1980) were heavier, and small individuals lighter, than those collected during the subsequent four sampling periods (1981 and 1982).

Table 12. Analyses of covariance of difference in dry meat weight, using length as the covariate, for bivalves collected at a depth of 7 m in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. F-values are given with significance levels (ns = $P > 0.05$; * $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$).

Analysis[3]	Species	df[4] ->	Equality of Group Means			Equality of Slopes			No. of specimens
			Period 4 (3)	Bay 2 (3)	Period x Bay 8 (9)	Period 4 (3)	Bay 2 (3)	Period x Bay 8 (9)	
3 bay/5 period	Astarte borealis		–[5]	0.70 ns	1.79 ns	4.32 **	0.99 ns	1.26 ns	683
	Macoma calcarea		5.26 ***	2.20 ns	1.59 ns	1.60 ns	1.41 ns	0.81 ns	646
	Mya truncata		3.63 **	4.23 *	0.80 ns	0.83 ns	2.09 ns	0.59 ns	719
4 bay/4 period	Astarte borealis		4.72 **	12.24 ***	1.81 ns	0.97 ns	0.42 ns	1.28 ns	745
	Macoma calcarea		2.33 ns	–[5]	3.45 ***	1.13 ns	7.89 ***	1.06 ns	718
	Mya truncata		1.69 ns	–[5]	0.60 ns	0.63 ns	3.49 *	0.92 ns	794
	Serripes groenlandicus		–[5]	–[5]	–[5]	0.76 ns	0.07 ns	2.04 *	362

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
3 3 bay/5 period analysis excludes Bay 7; 4 bay/4 period analysis excludes Pre-spill Period 1.
4 Numerator df are shown for 3 bay/5 period analysis followed by 4 bay/4 period (in parentheses); denominator df are (no. of specimens - 1).
5 Results of 'Equality of Group Means' not shown because of heterogeneity of slopes of regression lines for the effect.

After adjustment for length, mean weights of Macoma calcarea and Mya truncata varied significantly among sampling periods (Table 12). Mean weight of Mya truncata was greater in the first pre-spill sampling period than in the other four periods, and individuals of Macoma calcarea collected during the first pre-spill and second post-spill sampling periods (September 1980 and August 1982) were generally heavier than those collected during the other three sampling periods. Thus weight-length relationships in all three species differed among sampling periods. Differences among bays were only evident in the case of Mya truncata; adjusted mean weights of individuals collected in Bay 9 were lower than in the other two bays. In this type of analysis (excluding Bay 7), there was no significant period x bay interaction in either the weight-length slopes or the adjusted mean weights of individuals.

When all four bays and only the last four sampling periods were considered, slopes differed significantly for all species except Astarte borealis. Dry weights (excluding shell) of small individuals of Macoma calcarea collected in Bay 7 (reference bay) were higher, and those of large individuals lower, than in the other three bays. Slopes for Mya truncata also differed among bays, but the significance was marginal (Table 12) and inspection of the regression lines showed only small differences among bays. As for Macoma calcarea, small individuals collected in Bay 7 were heavier, and large individuals lighter, than was true in other bays.

After adjustment for length, dry meat weight of Astarte borealis differed among both bays and sampling periods. Individuals collected in Bay 7 and during the first post-spill sampling period were heavier than animals collected in other bays and other periods.

Bay x period interactions were significant in the cases of regression line slopes for Serripes groenlandicus and adjusted mean dry weights of Macoma calcarea (Table 12). Each of these interactions indicates the possibility that oil affected weight-length relationships.

Inspection of the weight vs. length regression lines for Serripes groenlandicus in each period and bay shows unexpected results (Fig. 6). Results for Bays 10 and 11 are included, but too few individuals were measured (5-20 per sampling period) to warrant further discussion; in any case, no progressive change in slopes occurred through time in either bay (Fig. 6). In Bay 9 (n = 28-45 per period), differences in slopes among periods were small, and no progressive temporal change was observed. However, in Bay 7 the among-period differences in slope were considerable (n = 18-33). Also, among-period differences in weight-at-length were greater for larger animals. An oil effect is indicated in this case because larger bivalves showed a progressive decrease in dry weight from the second pre-spill to the third post-spill period (Fig. 6). This is unexpected because Bay 7, the reference bay, received very low concentrations of dispersed oil. However, for some unknown reason the body burdens of hydrocarbons in Serripes groenlandicus immediately following the dispersed oil release were highest in this bay (Boehm 1983). This may explain the apparent decrease in weight-at-length during the post-spill sampling periods.

The period x bay interaction effect in adjusted dry meat weight of Macoma calcarea is evident in Figure 7. Cross and Thomson (1982) reported that, for this species, differences in weight vs. length slopes were evident only in Bay 7. For young Macoma calcarea in Bay 7, the reference bay, weight

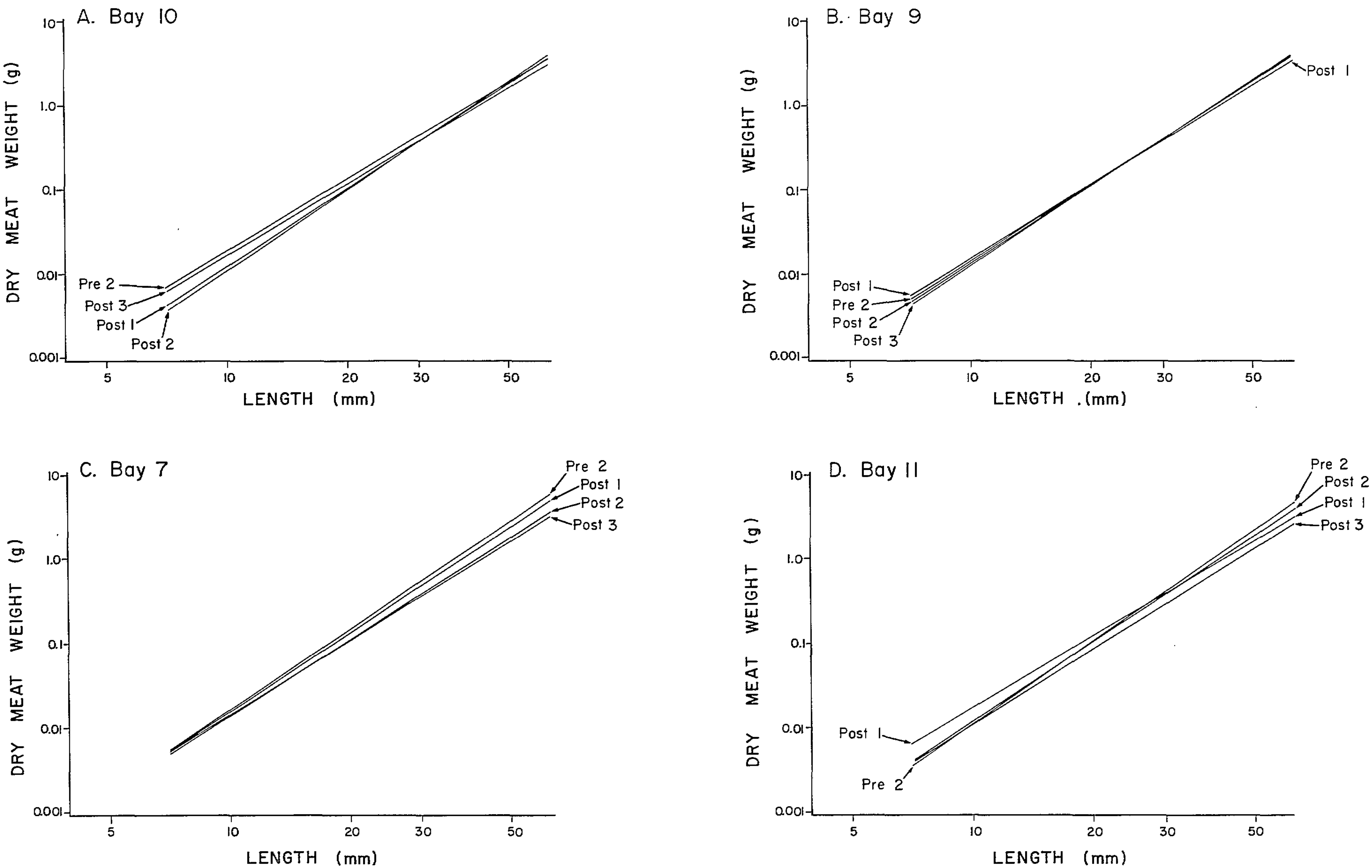


FIGURE 6. Least square regression lines of dry meat weight vs. length for *Serripes groenlandicus* in the four bays at Cape Hatt, northern Baffin Island, during pre-spill sampling in August 1981 and during post-spill sampling in September 1981 and August and September 1982.

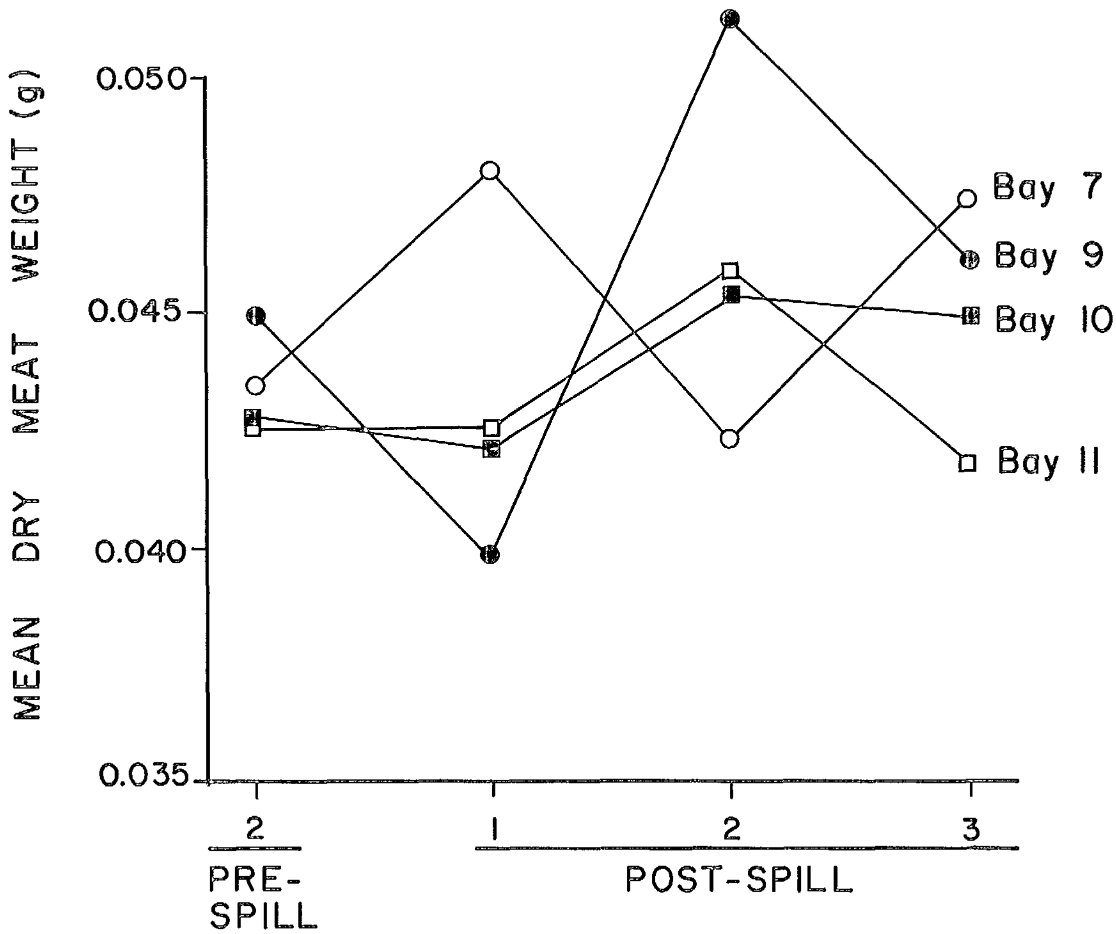


FIGURE 7. Backtransformed adjusted group mean dry meat weight of *Macoma calcarea* determined in analysis of covariance. Animals were collected at the 7 m depth in four bays at Cape Hatt, northern Baffin Islnd, during pre-spill sampling in August 1981 and during post-spill sampling in September 1981 and August and September 1982.

per unit length increased between August and September 1981. In contrast, in both 1981 and 1982, adjusted mean dry weight (excluding shell) decreased from August to September in Bays 9, 10 and 11 (Fig. 7). The increase in body tissue relative to length in Bay 7 likely represented a natural seasonal increase in gonadal or storage materials, which are necessary to meet metabolic requirements in the winter. Increase in length in Macoma balthica apparently ceases during winter in temperate, boreal and arctic waters (Green 1973; Buekema and de Bruin 1977; Chambers and Milne 1979; Bachelet 1980). In the Dutch Wadden Sea (Buekema and de Bruin 1977), Macoma balthica increased in length and tissue weight from March to June; in the subsequent 8-9 months length remained constant, whereas almost two-thirds of the summer's increase in dry tissue weight was lost. Thus the observed seasonal increase in weight relative to length in the reference bay in both 1981 and 1982 is not unexpected. The lack of such an effect or its reversal in the other (oiled) bays may be attributable to oil effects on feeding, gonadal development or metabolic processes. Oil has been reported to interfere with feeding behaviour (Atema and Stein 1974; Atema 1976; Hyland and Miller 1979; Augenfeld 1980) and to increase metabolic rate (Hargrave and Newcombe 1973; Fong 1976).

3.1.8 Community Structure

3.1.8a Approach

Perturbation of the benthic marine environment often results in large-scale changes in infaunal community structure (Pearson and Rosenberg 1978). Faunal changes resulting from the introduction of oil may be drastic and the degree of change is related to the intensity and duration of oiling (Sanders et al. 1980). One of the best approaches for detecting oil effects appears to be the community or ecosystem approach (Mann and Clark 1978; Elmgren et al. 1980).

We are using changes in benthic community structure as the overall test of oil effects in the experimental bays at Cape Hatt. The term community, in these tests, refers to an assemblage of benthic animals that occur together. Since distribution of benthic animals may be affected by currents, food availability, substrate and depth, similar assemblages of animals may be found under similar environmental conditions. Factor analysis is used to identify the assemblages found in the experimental bays at Cape Hatt. The abundance of each group in each sample (factor score) is also computed in this analysis. A high factor score indicates that the assemblage of animals associated with a factor is common in the sample in question; a low or negative factor score indicates that the animals in the assemblage are rare or absent in the sample, and that any species negatively associated with the factor are common. The factor analysis thus reduces a large number of species variables to a smaller number of assemblage variables. By testing for statistically significant among-bay and among-period differences in factor scores (representing species assemblages), we are testing for differences in overall community composition.

A multivariate analysis of variance is being used to determine the significance of differences in factor scores among bays and periods. This analysis simultaneously considers scores for all factors determined in factor analysis. The test for oil effects is a test for changes in benthic community composition in the experimental (oiled) bays that do not occur in the reference bay. This test is represented by the interaction term in the multivariate analysis of variance. The analysis also tests for differences in community composition among sampling periods and among bays. Graphical representations of the results of the multivariate analyses of variance were also produced.

Cross and Thomson (1981) showed that there were significant between-depth differences in the infaunal communities in the bays at Cape Hatt. Furthermore, differences between depths were not consistent among bays (the bay by depth interaction term was significant). Inclusion of depth as a term in the overall analysis would have rendered interpretation difficult if not impossible. Depths were, therefore, treated separately; factor analyses and multivariate analyses of variance were performed on each depth separately.

The species considered for analysis were those that accounted for 1% or more of total infaunal numbers at each depth. In this way 21 taxa representing 83% of total numbers at the 3 m depth and 30 taxa representing 87% of total numbers at the 7 m depth were selected for factor analyses. Either density or biomass data would be adequate for the detection of large-scale change, but subtle faunal changes would be more readily detected in density data. The biomass data are dominated by the presence and abundance of older individuals and are relatively insensitive to numerical changes in younger individuals. Hence analyses were performed on density data.

The results of the factor analyses applied to the most common species collected at the 3 m and 7 m depths during all time periods and from all bays are summarized in Tables 13 and 14, respectively. At the 3 m depth, five factors with eigenvalues >1 were extracted. These accounted for 59.7% of the variance represented by the 21 species variables. At the 7 m depth, nine factors with eigenvalues >1 were extracted; they accounted for 57.2% of the variance represented by the 30 species variables. Each of these factors can be considered as representing a group of species that tend to occur together and whose densities vary more or less proportionately. Tables 13 and 14 list the species whose densities were strongly correlated with each of the factors. Some factors also represent certain species (those with negative signs) that tend to be absent or rare at locations where the the other species are common.

Factor scores were calculated for each sample and are summarized for each bay and time period at the 3 m depth in Figure 8, and at the 7 m depth in Figure 9.

Differences in community composition among bays and periods were assessed with multivariate analyses of variance using, as dependent variables, the factor scores for each of the factors derived in the previous analyses. These analyses test for differences in community composition among bays and periods by simultaneously considering the scores for all factors. Since these factors, in turn, represent assemblages of the most common species, the analyses test for departures from the 'average' community composition. Four separate analyses were done: for both 3 and 7 m depths using both the 3 bay/5 period and 4 bay/4 period approaches. The results of

Table 13. Results of factor analysis of the 21 most abundant benthic animals collected at 3 m depth at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982. The values shown are the correlations between the log-transformed densities of various species (the original variables) and each of the five factors determined in the analysis. Species whose densities were weakly correlated with a factor (−0.4 < r < 0.4) are not shown. Also shown is the variance explained by each factor expressed as a percentage of the variance of the original variables.

1. Variance explained	24.88%
Thyasiridae spp.	0.819
Mya truncata	0.763
Euchone analis	0.683
Astarte juveniles	0.683
Ophelia limacina	0.672
Astarte borealis	0.668
Cirratulidae spp.[1]	0.634
Cingula castanea	0.611
Pholoe minuta[2]	0.599
Astarte montagui	0.567
Retusa obtusa	0.520
Trichotropis borealis	0.492

2. Variance explained	10.28%
Musculus discors	0.802
Musculus juveniles	0.799
Nereimyra punctata	0.565

3. Variance explained	9.39%
Pholoe minuta[2]	0.444
Myriotrochus rinkii	0.728
Trichotropis borealis	0.422
Capitella capitata	−0.624

4. Variance explained	7.97%
Spio spp.[3]	0.750
Nemertea spp.	0.593
Harmothoe imbricata	−0.455

5. Variance explained	7.15%
Eteone longa	0.690
Trichotropis borealis	−0.447

[1] Includes *Chaetozone setosa* and *Tharyx marioni*.
[2] Includes *Pholoe longa*.
[3] Includes unidentified species.

Table 14. Results of factor analysis of the 30 most abundant benthic animals collected at 7 m depth at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982. The values shown are the correlations between the log-transformed densities of various species (the original variables) and each of the nine factors determined in the analysis. Species whose densities were weakly correlated with a factor ($-0.4 < r < 0.4$) are not shown. Also shown is the variance explained by each factor expressed as a percentage of the variance of the original variables.

1. Variance explained	9.15%
Thyasiridae spp.	0.824
Macoma calcarea	0.662
Scoloplos armiger	0.549
Spio spp.[1]	0.439
Macoma juveniles	0.433
Serripes groenlandicus	0.478

2. Variance explained	8.89%
Moelleria costulata	0.728
Cingula castanea	0.590
Retusa obtusa	0.560
Trichotropis borealis	0.514
Macoma juveniles	0.443
Musculus juveniles	0.439
Nuculana minuta	0.420

3. Variance explained	8.30%
Astarte montagui	0.811
Astarte borealis	0.793
Mya truncata	0.441
Nuculana minuta	0.441
Praxillella praetermissa	0.443
Astarte juveniles	0.414
Maldane sarsi	0.454

4. Variance explained	6.29%
Myriotrochus rinkii	0.754
Cirratulidae spp.[2]	0.578
Musculus juveniles	0.436

5. Variance explained	6.25%
Macoma moesta	0.613
Musculus niger	0.567
Spio spp.[1]	-0.511
Mya truncata	0.413

6. Variance explained	5.43%
Harmothoe imbricata	0.751
Nereimyra punctata	0.505
Pholoe minuta[3]	0.446

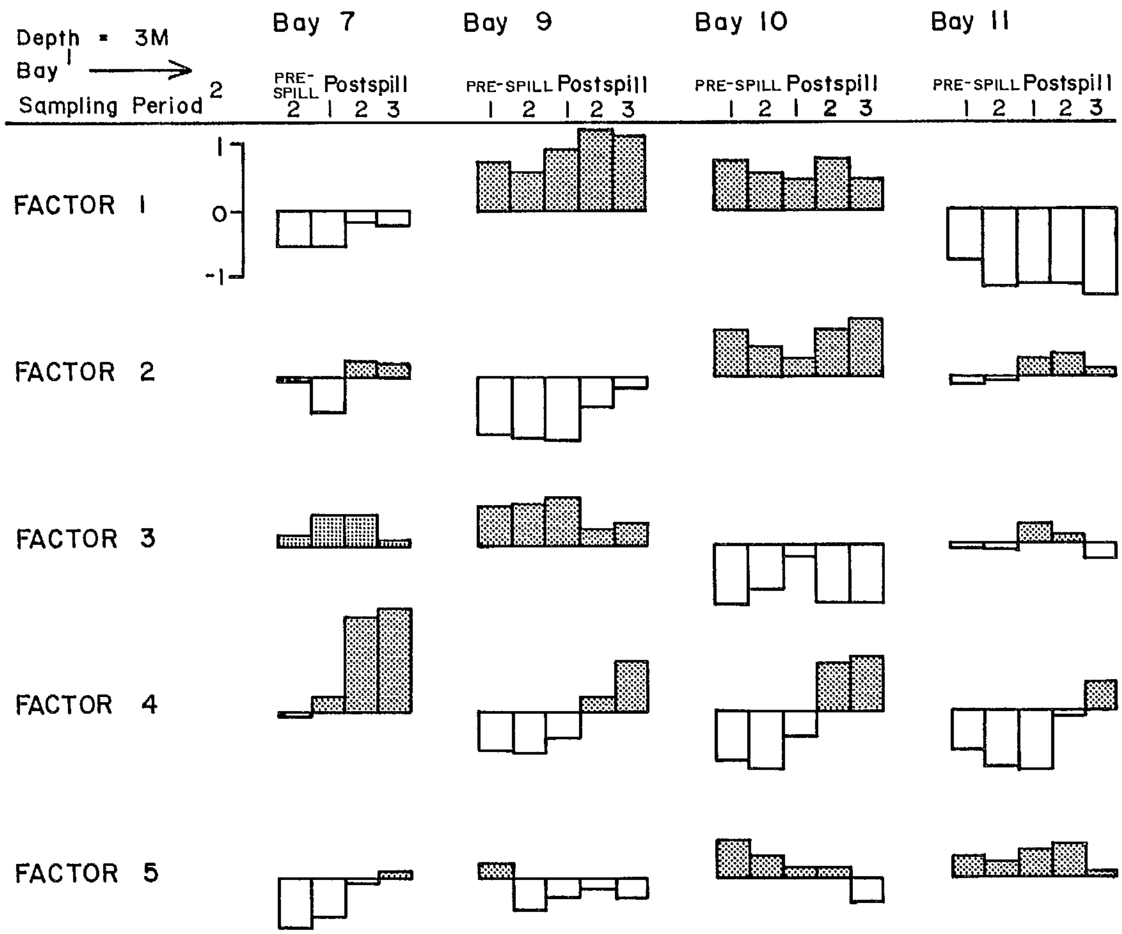
7. Variance explained	4.46%
Capitella capitata	0.781
Eteone longa	0.469

8. Variance explained	4.25%
Aricidea spp.[4]	0.789

9. Variance explained	4.12%
Pectinaria granulata	0.788

[1] Includes unidentified species.
[2] Includes *Chaetozone setosa* and *Tharyx marioni*.
[3] Includes *Pholoe longa*.
[4] Includes *Aricidea hartmanae*.

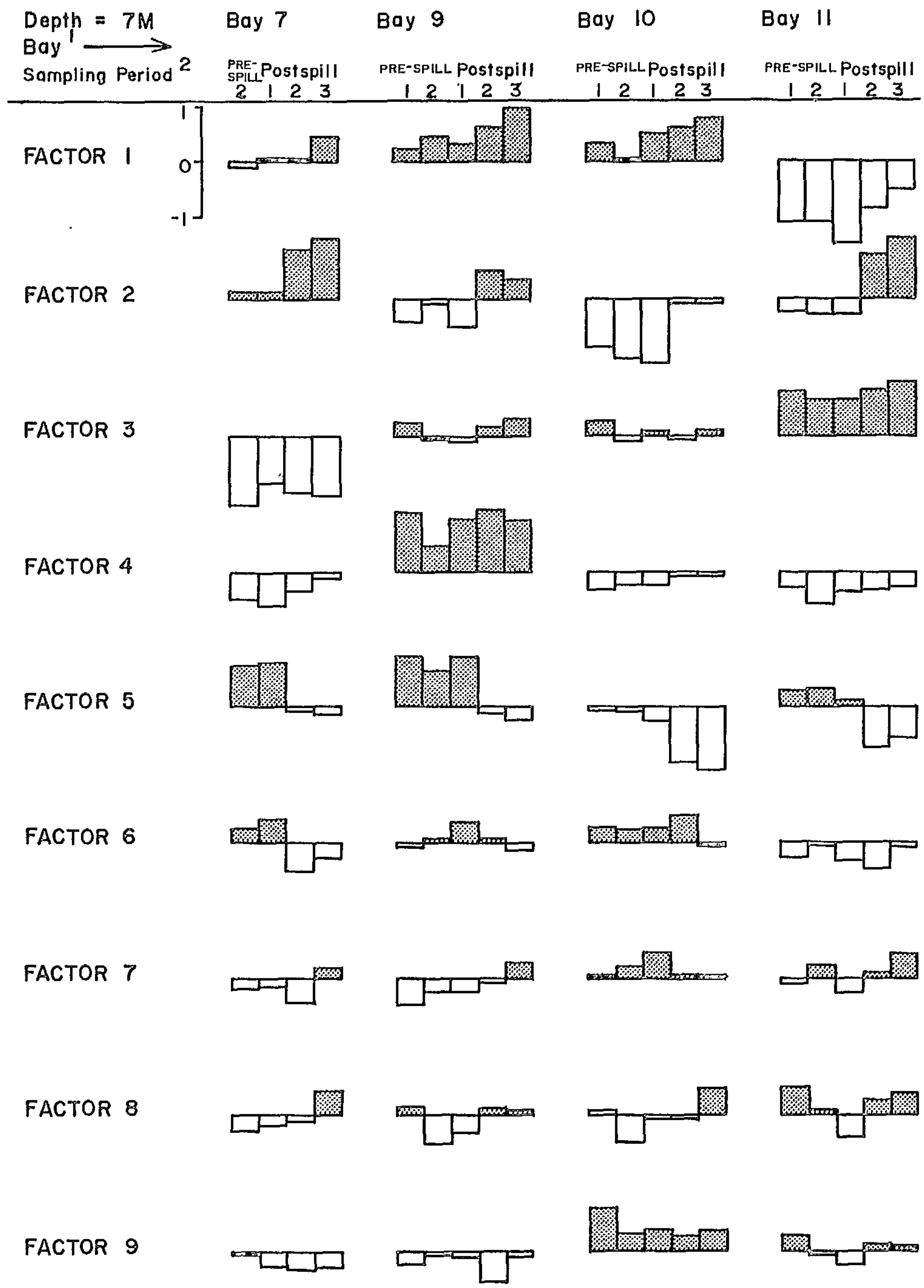
FIGURE 8. Mean factor scores for each period and bay at the 3 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and August and September 1981 and 1982[2].



[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

FIGURE 9. Mean factor scores for each period and bay at 7 m depth in four bays at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982.



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[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

these analyses, together with (univariate) analyses of variance for each factor, are shown in Tables 15 and 16.

3.1.8b Spatial Effects

Most of the significant (P<0.05) variation in all four analyses was spatial, including both variation among transects within bays and variation among bays. Variation among transects was significant in all four multivariate analyses, in all 12 univariate analyses for 3 m depth, and in 16 of 18 univariate analyses at 7 m depth. This indicates a patchy distribution of infaunal assemblages on the 50-m scale at both depths.

Significant variation among bays occurred with a similar frequency as that among transects: in three of four multivariate analyses, in 8 of 10 univariate analyses at 3 m depth, and in 14 of 18 univariate analyses at 7 m depth (Tables 15 and 16). In one multivariate analysis of 7 m data (3 bay/5 period), a marginally significant interaction between periods and transects resulted in the use of the transect within bay error term rather than the pooled transects error term as the denominator in the tests for main effects. The reduced denominator degrees of freedom produced a nonsignificant (P=0.058) difference among bays.

At 7 m depth, factors six through nine, all representing polychaetes, were least variable among bays (Fig. 9; Tables 15 and 16). Abundances of the first five factors were similar in three of the experimental bays, and consistently different in a fourth bay.

Table 15. Multivariate and univariate analyses of variance (MANOVA and ANOVA) for factor scores determined in factor analyses of infaunal density in three bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01, *** P≤0.001) for univariate analyses, and with actual probabilities for multivariate analyses.

			Source of Variation and univariate df[3]				
Depth	Variable		Period 4,6 or 30	Bay 2,6 or 30	Period x Bay[4] 8,6 or 30	Transect (Bay) 6,313	Per x Trans (Bay) 24,313
3 m	MANOVA						
	Pillai's trace	F ->	3.11	38.85	0.97	12.73	1.19
		P ->	0.0001	0.0001	0.528	0.0001	0.086
		df ->	20,116	10,54	40,150	30,1565	120,1565
	ANOVAS						
	Factor 1		1.93 ns	165.47 ***	1.32 ns	13.66 ***	0.89 ns
	Factor 2		1.08 ns	18.72 ***	0.44 ns	17.90 ***	0.74 ns
	Factor 3		1.11 ns	17.27 ***	0.26 ns	14.30 ***	1.45 ns
	Factor 4		9.99 **	1.30 ns	0.31 ns	7.11 ***	1.67 *
	Factor 5		1.19 ns	2.98 ns	0.38 ns	12.56 ***	0.95 ns
7 m	MANOVA						
	Pillai's trace	F ->	0.85[5]	5.41[5]	0.55[5]	3.72	1.18
		P ->	0.646	0.058	0.972	0.0001	0.042
		df ->	24,16	12,4	48,36	54,1860	216,2817
	ANOVAS						
	Factor 1		2.82 ns	48.90 ***	0.36 ns	5.12 ***	1.61 *
	Factor 2		34.39 ***	36.29 ***	1.67 ns	1.71 ns	0.90 ns
	Factor 3		1.24 ns	16.29 **	0.26 ns	2.52 *	1.71 *
	Factor 4		0.45 ns	15.76 **	0.22 ns	6.57 ***	1.59 *
	Factor 5		23.94 ***	30.18 ***	0.31 ns	3.26 **	1.22 ns
	Factor 6		0.27 ns	4.05 *	0.55 ns	6.74 ***	0.95 ns
	Factor 7		2.07 ns	3.44 *	1.44 ns	2.65 *	0.75 ns
	Factor 8		5.48 **	1.48 ns	0.89 ns	2.59 *	0.94 ns
	Factor 9		0.99 ns	10.17 ***	0.61 ns	5.43 ***	1.04 ns

1 Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

3 Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.

4 The Period x Bay term is the test of oil effects.

5 Only factors 1-6 were considered in the MANOVA because denominator df = 6.

Table 16. Multivariate and univariate analyses of variance (MANOVA and ANOVA) for factor scores determined in factor analyses of infaunal density in four bays[1] at Cape Hatt, northern Baffin Island, during August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01, *** P≤0.001) for univariate analyses, and with actual probabilities for multivariate analyses.

			Source of Variation and univariate df[3]				
Depth	Variable		Period 3,8 or 32	Bay 3,8 or 32	Period x Bay[4] 9,8 or 32	Transect (Bay) 8,334	Per x Trans (Bay) 24,334
3 m	MANOVA						
	Pillai's trace	F ->	4.72	27.15	0.82	8.95	1.10
		P ->	0.0001	0.0001	0.781	0.0001	0.230
		df ->	15,90	15,90	45,160	40,1670	120,1670
	ANOVAS						
	Factor 1		2.95 *	112.97 ***	0.66 ns	9.01 ***	0.89 ns
	Factor 2		2.63 ns	10.49 ***	0.50 ns	12.80 ***	0.59 ns
	Factor 3		1.77 ns	9.27 ***	0.32 ns	11.10 ***	1.24 ns
	Factor 4		22.37 ***	11.08 **	0.32 ns	5.45 ***	1.87 **
	Factor 5		0.84 ns	5.08 **	0.71 ns	6.68 ***	0.96 ns
7 m	MANOVA						
	Pillai's trace	F ->	2.43	34.12	0.94	2.78	1.09
		P ->	0.001	0.0001	0.617	0.0001	0.174
		df ->	27,78	27,78	81,288	72,2664	216,3006
	ANOVAS						
	Factor 1		7.40 ***	51.06 ***	0.61 ns	4.50 ***	1.07 ns
	Factor 2		41.53 ***	33.92 ***	1.51 ns	2.27 *	0.82 ns
	Factor 3		0.94 ns	63.42 ***	0.47 ns	2.04 *	1.28 ns
	Factor 4		1.90 ns	26.71 ***	0.55 ns	4.88 ***	1.24 ns
	Factor 5		30.16 ***	22.68 ***	0.28 ns	2.91 **	1.03 ns
	Factor 6		2.11 ns	2.79 ns	1.19 ns	3.85 ***	0.98 ns
	Factor 7		1.67 ns	1.63 ns	0.97 ns	1.53 ns	1.51 ns
	Factor 8		7.89 ***	0.67 ns	0.87 ns	2.06 *	0.81 ns
	Factor 9		0.41 ns	3.79 *	0.35 ns	6.56 ***	1.09 ns

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

2 Pre-spill Period 2 (August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

3 Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.

4 The Period x Bay term is the test of oil effects.

At 3 m depth, F-values for bay differences in the univariate analyses of variance indicate that the first factor, representing 12 species, showed the greatest differences among bays; values in the dispersed oil bays were different from those in the other two bays (Fig. 8). The second factor, representing mussels and a polychaete, distinguished the two dispersed oil bays from each other (Fig. 8). At 3 m depth, Bays 7 (reference bay) and 11 (surface oil release bay) were the most similar in terms of animals present (Fig. 10).

3.1.8c Temporal Effects

At 3 m depth, the abundances of the animal assemblages differed significantly among sampling periods (Tables 15 and 16). The greatest difference among periods appears to have resulted from an increase in abundance of the polychaetes and nemerteans represented by the fourth factor (Fig. 8). This variability appears to have been an annual rather than a seasonal effect (Figures 8 and 10). The August and September sampling periods are not clearly discriminated.

Temporal variation was also evident at the 7 m depth (Fig. 11A). This variability was also annual and was caused by a marked difference in species assemblages found in 1982 from those found in 1981. This difference existed only in comparisons that included the reference bay and sampling periods in 1981 and 1982 (Table 16). Temporal differences were not evident when the reference bay was excluded and all five sampling periods were included (Table 15).

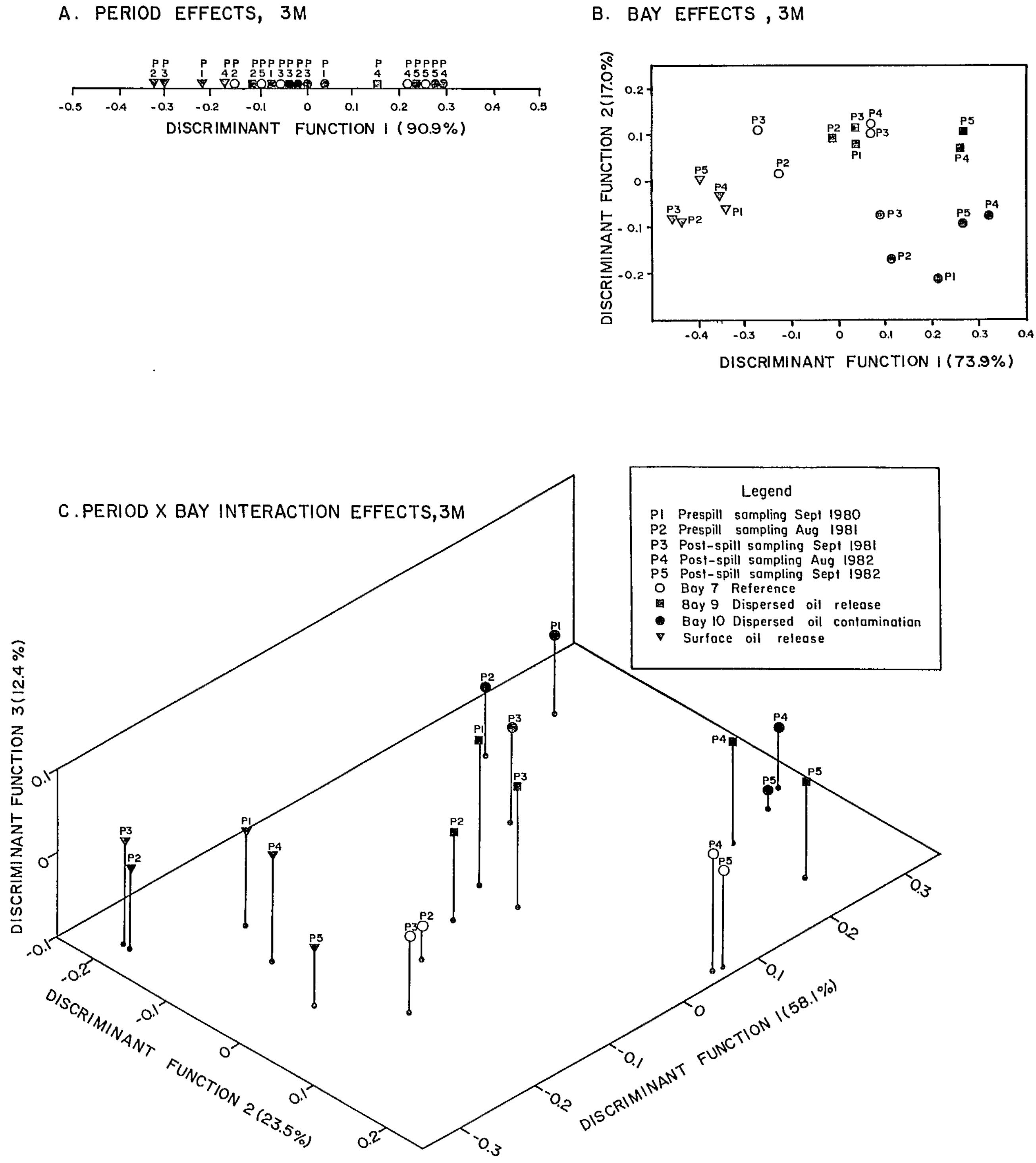


FIGURE 10. Graphical representation of results in multivariate analysis of variance using data collected at 3 m depth in four bays at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982. The plots display the results of the tests for main effects and interactions using the transect term as the error term.

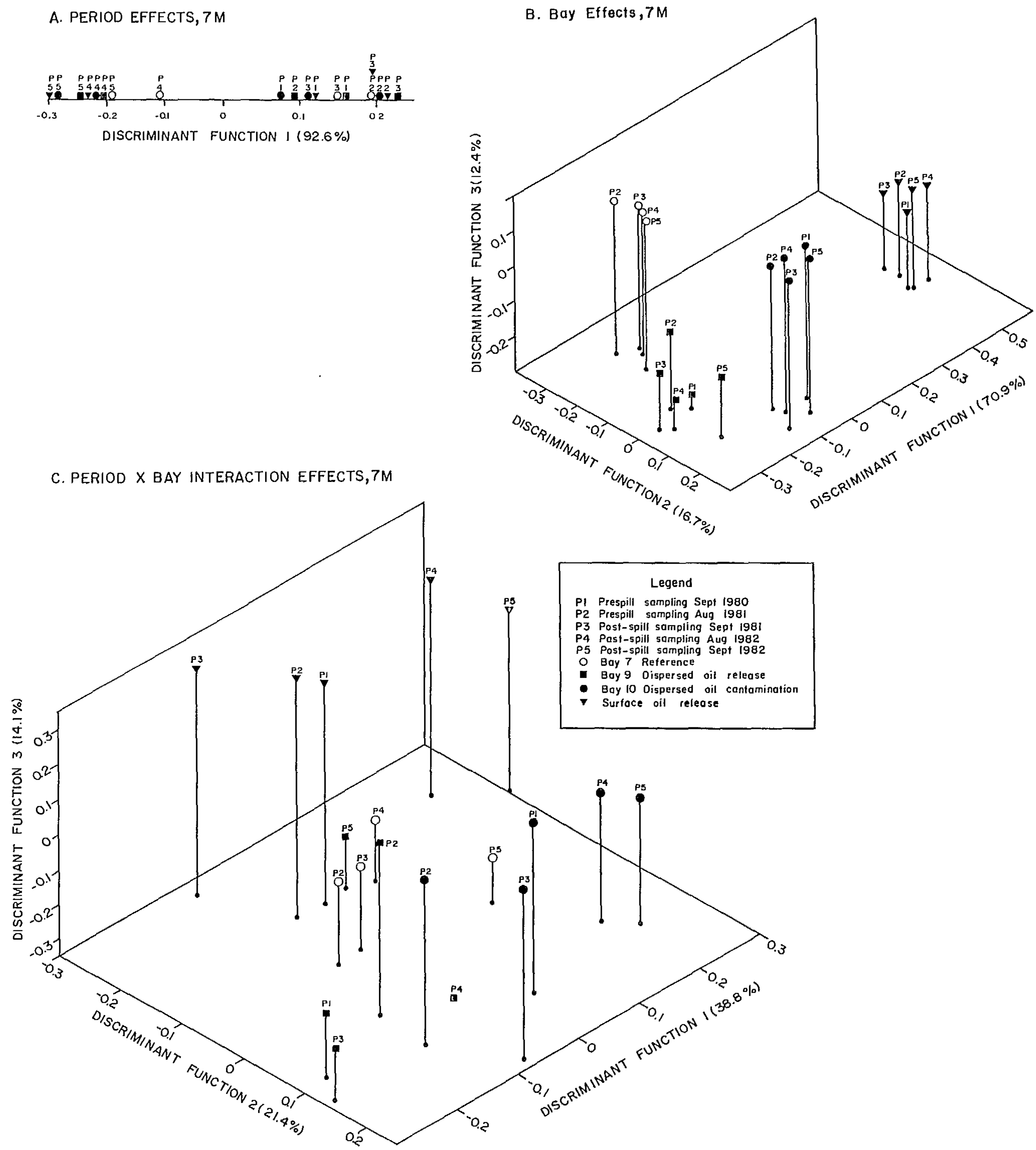


FIGURE 11. Graphical representation of results in multivariate analysis of variance using data collected at 7 m depth in four bays at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982. The plots display the results of the tests for main effects and interaction using the transect term as the error term.

3.1.8d Oil Effects

In the present study, which includes temporal and spatial 'controls', effects of oil or dispersed oil on community composition would be evident as pre- to post-spill changes in experimental bays that do not occur in the reference bay. The main test of oil effects, the period x bay interaction effect, was not significant in any univariate or multivariate analysis at either depth with either the 3 bay/5 period or the 4 bay/4 period approach (Tables 15 and 16). Thus, effects of oil or dispersed oil on community composition or on dominant species assemblages were not evident in comparisons of data collected 1 year and 2-4 weeks before the oil releases and 2-4 weeks and 1 year after the oil releases. This absence of detectable community effects is a reason to be cautious about the interpretation of the significant period x bay interaction effects for a small proportion of the simple biomass and density variables (Tables 6 and 7).

The graphical representations of these interaction terms on Figures 10 and 11 show that the relative locations of periods within bays are quite similar among bays, and that the relative locations of bays within periods are similar among periods.

3.1.9 Trophic Relationships

The infaunal animals (excluding gastropods) collected by the airlift sampler were classified into feeding guilds based on data available in the literature (Table 17). The feeding modes follow those described by Fauchald and Jumars (1979).

Table 17. Feeding mode of benthic infaunal animals (excluding gastropods) from Cape Hatt, northern Baffin Island.

	Polychaetes	Bivalves	Others
Carnivores	Phyllodocidae Polynoidae Sigalionidae Hesionidae Syllidae Glyceridae Nephtyidae Lumbrineridae		Nemertea Priapulida Asteroidea
Deposit Feeders	Orbiniidae Capitellidae Maldanidae Opheliidae Scalibregmidae Nereidae Pectinaridae		Sipuncula Holothuroidea
Surface Deposit Feeders	Paraonidae Spionidae Cirratulidae Sphaerodoridae Oweniidae Flabelligeridae Ampharetidae Terebellidae Trichobranchidae	Nuculidae Nuculanidae Tellinidae	Echiura Ophiuroidea Echinoidea
Filter Feeders	Sabellidae Spirorbidae	Mytilidae Thyasiridae Astartidae Cardiidae Myidae Hiatellidae Lyonsiidae Thraciidae	Acidiacea

References for feeding type: Ockelmann 1958; Reid and Reid 1969; Himmelman and Steele 1971; Barnes 1974; Ansell and Parulekar 1978; Mohlenberg and Riisgard 1978; Fauchald and Jumars 1979.

Filter feeders extract particulate material from the water. Sabellid polychaetes feed externally using a brachial 'fan' whereas bivalves pump water through their mantle cavity and remove particulate material with their gills. Mya truncata burrows deeply in the sediment and extends a siphon to the surface. Mussels (Musculus sp.) are usually attached to rocks or algae and filter material from water entering through a gape in their shell. Many benthic filter feeders ingest material of benthic rather than pelagic origin (Marshall 1970).

Some deposit feeders ingest sand or mud directly from the substrate. These include tube-dwellers (maldanid polychaetes) and polychaetes that burrow through the mud such as Capitella capitata (Fauchald and Jumars 1979). Deposit feeders derive their nutrition from bacteria associated with the organic matter and detritus found in the sediments. The deposit feeders listed in Table 17 generally feed at some depth below the surface of the sediment. The activity of these animals is especially important in reworking the surface layers of the sediment (e.g. Cadée 1979).

Surface deposit feeders feed at the sediment-water interface. Their food includes benthic microalgae and bacteria. Most of the polychaetes included in this group (Table 17) feed by means of tentacles (Fauchald and Jumars 1979). The bivalve Nuculana minuta extends a pair of tentacles or proboscides over the surface of the sediment (Ansell and Parulekar 1978), and the bivalve Macoma calcarea draws in fine particulate material from the sediment surface with the inhalant siphon (Reid and Reid 1969).

The carnivores listed in Table 17 are all motile predators.

An animal's mode of feeding may determine its degree of exposure to oil. A short exposure to dispersed oil may not affect filter feeders as they may stop feeding temporarily. The resultant oil-containing flocs that accumulate on the surface of the sediment may, however, seriously affect surface deposit feeders. In active benthic environments, wave action and sediment transport may incorporate undispersed oil into the sediment and seriously affect burrowing deposit feeders.

During all five sampling periods and in all four bays, filter feeding was the dominant feeding mode at both depths (57.2 to 93.2% of infaunal biomass, depending on depth, bay and period; Table 18). Surface deposit feeding was the second most common mode of feeding at 7 m depth (5.5 to 25.3% of infaunal biomass) and the least common at 3 m depth (0.5 to 7.1%). The latter may be a result of greater instability of the sediment surface in shallow water due to wave action.

Deposit feeders and carnivores comprised similar and intermediate percentages of infaunal biomass at 3 m depth (1.7 to 25.3%); at 7 m depth these two feeding guilds were again of similar importance, but were the least common in this case (Table 18).

Results of analysis of variance for the 3 bay/5 period and 4 bay/4 period approaches are given in Table 19. Among-transect within-bay variability was greater at 3 m depth than at 7 m depth in both types of analysis. Transect effects were highly significant ($P<0.001$) for all feeding modes at 3 m depth in both analysis types. At 7 m depth, variation among transects was significant only for filter feeders and only in the 4 bay/4 period analysis.

Table 18. Percent contribution to total infaunal biomass[1] by major feeding mode in four bays[2] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[3].

	Period	3 m depth				7 m depth			
		Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Carnivores	Pre-spill 1	-	3.21	3.98	10.62	-	1.77	1.50	0.93
	Pre-spill 2	10.47	2.19	3.14	13.42	2.05	1.67	10.64	2.08
	Post-spill 1	6.38	1.70	4.34	25.25	3.98	1.26	1.22	0.69
	Post-spill 2	7.99	1.69	3.24	13.99	2.54	1.89	0.60	2.37
	Post-spill 3	10.50	2.47	2.82	18.67	5.08	1.99	9.65	1.25
Filter feeders	Pre-spill 1	-	88.92	86.03	67.50	-	90.94	89.58	88.98
	Pre-spill 2	77.20	89.06	88.23	72.26	69.91	77.55	77.15	89.08
	Post-spill 1	84.43	91.52	85.89	57.21	74.18	85.05	86.91	91.34
	Post-spill 2	81.51	93.16	85.92	75.33	76.49	84.09	85.85	89.51
	Post-spill 3	78.83	91.47	90.72	61.66	74.39	85.24	79.58	90.57
Deposit feeders	Pre-spill 1	-	4.38	6.64	17.76	-	1.80	2.41	2.40
	Pre-spill 2	9.20	4.30	4.87	13.86	2.78	6.62	2.88	2.25
	Post-spill 1	4.73	3.12	4.56	13.55	2.85	2.12	2.48	2.06
	Post-spill 2	7.11	2.86	3.79	9.61	2.44	1.72	2.12	2.23
	Post-spill 3	6.76	2.73	3.09	12.83	3.25	2.15	2.39	1.93
Surface deposit feeders	Pre-spill 1	-	3.49	3.36	4.12	-	5.49	6.51	7.70
	Pre-spill 2	3.12	4.45	3.75	0.46	25.26	14.17	9.33	6.59
	Post-spill 1	4.45	3.67	5.21	3.99	18.98	11.56	9.39	5.91
	Post-spill 2	3.39	2.28	7.05	1.08	18.53	12.30	11.43	5.89
	Post-spill 3	3.91	3.34	3.37	6.84	17.29	10.62	8.38	6.25

[1] Does not include gastropods or other animals that were not classified into feeding guilds.
[2] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[3] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

Table 19. Three-factor analyses of variance for biomass of animals according to feeding mode in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P<0.05; ** P<0.01, *** P<0.001).

Analysis[3]	Depth	Feeding mode/df[4]	Source of Variation				
			Period	Bay	Period x Bay[5]	Transect (Bay)	Per x Trans (Bay)
3 bay/5 period	3 m	Carnivores	1.02 ns	1.84 ns	1.19 ns	6.12 ***	1.43 ns
		Filter feeders	0.48 ns	82.91 ***	0.57 ns	9.00 ***	0.94 ns
		Deposit feeders	0.36 ns	11.20 **	0.13 ns	5.75 ***	1.60 *
		Surface-deposit feeders	0.36 ns	37.39 ***	0.39 ns	15.20 ***	1.07 ns
	7 m	Carnivores	2.06 ns	3.54 *	0.81 ns	0.43 ns	1.01 ns
		Filter feeders	3.64 *	5.90 **	1.09 ns	1.79 ns	1.20 ns
		Deposit feeders	2.08 ns	0.92 ns	0.51 ns	2.07 ns	0.99 ns
		Surface-deposit feeders	0.76 ns	23.24 ***	0.46 ns	1.84 ns	1.54 ns
		Degrees of freedom[4]	4,6 or 30	2,6 or 30	8,6 or 30	6,313	24,313
4 bay/4 period	3 m	Carnivores	0.51 ns	0.35 ns	0.31 ns	5.36 ***	1.77 *
		Filter feeders	0.49 ns	42.47 ***	0.23 ns	7.44 ***	0.83 ns
		Deposit feeders	0.40 ns	10.88 **	0.31 ns	3.48 ***	1.77 *
		Surface-deposit feeders	0.96 ns	27.49 ***	0.35 ns	8.27 ***	0.90 ns
	7 m	Carnivores	1.24 ns	2.65 ns	0.92 ns	1.85 ns	1.14 ns
		Filter feeders	0.66 ns	5.15 **	0.57 ns	3.38 ***	0.92 ns
		Deposit feeders	1.51 ns	0.96 ns	1.11 ns	1.43 ns	0.74 ns
		Surface-deposit feeders	0.60 ns	21.43 ***	0.16 ns	1.72 ns	1.78 *
		Degrees of freedom[4]	3,8 or 32	3,8 or 32	9,8 or 32	8,334	24,334

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
3 3 bay/5 period analysis excludes Bay 7; 4 bay/4 period analysis excludes Pre-spill Period.
4 Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.
5 The Period x Bay term is the test of oil effects.

Among-bay variability, like among-transect variability, was greater at 3 m than at 7 m depth. In both types of analysis, bay effects at 3 m depth were significant for all feeding modes except carnivores (Table 19). Bay 9 (dispersed oil release) supported the highest biomass of filter feeders, deposit feeders and surface deposit feeders, and all three feeding guilds were least abundant in Bay 11 (surface oil release). At 7 m depth, bay differences were significant for filter feeders and surface deposit feeders in both analysis types, and for carnivores only in the analysis that excludes Bay 7 (reference). Biomass of filter feeders was similar in Bays 9, 10 and 11 and lowest in Bay 7, whereas surface deposit feeders showed a trend (4 of 5 periods) towards decreasing biomass from Bay 7 to 11 (Table 20). The biomass of carnivores was low and similar among bays; two unusually large values (140.7 g/m^2 and 136.8 g/m^2; Table 20) in Bay 10 resulted from the presence of a relatively large starfish in one sample from each period.

Variation among periods was significant in only one of eight cases (Table 19). Mean biomass of filter feeders in each bay was higher in September 1980 (Pre-spill Period 1) than in any of the following periods (Table 20).

Interaction effects were not significant for any feeding guild at either depth. The absence of any period x bay interaction indicates that no effects of oil or dispersed oil were detectable. Most of the variation in the four infaunal feeding guilds examined was spatial. This spatial variability was evident on both small (transect) and relatively large (bay) scales, and in all four feeding guilds. There was no evidence of any oil-related change.

Table 20. Mean biomass (g/m^2) of infaunal animals[1] according to major feeding mode in four bays[2] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[3]. Data are expressed as mean ± standard deviation and are based on 8 replicate 0.0625 m^2 airlift samples on each of three transects for each depth, period and bay.

		3 m depth				7 m depth			
	Period	Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Carnivores	Pre-spill 1	-	18.9 ± 17.2	11.9 ± 8.9	8.5 ± 6.9	-	50.8 ± 178.2	23.8 ± 58.2	14.5 ± 30.5
	Pre-spill 2	18.6 ± 38.5	14.5 ± 13.0	10.4 ± 7.3	11.0 ± 6.3	20.8 ± 45.2	25.9 ± 38.8	140.7 ± 385.9	28.5 ± 68.9
	Post-spill 1	14.4 ± 12.9	14.8 ± 10.9	20.4 ± 20.0	20.5 ± 19.7	52.2 ± 78.5	16.5 ± 25.5	14.4 ± 24.5	8.3 ± 10.9
	Post-spill 2	20.6 ± 45.4	15.6 ± 29.9	15.2 ± 17.5	12.7 ± 8.7	32.7 ± 69.2	30.6 ± 50.4	7.7 ± 6.5	29.4 ± 48.1
	Post-spill 3	22.6 ± 48.9	23.8 ± 21.9	11.3 ± 22.3	13.3 ± 22.4	74.7 ± 149.1	39.8 ± 68.5	136.8 ± 553.5	18.0 ± 30.9
Filter feeders	Pre-spill 1	-	523.4 ± 390.7	257.0 ± 205.5	54.0 ± 80.7	-	2614.5 ± 1111.2	1417.8 ± 770.5	1386.5 ± 811.3
	Pre-spill 2	137.3 ± 158.6	587.1 ± 447.7	292.3 ± 253.2	59.2 ± 133.2	708.3 ± 593.3	1201.3 ± 807.6	1020.1 ± 640.6	1224.4 ± 757.5
	Post-spill 1	190.5 ± 187.7	797.5 ± 663.4	403.2 ± 356.4	46.5 ± 85.2	972.4 ± 583.6	1109.2 ± 562.3	1032.9 ± 569.3	1103.6 ± 725.9
	Post-spill 2	210.1 ± 236.7	859.0 ± 603.5	403.8 ± 426.3	68.6 ± 95.5	986.7 ± 962.6	1362.8 ± 761.7	1099.5 ± 896.2	1106.5 ± 511.2
	Post-spill 3	169.5 ± 187.0	882.6 ± 661.7	363.6 ± 308.8	43.8 ± 71.7	1094.1 ± 968.6	1708.1 ± 983.0	1128.7 ± 882.7	1300.3 ± 820.5
Deposit feeders	Pre-spill 1	-	25.8 ± 12.2	19.8 ± 18.2	14.2 ± 14.8	-	51.8 ± 88.0	38.1 ± 27.9	37.3 ± 23.4
	Pre-spill 2	16.4 ± 22.7	28.4 ± 16.8	16.1 ± 13.4	11.3 ± 10.9	28.1 ± 33.7	102.5 ± 321.3	38.1 ± 41.9	31.0 ± 30.3
	Post-spill 1	10.7 ± 8.6	27.2 ± 15.8	21.4 ± 9.8	11.0 ± 9.9	37.4 ± 34.1	27.7 ± 16.5	29.5 ± 23.6	24.9 ± 14.9
	Post-spill 2	18.3 ± 30.9	26.4 ± 14.7	17.8 ± 18.5	8.8 ± 7.6	31.4 ± 34.9	27.9 ± 27.7	27.2 ± 14.3	27.6 ± 20.1
	Post-spill 3	14.5 ± 24.5	26.3 ± 15.7	12.4 ± 9.0	9.1 ± 8.4	47.8 ± 63.5	43.1 ± 36.6	33.9 ± 36.0	27.7 ± 17.3
Surface deposit feeders	Pre-spill 1	-	20.5 ± 24.0	10.0 ± 8.6	3.3 ± 7.5	-	157.9 ± 104.7	103.0 ± 44.0	119.9 ± 126.7
	Pre-spill 2	5.6 ± 9.5	29.3 ± 30.4	12.4 ± 23.5	0.4 ± 0.8	255.9 ± 180.3	219.5 ± 198.0	123.3 ± 84.4	90.6 ± 95.7
	Post-spill 1	10.0 ± 16.3	32.0 ± 33.9	24.5 ± 83.5	3.2 ± 8.3	248.9 ± 194.7	150.8 ± 121.9	111.6 ± 85.8	71.4 ± 38.5
	Post-spill 2	8.7 ± 13.0	21.1 ± 19.9	33.1 ± 74.3	1.0 ± 1.7	239.1 ± 159.5	199.3 ± 124.3	146.3 ± 98.6	72.7 ± 45.6
	Post-spill 3	8.4 ± 10.3	32.2 ± 29.0	13.5 ± 19.3	4.9 ± 12.0	254.2 ± 177.0	212.8 ± 254.6	118.8 ± 64.8	89.7 ± 49.7
Total	Pre-spill 1	-	588.6 ± 409.4	298.7 ± 219.6	79.9 ± 96.2	-	2875.0 ± 1166.7	1582.7 ± 766.3	1558.2 ± 839.7
	Pre-spill 2	177.8 ± 180.6	659.3 ± 473.2	331.3 ± 269.1	81.9 ± 133.6	1013.1 ± 649.4	1549.2 ± 1040.6	1322.3 ± 694.0	1374.5 ± 778.0
	Post-spill 1	225.6 ± 200.7	871.4 ± 682.1	469.5 ± 348.1	81.2 ± 93.7	1311.0 ± 619.1	1304.2 ± 641.4	1188.4 ± 597.6	1208.3 ± 743.0
	Post-spill 2	257.7 ± 272.1	922.0 ± 615.3	470.0 ± 472.2	91.1 ± 97.6	1289.9 ± 1004.7	1620.6 ± 815.9	1280.7 ± 901.7	1236.2 ± 515.5
	Post-spill 3	215.1 ± 211.1	964.9 ± 671.6	400.8 ± 324.7	71.1 ± 90.4	1470.9 ± 1002.4	2003.9 ± 925.0	1418.2 ± 951.0	1435.7 ± 839.9

[1] Does not include gastropods or other animals that were not classified into feeding guilds.
[2] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[3] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

3.2 Epibenthos

For the purposes of the present study, the term 'epibenthos' refers to motile members of the benthic community. We include those animals capable of rapid movement through the lower part of the water column (e.g. crustaceans). We also include those that move relatively slowly on the sediment surface, but are capable of covering relatively large distances because of their size (e.g. urchins, starfish). As previously mentioned, the purpose of this definition is to facilitate the interpretation of any changes in faunal densities in the study bays after oiling. In the cases of the above animals, it will not be possible to distinguish with certainty the relative roles of mortality and emigration in determining any changes in densities. Hence relatively little effort is directed to the analysis of the distributions of epibenthic animals. A further justification for the inclusion of urchins and starfish in this section is the fact that sampling methods applied to these large and sparsely distributed animals were different and less intensive than those applied to the infauna.

3.2.1 Crustaceans

The available data on highly motile epibenthic crustaceans at Cape Hatt are from the same airlift samples upon which infaunal results are based. Estimates for epibenthic crustaceans likely are not as accurate as those for infauna, however, due both to escape of organisms from the area sampled and to inclusion of those inadvertently drawn into the airlift from outside the 0.0625 m^2 sampling area. A modification to the sampler, developed for EAMES studies to overcome this shortcoming (see Thomson and Cross 1980), was not practical in the present study because of difficulties in operating the airlift in the mixed sediment-rock substrate. No quantitative estimates are available for the extent to which epibenthic crustaceans were over- or underestimated in the present study.

Epibenthic crustaceans collected in airlift samples consisted entirely of ostracods (56.3-69.3% of numbers, depending on period), amphipods (22.4-35.0%) and cumaceans (7.2-9.6%). Ostracods, five species of amphipods, and two species of cumaceans accounted for 83.4 to 88.4% of total numbers, and 75.6 to 84.0% of total biomass, depending on period (Table 21). All of these species are common in nearshore high arctic waters (Sekerak et al. 1976; Buchanan et al. 1977; Thomson and Cross 1980).

Among-transect within-bay variability was greater at 3 m than at 7 m depth. In shallow water, variation among transects was highly significant ($P \leq 0.001$) for seven of nine crustaceans in both analysis types (Tables 22 and 23). Transect variability was considerably lower in the amphipod family Calliopiidae and genus _Anonyx_; in both taxa, transect differences were non-significant (4 bay/4 period analysis) or marginally significant (3 bay/5 period analysis). At 7 m depth, results of the two analysis types were again consistent. The densities of five of eight taxa varied significantly among transects, whereas the cumacean _Lamprops fuscata_ and amphipods of the genera _Guernea_ and _Monoculodes_ were evenly distributed among transects (Tables 22 and 23).

Differences among bays at 3 m depth were significant for six of nine crustaceans, non-significant in the amphipod family Lysianassidae, and not

Table 21. Percent contribution of dominant crustaceans to total epibenthic biomass and density in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Based on 908 airlift samples, each covering 0.0625 m^2, from 3 and 7 m depths.

Taxon	% of total density					% of total biomass (wet weight)				
	Pre-spill 1	Pre-spill 2	Post-spill 1	Post-spill 2	Post-spill 3	Pre-spill 1	Pre-spill 2	Post-spill 1	Post-spill 2	Post-spill 3
Ostracoda (Myodocopa)	54.85	69.13	64.69	56.11	62.36	27.64	36.93	30.64	33.75	26.18
Anonyx nugax (A)	7.43	0.62	1.15	0.22	1.39	47.14	26.15	30.19	6.79	37.97
Guernea sp. (A)	7.00	7.79	8.48	7.65	7.66	0.71	1.43	1.26	1.50	1.01
Lamprops fuscata (C)	6.66	4.92	4.66	4.99	3.67	0.86	1.33	1.32	1.91	1.00
Paroediceros lynceus (A)	2.49	0.85	0.89	0.93	1.19	3.04	3.23	3.66	5.88	4.07
Orchomene minuta (A)	0.67	1.68	1.10	2.92	0.80	0.68	2.05	1.26	26.79	0.73
Pontoporeia femorata (A)	1.50	2.25	2.50	2.31	3.56	1.54	5.88	6.55	6.66	6.93
Ostracoda (Podocopa)	1.44	0.12	1.93	0.60	0.56	0.11	0.05	0.32	0.16	0.11
Brachydiastylis resima (C)	1.31	1.08	0.93	0.83	0.86	0.29	0.50	0.38	0.57	0.49
Total	83.35	88.44	86.33	86.56	82.05	82.01	77.55	75.58	84.01	78.49
Total epibenthos (no./m^2 or g/m^2)	1152.1	1200.7	1342.3	2000.0	1901.1	7.2	4.0	4.7	5.6	7.3

(A) = amphipod, (C) = cumacean.

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982.)

Table 22. Three-factor analyses of variance for the densities of epibenthic Crustacea in three bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = $P>0.05$; * $P\leq0.05$; ** $P\leq0.01$, *** $P\leq0.001$).

		Source of Variation and df[3]				
Depth	Taxon	Period 4,6 or 30	Bay 2,6 or 30	Period x Bay[4] 8,6 or 30	Transect (Bay) 6,313	Per x Trans (Bay) 24,313
3 m	Oedicerotidae spp.[6]	1.00 ns	17.27 ***	1.12 ns	9.44 ***	1.33 ns
	Lysianassidae spp.[6]	1.33 ns	0.77 ns	0.28 ns	7.50 ***	1.64 *
	Calliopiidae spp.[6]	–[5]	–[5]	2.54 *	2.46 *	1.35 ns
	Paroediceros lynceus	0.48 ns	10.51 ***	0.34 ns	13.45 ***	0.98 ns
	Orchomene minuta	0.75 ns	4.81 *	1.04 ns	8.77 ***	1.40 ns
	Protomedia fasciata	0.49 ns	6.71 **	0.98 ns	8.33 ***	1.15 ns
	Guernea sp.	0.57 ns	14.62 **	0.39 ns	8.67 ***	1.83 *
	Anonyx spp.[6]	–[5]	–[5]	3.22 **	2.79 *	1.25 ns
	Lamprops fuscata	1.45 ns	9.58 ***	0.71 ns	14.56 ***	0.81 ns
7 m	Oedicerotidae spp.[6]	4.14 **	15.20 ***	1.72 ns	3.21 **	1.23 ns
	Lysianassidae spp.[6]	4.96 *	8.19 *	0.91 ns	2.50 *	1.70 *
	Anonyx spp.[6]	9.92 **	3.13 ns	1.54 ns	2.47 *	2.23 ***
	Monoculodes spp.[6]	0.74 ns	30.63 ***	2.19 ns	1.70 ns	0.69 ns
	Guernea sp.	13.14 ***	0.42 ns	1.23 ns	1.99 ns	1.04 ns
	Pontoporeia femorata	0.84 ns	1.68 ns	0.19 ns	15.19 ***	1.61 *
	Lamprops fuscata	3.19 *	5.60 **	1.35 ns	1.26 ns	1.03 ns
	Myodocopa spp.	1.04 ns	1.57 ns	0.23 ns	8.33 ***	1.57 *

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

3 Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant ($P\leq0.05$), Transect (Bay) alone was used to test main effects.

4 The Period x Bay term is the test of oil effects.

5 Interpretation of main effects confounded by significant interaction of Period x Bay term.

6 Oedicerotidae includes *Bathymedon*, *Monoculodes*, *Monoculopsis*, *Paroediceros* and *Westwoodilla*; Lysianassidae includes *Anonyx*, *Boeckosimus*, *Onisimus*, *Opisa*, *Orchomene*, *Centromedon* and *Tmetonyx*; Calliopiidae includes *Apherusa*. Genera indicated include species listed in Appendix B.

Table 23. Three-factor analyses of variance for the densities of epibenthic Crustacea in four bays[1] at Cape Hatt, northern Baffin Island, during August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01, *** P≤0.001).

Depth	Taxon	Source of Variation and df[3]				
		Period 3,8 or 32	Bay 3,8 or 32	Period x Bay[4] 9,8 or 32	Transect (Bay) 8,334	Per x Trans (Bay) 24,334
3 m	Oedicerotidae spp.[6]	1.34 ns	6.95 *	0.47 ns	4.69 ***	1.58 *
	Lysianassidae spp.[6]	6.86 **	2.54 ns	0.69 ns	4.07 ***	1.24 ns
	Calliopiidae spp.[6]	–[5]	–[5]	2.41 *	1.70 ns	1.11 ns
	Paroediceros lynceus	1.19 ns	9.41 ***	0.35 ns	7.50 ***	1.14 ns
	Orchomene minuta	1.31 ns	3.94 *	0.69 ns	6.52 ***	1.48 ns
	Protomedia fasciata	0.41 ns	11.58 ***	0.59 ns	7.90 ***	1.00 ns
	Guernea sp.	0.97 ns	10.69 **	0.43 ns	7.18 ***	1.64 *
	Anonyx spp.[6]	–[5]	–[5]	4.59 ***	1.52 ns	1.10 ns
	Lamprops fuscata	1.09 ns	7.91 ***	0.56 ns	10.43 ***	0.80 ns
7 m	Oedicerotidae spp.[6]	1.82 ns	3.73 *	0.67 ns	2.99 **	1.43 ns
	Lysianassidae spp.[6]	3.87 *	15.45 ***	1.22 ns	3.00 **	1.37 ns
	Anonyx spp.[6]	4.07 *	3.93 ns	1.24 ns	2.85 **	2.05 **
	Monoculodes spp.[6]	0.77 ns	32.31 ***	1.89 ns	1.76 ns	0.83 ns
	Guernea sp.	12.05 ***	5.95 **	1.46 ns	1.20 ns	0.96 ns
	Pontoporeia femorata	1.47 ns	4.89 *	0.20 ns	11.19 ***	1.58 *
	Lamprops fuscata	0.80 ns	3.70 ns	1.65 ns	1.28 ns	0.95 ns
	Myodocopa spp.	2.04 ns	6.33 **	0.48 ns	5.18 ***	1.35 ns

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

2 Pre-spill Period 2 (August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

3 Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P<0.05), Transect (Bay) alone was used to test main effects.

4 The Period x Bay term is the test of oil effects.

5 Interpretation of main effects confounded by significant interaction of Period x Bay term.

6 Oedicerotidae includes *Bathymedon*, *Monoculodes*, *Monoculopsis*, *Paroediceros* and *Westwoodilla*; Lysianassidae includes *Anonyx*, *Boeckosimus*, *Onisimus*, *Opisa*, *Orchomene*, *Centromedon* and *Tmetonyx*; Calliopiidae includes *Apherusa*. Genera indicated include species listed in Appendix B.

interpretable in two taxa because of significant interaction terms (Tables 22 and 23); results of the two analysis types were consistent in all cases. At this depth, Bay 10 (dispersed oil contamination) supported the highest densities of four of six amphipod taxa, whereas the cumacean Lamprops fuscata and the amphipods Guernea sp. and Protomedia fasciata were most abundant in Bay 9 (Table 24; Fig. 12). At 7 m depth, results of the two analysis types were inconsistent. In both types of analysis, bay effects were significant for the amphipod families Oedicerotidae and Lysianassidae and the genus Monoculodes, and non-significant in the genus Anonyx (Tables 22 and 23). Bay differences in Lysianassidae are not clear because of an unusually high mean density (1776.7 no./m2) in Bay 10; one sample contained >2500 individuals of Orchomene minuta. Densities of Oedicerotidae were lower in Bay 9 and similar in the other three bays, and Monoculodes spp. were most abundant in Bays 10 and 11 (Fig. 13). In three of four cases where results of the different analysis types conflicted, the analysis including Bay 7 showed significant bay differences; in these cases densities in Bay 7 were either highest (myodocopid ostracods and the amphipod Pontoporeia femorata) or lowest (Guernea sp.). The density of the cumacean Lamprops fuscata was highest and similar in Bays 9 and 11, and similar in the other two bays.

Variation among periods was greater at 7 m depth than at 3 m depth (Tables 22 and 23). At 3 m depth, period effects were significant in only 1 of 14 tests where main effects were not confounded by significant interaction. The amphipod family Lysianassidae generally increased from 1981 to 1982. At 7 m depth, period variability in both analysis types was significant for Lysianassidae, Anonyx spp. and Guernea spp., and non-significant for Monoculodes spp., Pontoporeia femorata and ostracods.

Table 24. Mean density (no./m^2) of major taxa and dominant species of epibenthic crustaceans in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Data are expressed as mean ± standard deviation and are based on 8 replicate 0.0625 m^2 airlift samples on each of three transects for each depth, period and bay.

		3 m depth				7 m depth			
	Period	Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Ostracoda	Pre-spill 1	-	42.7 ± 46.1	44.7 ± 101.6	9.3 ± 14.1	-	966.0 ± 735.5	1728.7 ± 848.7	1113.3 ± 723.6
	Pre-spill 2	9.3 ± 19.4	28.7 ± 49.5	12.5 ± 15.2	2.7 ± 7.7	2046.7 ± 988.5	1720.7 ± 733.1	1543.7 ± 620.3	284.0 ± 974.4
	Post-spill 1	10.0 ± 15.5	223.3 ± 500.8	15.3 ± 30.0	10.6 ± 26.1	2236.7 ± 675.5	1819.3 ± 1208.9	1775.5 ± 782.6	1074.7 ± 883.8
	Post-spill 2	16.7 ± 26.5	90.7 ± 103.1	35.0 ± 52.2	8.7 ± 42.5	2673.9 ± 1137.4	2252.0 ± 925.8	2268.7 ± 1399.4	1727.7 ± 1285.8
	Post-spill 3	24.0 ± 25.8	94.0 ± 121.7	32.7 ± 41.5	11.3 ± 16.7	2912.0 ± 1448.7	2622.0 ± 1293.8	2251.1 ± 1064.5	1622.0 ± 967.4
Amphipoda	Pre-spill 1	-	222.7 ± 141.5	344.0 ± 268.6	286.0 ± 180.7	-	269.3 ± 244.7	642.0 ± 366.8	583.3 ± 296.9
	Pre-spill 2	171.3 ± 108.4	246.0 ± 361.0	252.9 ± 255.8	216.8 ± 274.4	341.3 ± 213.2	289.3 ± 156.8	258.1 ± 97.7	376.7 ± 239.5
	Post-spill 1	218.7 ± 162.9	463.3 ± 447.8	292.0 ± 295.5	277.0 ± 336.9	334.7 ± 157.4	251.3 ± 106.5	389.7 ± 181.6	462.3 ± 243.6
	Post-spill 2	313.4 ± 227.7	319.3 ± 252.8	574.4 ± 367.0	356.5 ± 387.5	421.7 ± 231.7	534.7 ± 819.9	2496.3 ± 9465.1	587.6 ± 208.3
	Post-spill 3	490.0 ± 357.5	356.0 ± 156.6	722.2 ± 542.5	385.2 ± 224.6	532.0 ± 242.3	457.3 ± 178.6	747.7 ± 418.1	853.3 ± 570.5
Anonyx nugax	Pre-spill 1	-	4.0 ± 8.5	12.7 ± 39.7	24.0 ± 84.3	-	86.0 ± 221.3	296.7 ± 308.6	90.0 ± 81.3
	Pre-spill 2	2.0 ± 5.4	2.0 ± 7.2	0	3.3 ± 10.5	3.3 ± 8.1	20.7 ± 46.8	8.3 ± 12.6	19.3 ± 26.3
	Post-spill 1	10.7 ± 17.4	2.7 ± 6.1	0.7 ± 3.3	0.7 ± 3.3	30.0 ± 62.6	6.7 ± 10.5	32.0 ± 33.4	41.4 ± 40.6
	Post-spill 2	0	0	0.7 ± 3.3	0.7 ± 3.3	2.7 ± 7.7	8.0 ± 14.9	18.0 ± 59.0	5.3 ± 10.2
	Post-spill 3	2.7 ± 6.1	1.3 ± 4.5	8.7 ± 18.9	2.0 ± 5.4	10.0 ± 24.9	50.7 ± 68.3	94.7 ± 123.0	42.0 ± 44.2
Guernea sp.	Pre-spill 1	-	72.0 ± 63.8	41.3 ± 63.3	14.0 ± 25.5	-	91.3 ± 64.6	112.7 ± 78.9	152.0 ± 97.0
	Pre-spill 2	12.7 ± 17.0	96.7 ± 122.4	47.9 ± 33.6	10.7 ± 18.7	117.3 ± 48.7	172.7 ± 110.0	119.7 ± 70.2	169.3 ± 147.5
	Post-spill 1	36.7 ± 47.8	206.0 ± 143.4	76.7 ± 81.7	12.5 ± 15.2	95.3 ± 67.5	148.0 ± 76.8	187.3 ± 109.2	145.3 ± 87.0
	Post-spill 2	34.7 ± 35.2	116.7 ± 79.7	88.6 ± 100.2	24.7 ± 39.2	139.4 ± 86.5	250.0 ± 145.4	285.0 ± 214.5	285.2 ± 170.1
	Post-spill 3	32.7 ± 64.8	138.0 ± 56.0	35.8 ± 54.2	10.0 ± 19.2	179.3 ± 122.2	253.3 ± 108.1	255.0 ± 132.0	260.7 ± 125.2
Orchomene minuta	Pre-spill 1	-	5.3 ± 9.0	20.7 ± 49.4	8.7 ± 10.5	-	2.7 ± 7.7	4.0 ± 10.8	4.7 ± 10.0
	Pre-spill 2	17.3 ± 29.4	29.3 ± 44.2	70.7 ± 219.2	5.3 ± 19.8	4.7 ± 11.0	5.3 ± 10.2	11.1 ± 14.0	19.3 ± 23.6
	Post-spill 1	10.7 ± 25.3	27.3 ± 47.5	50.0 ± 214.6	3.8 ± 6.8	1.3 ± 4.5	3.3 ± 6.6	4.7 ± 12.0	16.3 ± 23.7
	Post-spill 2	16.7 ± 16.0	28.7 ± 65.7	73.3 ± 173.9	15.3 ± 45.6	8.7 ± 13.3	130.7 ± 572.9	1776.7 ± 8476.0	16.7 ± 18.6
	Post-spill 3	16.7 ± 23.3	9.3 ± 15.6	60.7 ± 81.3	12.0 ± 21.7	4.0 ± 11.8	0	4.7 ± 14.5	15.3 ± 26.0
Paroediceros lynceus	Pre-spill 1	-	4.7 ± 11.0	34.0 ± 72.4	11.3 ± 13.7	-	4.7 ± 10.0	41.3 ± 47.2	76.0 ± 92.1
	Pre-spill 2	2.7 ± 6.1	1.3 ± 4.5	18.1 ± 25.7	19.3 ± 35.0	4.7 ± 8.8	3.3 ± 8.1	13.9 ± 12.1	18.7 ± 28.2
	Post-spill 1	3.3 ± 9.4	2.7 ± 7.7	30.0 ± 42.3	13.6 ± 34.2	2.0 ± 7.2	3.3 ± 8.1	9.3 ± 11.5	32.0 ± 32.4
	Post-spill 2	17.3 ± 61.9	0.7 ± 3.3	69.3 ± 115.6	15.3 ± 32.2	2.0 ± 5.4	3.3 ± 6.6	20.0 ± 25.1	20.0 ± 23.7
	Post-spill 3	18.7 ± 52.7	2.0 ± 5.4	59.0 ± 108.0	38.4 ± 54.6	5.3 ± 10.2	8.7 ± 14.9	16.0 ± 21.1	33.3 ± 34.0
Cumacea	Pre-spill 1	-	26.7 ± 36.4	36.7 ± 84.5	10.7 ± 27.8	-	142.0 ± 110.0	136.0 ± 94.8	308.7 ± 162.7
	Pre-spill 2	19.3 ± 30.9	139.3 ± 375.9	20.8 ± 33.0	24.0 ± 46.7	102.7 ± 85.6	122.7 ± 85.3	111.3 ± 93.7	256.0 ± 245.2
	Post-spill 1	35.3 ± 41.7	90.0 ± 93.3	115.3 ± 178.0	11.8 ± 20.0	72.0 ± 78.1	175.3 ± 109.0	134.4 ± 74.1	223.7 ± 164.0
	Post-spill 2	15.3 ± 21.9	190.0 ± 292.3	64.7 ± 112.8	126.1 ± 343.7	144.7 ± 114.8	206.0 ± 181.7	200.7 ± 141.8	375.3 ± 171.9
	Post-spill 3	22.7 ± 62.9	74.0 ± 76.6	58.7 ± 171.4	14.7 ± 23.6	143.3 ± 110.8	152.7 ± 107.4	189.3 ± 143.5	440.7 ± 253.5
Lamprops fuscata	Pre-spill 1	-	24.0 ± 36.2	22.7 ± 62.4	10.7 ± 27.8	-	108.7 ± 98.4	110.0 ± 84.0	184.0 ± 137.5
	Pre-spill 2	18.7 ± 30.8	138.0 ± 376.4	20.8 ± 33.0	22.7 ± 46.4	58.0 ± 62.4	82.7 ± 91.9	39.7 ± 34.7	90.0 ± 88.0
	Post-spill 1	34.0 ± 41.2	87.3 ± 91.1	114.7 ± 176.9	4.2 ± 8.7	24.7 ± 29.5	115.3 ± 75.2	28.7 ± 25.8	90.8 ± 82.3
	Post-spill 2	15.3 ± 21.9	189.3 ± 290.3	64.0 ± 112.0	50.7 ± 102.5	84.0 ± 79.7	146.0 ± 162.2	82.7 ± 93.9	165.3 ± 126.3
	Post-spill 3	21.3 ± 63.1	69.3 ± 73.8	56.0 ± 170.0	11.3 ± 23.8	72.0 ± 51.0	96.7 ± 103.0	89.3 ± 90.5	142.0 ± 102.4

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

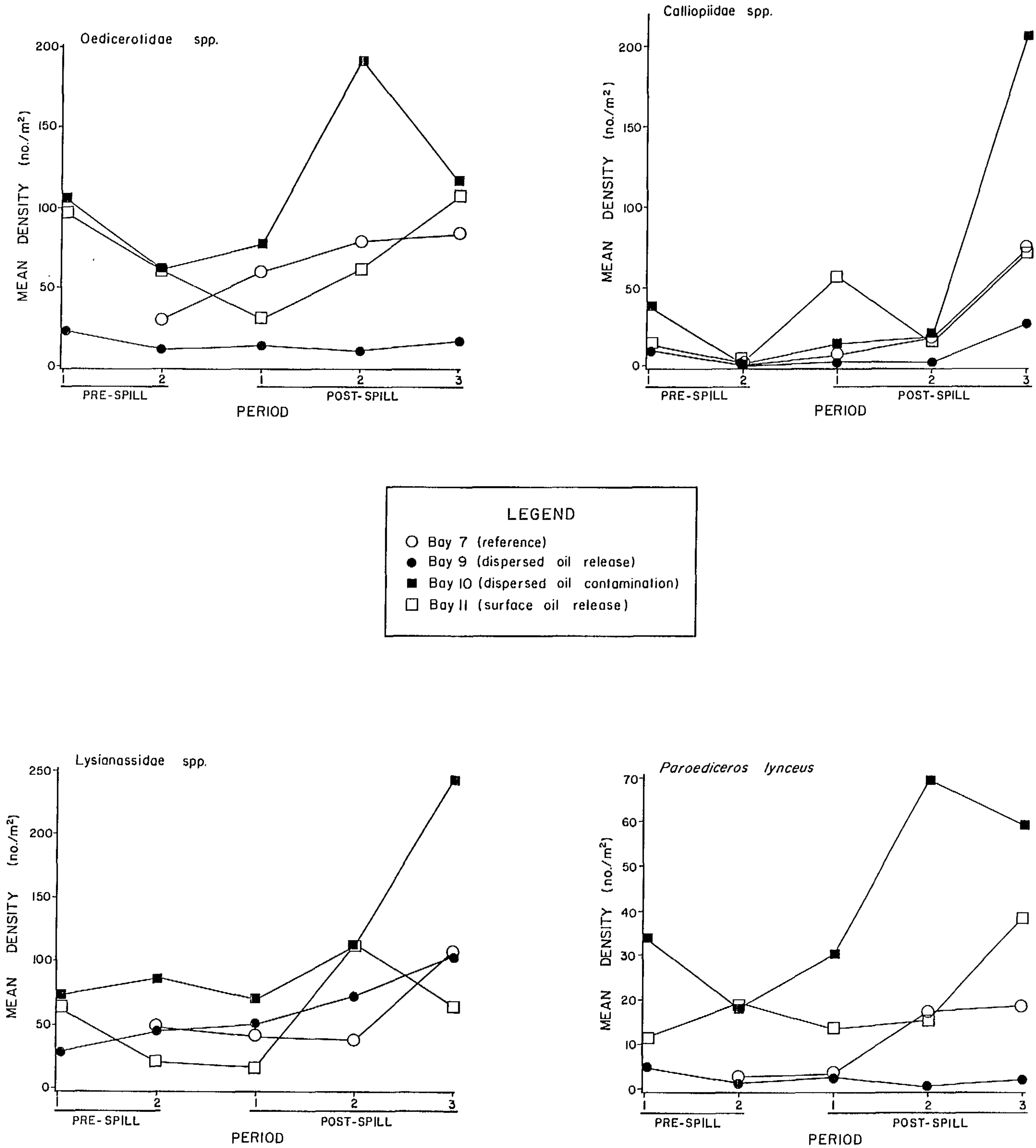
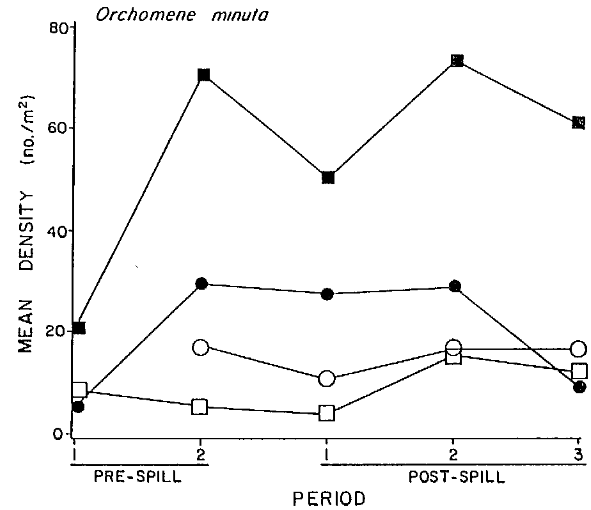
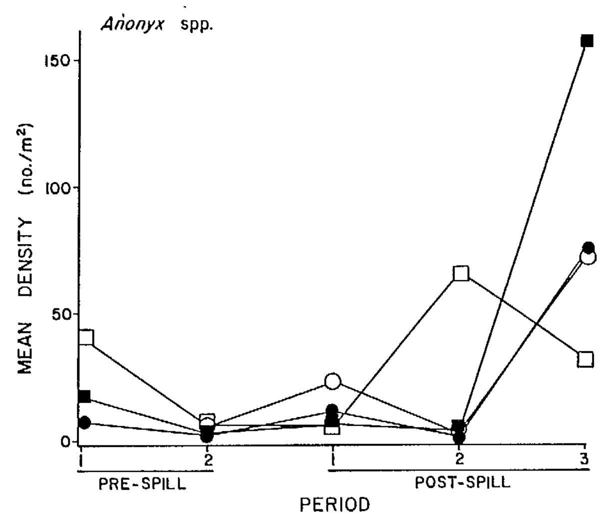
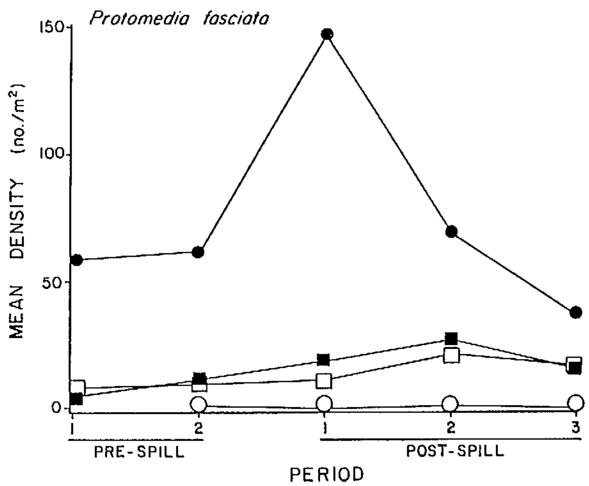
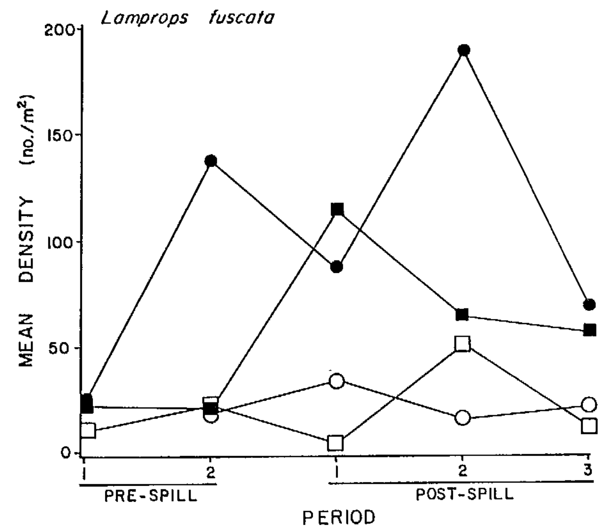


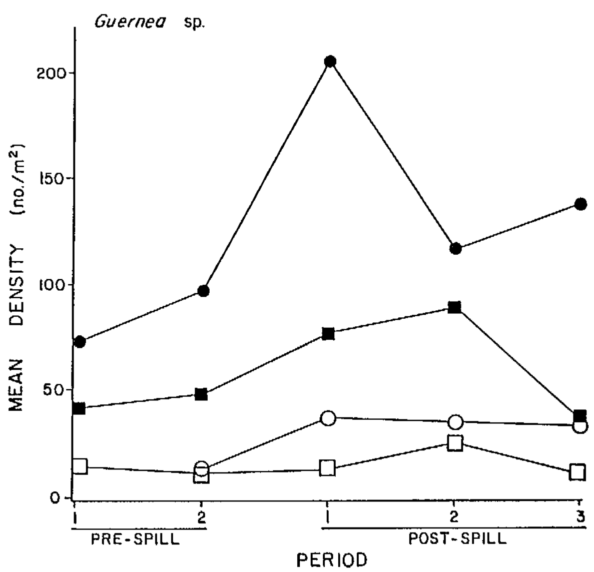
FIGURE 12. Mean density (no./m2) of selected species of crustacea at 3 m depth in four bays at Cape Hatt, northern Baffin Island, during pre-spill sampling in September 1980 and August 1981 and during post-spill sampling in September 1981 and August and September 1982. Data are expressed as the mean of 24 replicate 0.0625 m^2 airlift samples taken in each experimental bay during each sampling period.











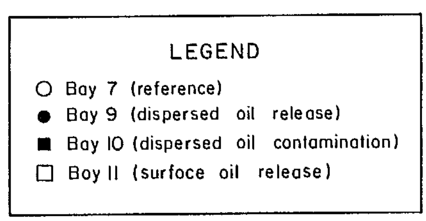


FIGURE 12. Continued

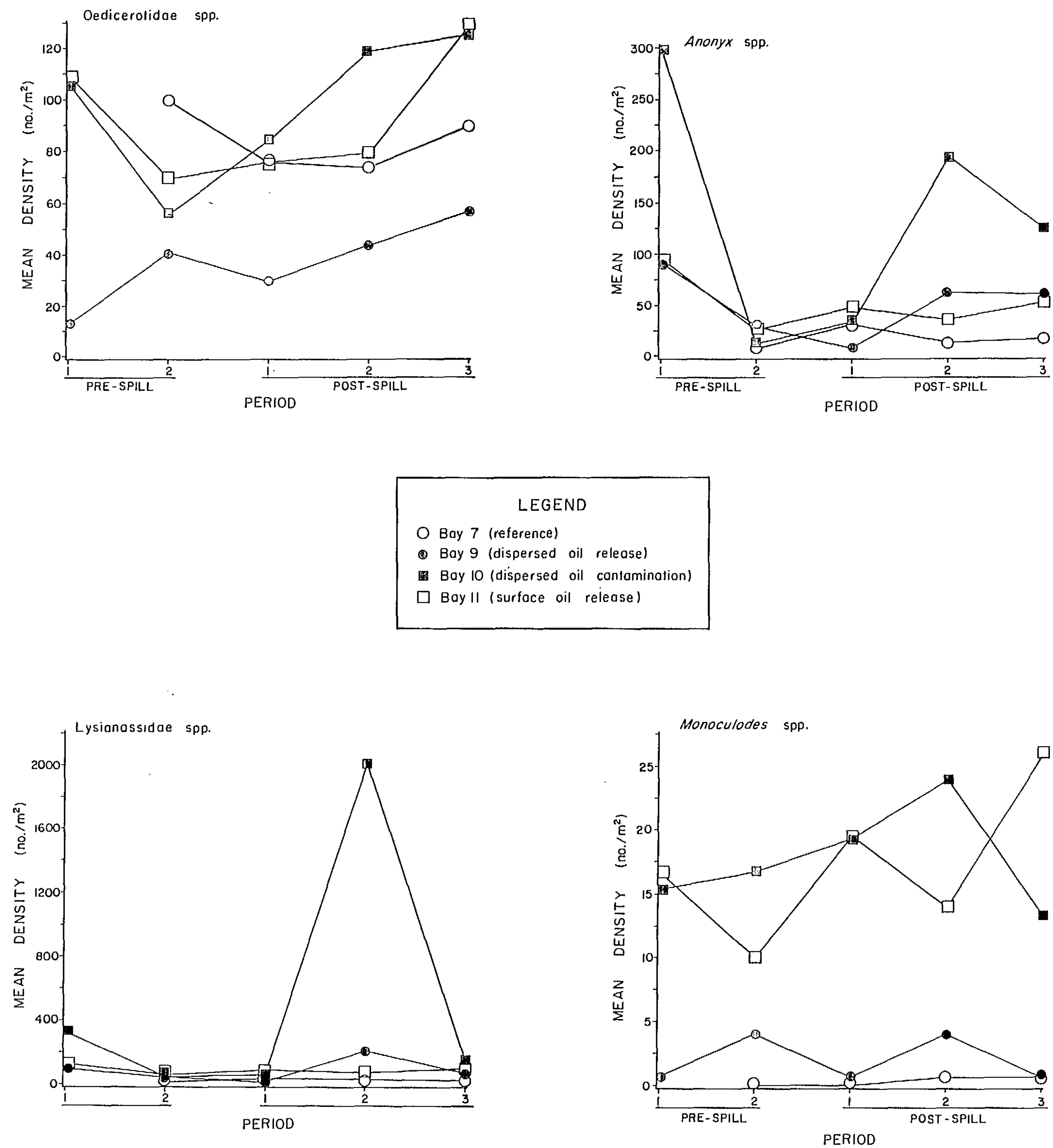


FIGURE 13. Mean density (no./m2) of selected species of crustacea at 7 m depth in four bays at Cape Hatt, northern Baffin Island, during pre-spill sampling in September 1980 and August 1981 and during post-spill sampling in September 1981 and August and September 1982. Data are expressed as the mean of 24 replicate 0.0625 m2 airlift samples taken in each experimental bay during each sampling period.

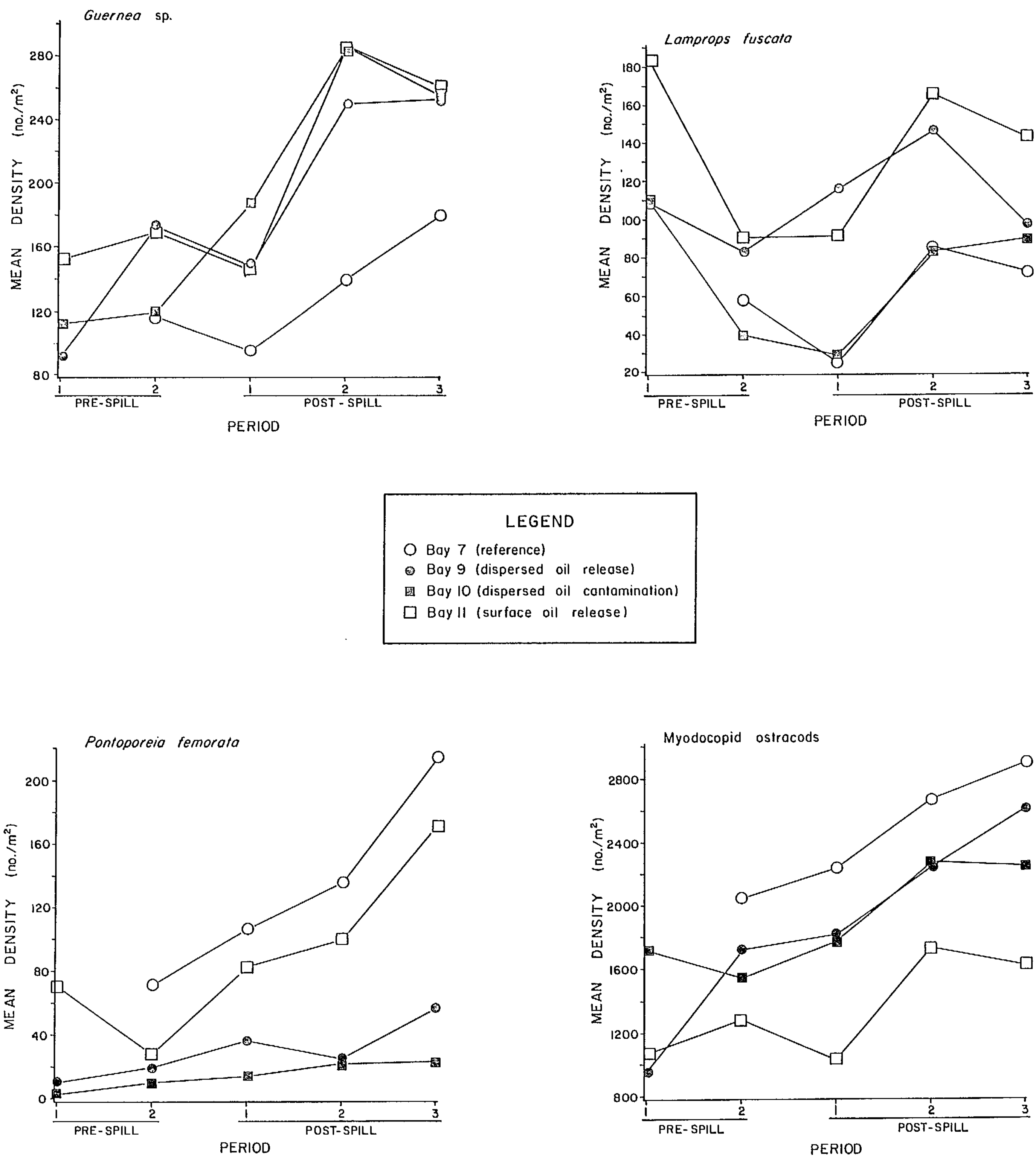


FIGURE 13. Continued

Densities of Anonyx spp. were highest in September 1980 (Pre-spill Period 1), whereas densities of Guernea sp. were higher in 1982. In the two cases where results of analysis types conflicted, period variability was only significant when all five periods were included in the analysis. The cumacean Lamprops fuscata was generally least abundant in August and September 1981, and mean numbers of Oedicerotidae were generally higher in September 1982 (Fig. 13).

Period x bay interaction effects were not significant at 7 m depth for any of the epibenthic crustaceans. At 3 m depth, however, there was a significant period x bay interaction in both types of analysis for the amphipods Anonyx spp. and Calliopiidae (Tables 22 and 23). Inspection of the data (Fig. 12) shows similar trends in both taxa, and clear differences between Bay 11 (surface oil release) and the other three bays (reference and dispersed oil bays). In the latter three bays, densities of Anonyx spp. and Calliopiidae were relatively constant from Pre-spill Period 1 to Post-spill Period 2, and then increased in the next month (August to September 1982), particularly in Bay 10 (dispersed oil contamination). In Bay 11, however, increases in densities occurred earlier (from Post-spill Periods 1 to 2 in Calliopiidae and from Post-spill Periods 2 to 3 in Anonyx spp.), and were followed by decreases over the next period in both species (Fig. 12).

This difference between the surface oil release bay on the one hand, and the reference and dispersed oil bays on the other hand, together with the similarity of effects in the two amphipod taxa, suggests an effect of the surface oil release. Numbers of Anonyx spp. and Calliopiidae increased and subsequently decreased in Bay 11 following the experimental surface oil release, and the timing of this sequence differed in the two taxa.

3.2.2 Echinoderms

The urchin Strongylocentrotus droebachiensis is widely distributed and often relatively abundant (up to 14 individuals/m^2) in the Lancaster Sound area, whereas the distribution of the starfish Leptasterias polaris is more restricted (Thomson and Cross 1980). Both species are of interest because of their trophic positions. Strongylocentrotus droebachiensis is a herbivore whose impact on benthic algal populations has been found to be considerable on both the east and west coasts of Canada (Miller and Mann 1973; Foreman 1977). Leptasterias polaris is a top predator feeding primarily on large bivalves, and hence may be affected indirectly by oil through changes in bivalve populations. Thus, in spite of the above-mentioned interpretational difficulties caused by the mobility of these animals, the densities of urchins and starfish are being monitored carefully throughout the course of this study. Too few urchins or starfish were present at the 3 m depth in the study bays to warrant discussion.

Densities of Strongylocentrotus droebachiensis and Leptasterias polaris at the 7 m depth in the study bays during each systematic sampling period, and immediately (2 to 4 days) after the dispersed oil release, are shown in Table 25. Results of analyses of variance for 3 bay/6 period and 4 bay/5 period analyses are given in Table 26. In these analyses, the 2-4 day post-spill data are treated as an additional period. Unfortunately, there is an empty cell for the period immediately after the surface oil release in both of these analyses.

Differences among transects were not significant for either species in either type of analysis. Among-bay differences, on the other hand, were

Table 25. Densities of urchins (Strongylocentrotus droebachiensis) and starfish (Leptasterias polaris) at 7 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Data are based on 15 in situ counts, each covering 10 m^2, in each period-bay combination.

		Bay 7		Bay 9		Bay 10		Bay 11	
Species	Period	Date[3]	Mean ± SD	Date[3]	Mean ± SD	Date[3]	Mean ± SD	Date[3]	Mean ± SD
Urchin (no./m^2)	Pre-spill 1		-	30/8	4.4 ± 1.5	13/9	1.6 ± 0.7	12/9	1.0 ± 0.4
	Pre-spill 2	15/8	10.0 ± 3.4	6/8	7.6 ± 2.2	13/8	1.9 ± 0.9	10/8	1.3 ± 0.5
	*	31/8	8.6 ± 2.2	29/8	2.9 ± 1.1	29/8	3.0 ± 1.1		-
	Post-spill 1	2/9	7.8 ± 3.5	3/9	5.5 ± 2.8	6/9	2.3 ± 0.7	1/9	1.3 ± 0.7
	Post-spill 2	12/9	5.8 ± 2.3	10/8	5.0 ± 1.8	9/8	1.6 ± 0.7	8,14/8	1.2 ± 0.5
	Post-spill 3	5/9	5.8 ± 2.6	5/9	5.4 ± 1.6	3/9	2.3 ± 0.8	2/9	1.2 ± 0.6
Starfish (no./10 m^2)	Pre-spill 1		-	30/8	1.0 ± 1.1	13/9	1.9 ± 1.3	12/9	0.7 ± 1.1
	Pre-spill 2	15/8	3.3 ± 2.5	6/8	1.1 ± 0.9	13/8	1.3 ± 0.9	10/8	0.5 ± 0.8
	*	31/8	5.8 ± 3.7	29/8	1.1 ± 1.5	29/8	2.3 ± 1.5		-
	Post-spill 1	2/9	4.5 ± 3.3	3/9	1.9 ± 1.2	6/9	2.7 ± 1.8	1/9	1.6 ± 2.0
	Post-spill 2	12/8	2.6 ± 2.0	10/8	1.5 ± 1.6	9/8	1.8 ± 1.2	8,14/8	1.1 ± 1.0
	Post-spill 3	5/9	3.3 ± 3.4	5/9	1.3 ± 1.4	3/9	1.9 ± 1.4	2/9	0.7 ± 0.7

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
2 Pre-spill Periods 1 and 2 (September 1980, August 1981), * (2 days after dispersed oil release) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
3 Dates shown are day and month for each year.

Table 26. Three-factor analyses of variance for densities[1] of urchins and starfish at 7 m depth in four bays[2] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[3]. F-values are shown with significance levels (ns = $P > 0.05$; * $P \le 0.05$; ** $P \le 0.01$, *** $P \le 0.001$).

Species	Analysis[4]	Source of Variation and df[5]				
		Period 5,34(4,38)	Bay 2,34(3,38)	Period x Bay 9,34(11,38)	Transect (Bay) 6,204(8,228)	Per. x Trans (Bay) 28,204(30,228)
Strongylocentrotus droebachiensis	3 bay/6 period			5.65 ***	0.85 ns	1.12 ns
	4 bay/5 period			6.18 ***	1.05 ns	1.01 ns
Leptasterias polaris	3 bay/6 period	5.12 **	23.90 ***	0.63 ns	1.18 ns	0.63 ns
	4 bay/5 period	5.12 **	28.35 ***	1.23 ns	0.68 ns	1.04 ns

1 Based on log-transformed *in situ* counts within five 1 x 10 m areas on each of three transects in each bay and period. See Table 25 for a summary of the data.

2 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

3 Pre-spill Periods 1 and 2 (September 1980, August 1981), two days after the dispersed oil release and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

4 3 bay/6 period analysis excludes Bay 7; 4 bay/5 period analysis excludes Pre-spill Period 1.

5 Degrees of freedom are shown for 3 bay/6 period analysis, followed by 4 bay/5 period analysis (in parentheses).

significant for Leptasterias polaris in both analyses. Leptasterias polaris was most abundant in Bay 7, and occurred at a relatively low and similar abundance in Bays 9, 10 and 11 (Table 25). Temporal differences were also significant for Leptasterias polaris: densities in all four bays were higher in 1981 post-spill sampling periods than in pre-spill periods or in 1982 post-spill periods. Bay and period effects for Strongylocentrotus droebachiensis are not given in Table 26 because of the significant period x bay interaction, but inspection of the data shows that urchins were more common in Bays 7 and 9 than in Bays 10 or 11.

The significance of the bay x period interaction effect for Strongylocentrotus droebachiensis (Table 26) and inspection of the data (Table 25) indicate an effect of the dispersed oil release. Urchin densities were constant in Bay 11 (surface oil release) in all sampling periods, with the possible exception of the immediate post-spill period for which no data were available. Densities decreased progressively in Bay 7 (reference) over the study period. In Bay 9, however, urchin density at 7 m depth decreased markedly immediately after the dispersed oil release, increased again within a week of the spill and remained relatively constant in the following year (1982). In Bay 10, which received dispersed oil in concentrations approximately an order of magnitude lower than those in Bay 9, urchin density at 7 m depth increased immediately after the spill, then decreased approximately one week later and again remained relatively constant in 1982.

Few dead or immobilized urchins were observed after the dispersed oil release; hence urchins must have emigrated from Bay 9, likely moving to deeper, uncontaminated water. The post-spill increase in urchin density following the release in Bay 10 is less easy to interpret. Dispersed oil entered Bay 10 at a depth of approximately 8-10 m and this may have caused a movement from deep to shallow water.

These data for Strongylocentrotus droebachiensis, combined with direct observations of effects on urchins and starfish made during and after the dispersed oil spill (Cross and Thomson 1982), indicate that dispersed oil did have an immediate effect, but that recovery occurred quickly. In all bays but the reference bay, urchin densities appear to have returned to pre-spill levels.

3.3 Macrophytic Algae

The benthic marine algae of the North American Arctic have been studied intermittently since the early nineteenth century, but early reports consisted of little more than species lists (Kent 1972). Recently, floristic and ecological studies have been performed in Labrador and Ungava Bay (Wilce 1959), West Greenland (Wilce 1964), Prince Patrick Island (Lee 1966), Pangnirtung Fiord (Kent 1972), and in several areas in the northern and southwestern Canadian Arctic (Lee 1980). These studies have shown that macrophytic algae are a common feature of arctic and subarctic nearshore waters, both on exposed rocky coasts and on soft bottoms. In the latter case, the algae are either loose-lying and still viable or are attached to mud, small rocks, shells and polychaete tubes (Lee 1966; Lee 1973, 1980). These floristic studies have provided much valuable information on species composition, zonation and reproduction of littoral and sublittoral macrophytes in high latitudes. Quantitative studies of kelps and conspicuous understory algae have also been carried out at several locations in the Lancaster Sound area (Thomson and Cross 1980), but to date combined floristic/biomass studies of benthic macroalgae have not been reported for the Canadian Arctic.

The overall effects of oil on macroalgal communities have not been studied in the Arctic, but Hsiao et al. (1978) determined that in situ primary production in two macroalgal species in the Beaufort Sea was significantly inhibited by all types and concentrations of oil tested. In other latitudes, studies of the effects of oil spills with and without the use of chemical dispersants have often demonstrated changes in the abundance of littoral and sublittoral macrophytic algae (see Natural Academy of Sciences 1975, Table 4-1). In some cases widespread mortality has been observed (e.g. Bellamy et al. 1967; Thomas 1973), whereas in other cases no mortality was apparent immediately following the spill (e.g. Nelson-Smith 1968). Subsequent changes following spills have included a proliferation of macroalgal growth, which has been attributed to the oil-related absence of herbivores including sea urchins (North et al. 1965) and limpets (Nelson-Smith 1968).

3.3.1 Species Composition

A total of 57 species of macroalgae were collected in the study bays at Cape Hatt (Table 27). This is a relatively small number when compared with the 126 species known in the arctic sublittoral (Wilce 1973) or the 183 arctic species and varieties (littoral and sublittoral) recorded by Lee (1980). This difference undoubtedly is largely attributable to the small

Table 27. Species list of benthic algae collected in four bays at Cape Hatt, northern Baffin Island, during August and September 1980, 1981 and 1982.

Species and Authority
Chlorophyceae
Ulothrix flacca (Dilwyn) Thuret *in* LeJolis
Blidingia minima (Nageli ex Kützing) Kylin
Chlorochytrium schmitzii Rosenvinge
Chlorochytrium dermatocolax Reinke
Spongomorpha sonderi Kützing
Spongomorpha sp.
Chaetomorpha linum (O.F. Müller) Kützing
Chaetomorpha melagonium (Weber et Mohr) Kützing
Phaeophyceae
Pilayella littoralis (L.) Kjellman
Giffordia ovata (Kjellman) Kylin
Myriactula lubrica (Rupr.) Jaasund
Symphyocarpus strangulans Rosenvinge
Eudesme virescens (Carmichael) J. Agardh
Phaeostroma pustulosum Kuckuck
Phaeostroma parasiticum Børgesen
Phaeostroma sp.
Elachistea lubrica Ruprecht
Stictyosiphon tortilis (Ruprecht) Reinke
Platysiphon verticillatus Wilce
Omphalophyllum ulvaceum Rosenvinge
Chordaria flagelliformis (O.F. Müller) C. Agardh
Delamarea attenuata (Kjellman) Rosenvinge
Dictyosiphon foeniculaceus (Hudson) Greville
Coelocladia arctica Rosenvinge
Desmarestia aculeata (L.) Lamouroux
Desmarestia viridis (O.F. Müller) Lamouroux
Punctaria glacialis Rosenvinge
Chorda filum (Linnaeus) Lamouroux
Chorda tomentosa Lyngbye
Agarum cribrosum (Mertens) Bory
Laminaria saccharina (L.) Lamouroux
Laminaria solidungula J. Agardh
Laminaria longicruris Pyl.
Haplospora globosa Kjellman
Sphacelaria plumosa Lyngbye
Sphacelaria arctica Harvey
Sphacelaria caespitula Lyngbye
Fucus distichus L. subsp. *evanescens* (C. Ag.) Powel
Rhodophyceae
Audouinella purpurea (Lightfoot) Woelkerling
Ahnfeltia plicata (Hudson) Fries
Neodilsea integra (Kjellman) A. Zinova
Devaleraea ramentaceum (L.) Guiry
Palmaria palmata (L.) O. Kuntze
Polysiphonia arctica J. Agardh
Rhodomela confervoides (Hudson) Silva f. *flagellaris* Kjellman
Phyllophora truncata (Pallas) A. Zinova
Ptilota serrata Kützing
Odonthalia dentata (L.) Lyngbye
Harveyella mirabilis (Reinsch) Reinke
Halosacciocolax kjellmanii S. Lund
Pantoneura baerii (Postels et Ruprecht) Kylin
Antithamnion boreale (Gobi) Kjellman
Chrysophyceae
Phaeosaccion collinsii Farlow
Berkeleya rutilans (Trent.) Ep.
Navicula ramosissima (Agardh) Cleve
Nitzschia sp.
Coscinodiscus sp.

area and relatively homogeneous substrate type studied at Cape Hatt relative to the wide geographical coverage and diversity of substrate types included in the above investigations.

The dominant species at 3 m in the study bays were Stictyosiphon tortilis, Pilayella littoralis and Dictyosiphon foeniculaceus. Together with tubular diatoms (it was impractical to separate these from Pilayella littoralis), these species comprised 77.1% of total macroalgal biomass when all bays and periods were combined. These species formed the lower algal stratum--the understory. The understory also included Sphacelaria spp. (primarily Sphacelaria arctica and Sphacelaria plumosa), Chaetomorpha linum and Chaetomorpha melagonium, which together comprised 5.3% of macroalgal biomass, and a number of other species that were not weighed separately (2.1% of biomass).

The dominant canopy species at 3 m were Neodilsea integra (4.9% of total biomass), Fucus distichus (4.1%), Laminaria spp. (4.1%) and Chorda spp. (0.7%). Other less abundant canopy species were Devalarea ramentaceum, Rhodomela confervoides, Punctaria glaciale and Desmarestia spp., which together comprised less than 2% of macroalgal biomass.

3.3.2 Biomass

Mean biomasses of total algae and dominant species collected in airlift samples along transects at 3 m depth in each of the study bays and periods are shown in Table 28. Mean biomass of total macroalgae was from 74.7 to 1032.6 g/m2, depending on bay and period. These values (based on formalin-

Table 28. Mean biomass of the 10 most abundant groups or species of macrophytic algae at 3 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Biomass expressed as mean ± SD of 10% formalin preserved wet weight and are based on 8 replicate 0.0625 m^2 airlift samples on each of three transects for each period and bay.

Species or Group	Period	Bay 7	Bay 9	Bay 10	Bay 11
Stictyosiphon tortilis	Pre-spill 1	-	60.83 ± 65.38	218.97 ± 177.62	145.67 ± 129.85
	Pre-spill 2	57.46 ± 40.08	42.04 ± 80.01	29.08 ± 34.40	328.89 ± 617.33
	Post-spill 1	43.69 ± 36.05	47.17 ± 82.31	38.52 ± 43.34	597.57 ± 1143.92
	Post-spill 2	142.16 ± 129.54	46.30 ± 79.21	214.03 ± 260.63	353.88 ± 391.35
	Post-spill 3	119.95 ± 121.55	40.58 ± 57.39	225.22 ± 351.58	779.54 ± 1284.41
Pilayella littoralis + diatoms[3]	Pre-spill 1	-	118.38 ± 56.19	231.10 ± 262.59	115.05 ± 149.53
	Pre-spill 2	60.83 ± 34.89	32.82 ± 28.14	41.24 ± 40.32	89.84 ± 131.67
	Post-spill 1	65.94 ± 57.87	48.80 ± 39.22	44.50 ± 50.57	194.52 ± 305.28
	Post-spill 2	44.24 ± 40.56	18.27 ± 23.64	81.88 ± 88.45	135.29 ± 184.34
	Post-spill 3	43.60 ± 52.01	30.73 ± 22.04	95.81 ± 90.37	93.97 ± 129.01
Dictyosiphon foeniculaceus	Pre-spill 1	-	66.63 ± 117.28	183.42 ± 183.06	2.86 ± 6.83
	Pre-spill 2	2.57 ± 2.51	15.13 ± 24.89	7.43 ± 8.18	0.87 ± 1.82
	Post-spill 1	4.46 ± 4.25	20.49 ± 32.45	15.17 ± 21.21	0.43 ± 0.67
	Post-spill 2	143.18 ± 159.71	7.20 ± 6.59	289.75 ± 345.68	5.25 ± 10.33
	Post-spill 3	161.39 ± 170.93	33.76 ± 31.86	184.70 ± 173.71	1.42 ± 2.43
Neodilsea integra	Pre-spill 1	-	0.01 ± 0.05	30.73 ± 97.71	0.18 ± 0.49
	Pre-spill 2	17.40 ± 44.40	<0.01	58.81 ± 160.10	1.46 ± 5.34
	Post-spill 1	13.85 ± 39.46	0	106.29 ± 254.24	1.32 ± 3.40
	Post-spill 2	36.24 ± 102.58	<0.01	32.10 ± 50.69	2.77 ± 6.10
	Post-spill 3	21.65 ± 43.93	<0.01	73.92 ± 162.83	0
Fucus distichus	Pre-spill 1	-	1.30 ± 2.82	8.34 ± 18.11	44.12 ± 91.82
	Pre-spill 2	8.31 ± 33.52	0.21 ± 0.95	8.37 ± 37.92	14.65 ± 25.52
	Post-spill 1	0.55 ± 1.47	0.81 ± 1.80	15.46 ± 50.46	38.29 ± 85.82
	Post-spill 2	8.81 ± 18.34	0.30 ± 0.54	25.48 ± 86.65	12.75 ± 31.92
	Post-spill 3	8.05 ± 32.84	4.61 ± 18.30	119.26 ± 241.02	10.54 ± 35.19
Laminaria spp.[4]	Pre-spill 1	-	2.44 ± 11.09	5.54 ± 19.29	1.22 ± 3.30
	Pre-spill 2	1.04 ± 4.39	0.08 ± 0.32	19.15 ± 36.00	7.21 ± 23.99
	Post-spill 1	<0.01	0.01 ± 0.07	65.43 ± 128.87	12.81 ± 21.68
	Post-spill 2	0.41 ± 0.91	0.01 ± 0.03	47.04 ± 64.14	33.07 ± 77.62
	Post-spill 3	0.20 ± 0.86	0	119.22 ± 239.50	17.23 ± 44.06
Sphacelaria spp.[4]	Pre-spill 1	-	1.16 ± 1.36	50.66 ± 72.37	14.92 ± 24.32
	Pre-spill 2	1.08 ± 1.12	0.39 ± 0.54	13.96 ± 17.18	5.19 ± 7.44
	Post-spill 1	1.03 ± 1.24	0.65 ± 0.73	8.92 ± 14 .83	16.50 ± 29.83
	Post-spill 2	3.04 ± 3.96	0.59 ± 1.18	38.22 ± 44.95	33.48 ± 53.53
	Post-spill 3	3.14 ± 4.28	0.68 ± 0.92	51.98 ± 74.26	59.38 ± 173.86
Chorda spp.[4]	Pre-spill 1	-	30.83 ± 29.97	5.13 ± 17.73	1.22 ± 3.17
	Pre-spill 2	0.11 ± 0.28	0.03 ± 0.05	0.03 ± 0.10	<0.01
	Post-spill 1	4.32 ± 8.62	3.12 ± 4.25	0.22 ± 0.67	0
	Post-spill 2	0.07 ± 0.26	0.15 ± 0.41	0.13 ± 0.28	<0.01
	Post-spill 3	0.44 ± 1.45	9.62 ± 14.18	1.07 ± 2.04	0.28 ± 0.94
Chaetomorpha spp.[4]	Pre-spill 1	-	0.03 ± 0.07	2.91 ± 6.16	4.48 ± 9.77
	Pre-spill 2	0.09 ± 0.14	0.01 ± 0.04	1.42 ± 1.90	5.81 ± 8.71
	Post-spill 1	0.07 ± 0.18	0.01 ± 0.03	1.25 ± 1.85	20.71 ± 36.40
	Post-spill 2	0.27 ± 0.68	0.04 ± 0.08	5.54 ± 6.80	27.33 ± 41.84
	Post-spill 3	0.16 ± 0.24	1.19 ± 5.27	6.63 ± 9.75	43.93 ± 86.56
Punctaria glaciale	Pre-spill 1	-	0.45 ± 1.60	0	0
	Pre-spill 2	2.52 ± 5.16	0.11 ± 0.38	0.15 ± 0.47	0
	Post-spill 1	12.39 ± 16.58	0.86 ± 3.30	0.86 ± 2.47	0
	Post-spill 2	24.40 ± 50.55	0.97 ± 3.07	0.64 ± 1.34	0.12 ± 0.57
	Post-spill 3	12.40 ± 18.22	0.27 ± 0.87	11.74 ± 26.50	0.26 ± 1.13
Total algae[5]	Pre-spill 1	-	288.20 ± 161.56	765.77 ± 643.56	347.39 ± 333.91
	Pre-spill 2	154.26 ± 82.51	91.43 ± 112.54	187.46 ± 191.10	477.66 ± 762.82
	Post-spill 1	148.76 ± 102.67	124.12 ± 133.52	315.70 ± 311.30	940.84 ± 1483.13
	Post-spill 2	405.42 ± 403.83	74.66 ± 100.50	743.58 ± 702.06	627.05 ± 670.36
	Post-spill 3	372.20 ± 308.38	123.78 ± 92.37	907.84 ± 796.98	1032.63 ± 1595.16

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
[3] P. littoralis and tubular diatoms not separated.
[4] Genera listed include species listed in Table 27.
[5] Includes other species not weighed individually.

preserved wet weight) probably underestimate fresh weight; Thomson and Cross (1980) reported a considerable (>30%) formalin-induced reduction in the weight of understory algae from Cape Fanshawe, Bylot Island. Algal biomass at Cape Hatt (Table 28) was higher than the biomass of macroalgae other than kelp at most of the 5 and 10 m stations studied by Thomson and Cross (1980). However, kelp biomass in the Lancaster Sound area was considerably higher (0.5-12.7 kg/m^2 fresh wet weight). The only estimates of kelp biomass at Cape Hatt were made on 3 m transects (Laminaria spp., Table 28); biomass would have been much higher in the narrow Laminaria zone that was observed at 4-5 m depth.

Understory species tended to be more evenly distributed among bays than were the larger canopy species (Table 28). Neodilsea integra was rare in Bay 9, Laminaria spp. were rare in Bays 7 and 9, and Punctaria glaciale and Chorda spp. were absent or rare in Bay 11. Because of the relatively even distributions of understory algae and the dominance of three understory species (see above), detailed analysis was restricted to the biomasses of total algae and these three species.

Results of analyses of variance for biomasses of total algae and dominant members of the understory community at 3 m are shown in Table 29. Differences among transects were significant for all variables except Dictyosiphon foeniculaceus (4 bay/4 period analysis only), indicating considerable patchiness on a small (50-m) scale.

Bay and period effects were in most cases confounded by significant period x bay interactions in analysis of variance (Table 29). Bay effects

Table 29. Three-factor analyses of variance for the biomass of macrophytic algae at 3 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05, ** P≤0.01, *** P≤0.001).

Analysis[3]	Taxon/df[4]	Source of Variation				
		Period	Bay	Period x Bay[5]	Transect (Bay)	Per x Trans (Bay)
3 bay/5 period[3]	Total algae	–[6]	–[6]	3.24 **	6.19 ***	1.22 ns
	Stictyosiphon tortilis	0.65 ns	7.23 *	0.53 ns	12.99 ***	1.70 *
	Dictyosiphon foeniculaceus	–[6]	–[6]	6.51 *	3.51 **	2.59 ***
	Pilayella littoralis + diatoms	–[6]	–[6]	3.78 **	5.40 ***	0.58 ns
	Degrees of freedom[4]	(4,6 or 30)	(2,6 or 30)	(8,6 or 30)	(6,311)	(24,311)
4 bay/4 period	Total algae	7.19 ***	28.39 ***	1.79 ns	3.85 ***	1.17 ns
	Stictyosiphon tortilis	1.54 ns	7.82 **	0.33 ns	8.93 ***	1.65 *
	Dictyosiphon foeniculaceus	–[6]	–[6]	30.79 ***	0.79 ns	2.01 **
	Pilayella littoralis + diatoms	–[6]	–[6]	2.74 *	3.14 **	0.75 ns
	Degrees of freedom[4]	(3,8 or 32)	(3,8 or 32)	(9,8 or 32)	(8,333)	(24,333)

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
3 3 bay/5 period analysis excludes Bay 7; 4 bay/4 period analysis excludes Pre-spill Period 1.
4 Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.
5 The Period x Bay term is the test of oil effects.
6 Interpretation of main effects confounded by significant interaction of Period x Bay term.

were significant in the three cases where interpretation of main effects was possible. Biomass of Stictyosiphon tortilis was highest in Bay 11, similar in Bays 7 and 10, and lowest in Bay 9. Total algal biomass was highest in Bays 10 and 11, intermediate in Bay 9, and lowest in Bay 7 (Duncan's Multiple Range Tests, $P<0.05$). Period effects were not significant for Stictyosiphon tortilis, whereas total algal biomass increased progressively from August 1981 to September 1981 to August and September 1982 (biomass was similar in the last two periods).

Period x bay interaction effects were significant for Dictyosiphon foeniculaceus and Pilayella littoralis in both types of analysis, and for total algal biomass in only the analysis of variance that includes all sampling periods (Table 29). These interaction effects indicate the possibility of oil or dispersed oil effects. Inspection of the data Fig. 14, Table 28) shows that interactions are complex in two cases, and hence interpretation of the results is difficult.

Temporal changes in the biomass of Pilayella littoralis (+ tubular diatoms) were not consistent among bays between any two sampling periods (Fig. 14). Differences between the two pre-spill periods were not the only source of the interaction because the analysis excluding Pre-spill Period 1 also showed a significant period x bay interaction. In subsequent periods, biomass in Bay 11 (surface oil release) increased markedly from August to September 1981 (pre-spill to post-spill), and decreased from August to September 1982. Biomass in the other three bays increased slightly or remained constant from August to September in both years.

Another possible source of the interaction was an increase in biomass in Bay 10, and a decrease in the other three bays between September 1981 and

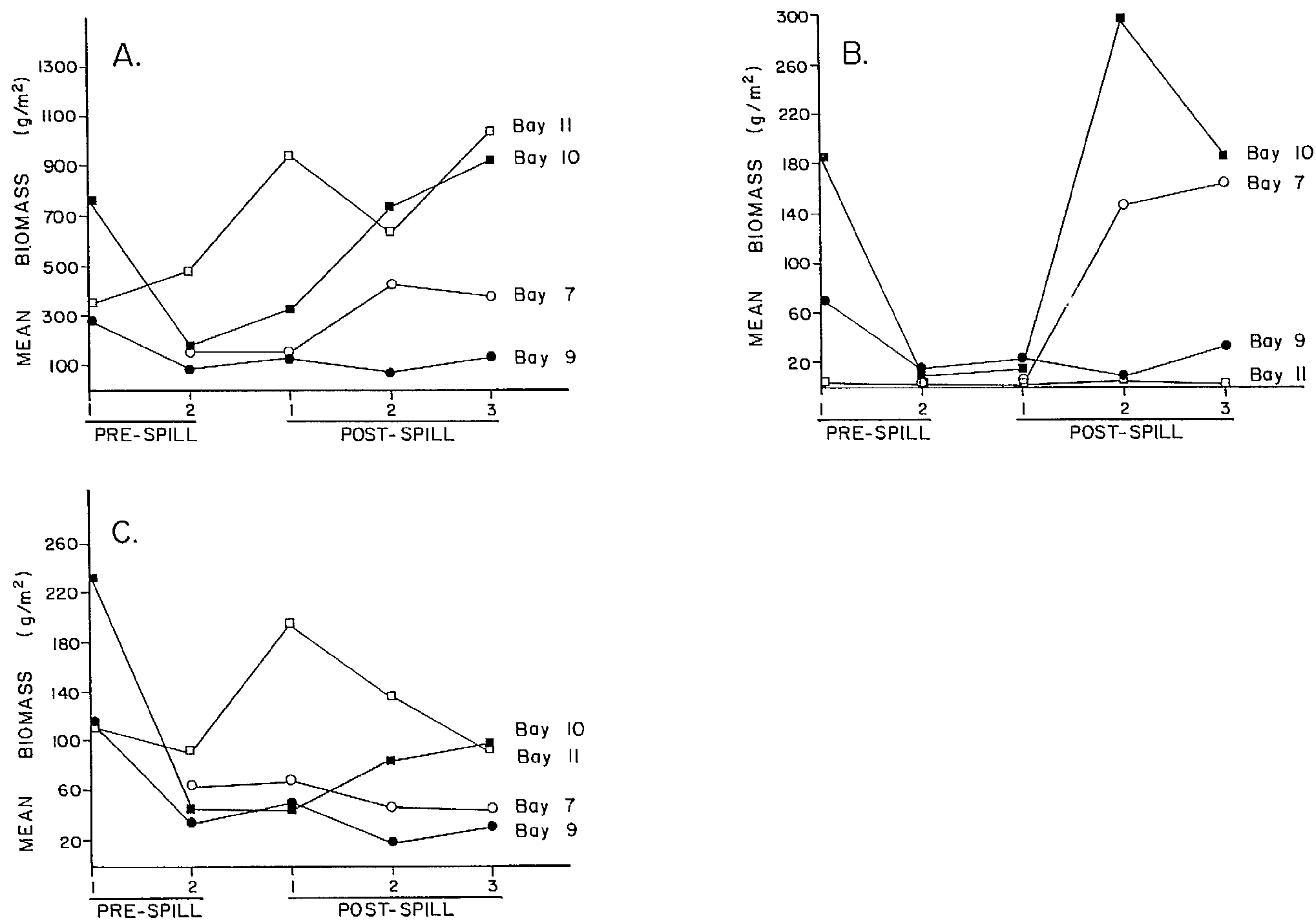


FIGURE 14. Mean biomass of total algae **(A)** Dictyosiphon foeniculaceus **(B)** and Pilayella littoralis **(C)** in four bays at Cape Hatt, northern Baffin Island, during pre-spill sampling in September 1980 and August 1981, and during post-spill sampling in September 1981 and August and September 1982.

August 1982. The latter difference does not appear to be oil-related because Bay 10 received amounts of dispersed oil intermediate to those that occurred in Bays 7 and 9. The former difference, that between Bay 11 and the other three bays, may represent an oil effect. Apparently the surface oil release initially stimulated growth in Pilayella littoralis at 3 m depth immediately after the release, and decreased its growth in the following summer.

Biomass of total algae (Fig. 14) showed a relatively similar pattern to that of the above species. In this case, however, the interaction effect was significant only when Pre-spill Period 1 was considered, and hence the source of interaction was the among-bay differences between pre-spill sampling periods; this is clearly not an oil effect.

The period x bay interaction for Dictyosiphon foeniculaceus is more easily interpreted. Biomass increased markedly from 1981 to 1982 in Bays 7 (reference) and 10 (light dispersed) and remained relatively low in Bays 9 (heavy dispersed) and 11 (surface release). This may indicate an effect of the surface oil and dispersed oil releases. The great variability between the two pre-spill sampling periods suggest, however, that the 1982 differences may represent normal annual and locational variation. Variability in biomasses within Bay 9 is too great to attribute differences between September 1980 and 1982 (66.6 ± 117.3 and 33.8 ± 31.9 g/m2, respectively) to an effect of dispersed oil.

Thus in only one of three significant period x bay interactions can the effects be attributed to oil. In one of four groups or species tested, Pilayella littoralis, the surface oil release appears to have stimulated growth in the month following the oil release and decreased summer growth one year following the surface oil release.

SECTION FOUR

DISCUSSION

4.1 Study Design and Statistical Inference

Prior to the beginning of the study we hypothesized that

1) The application of oil to a shallow water high arctic benthic community will cause a change in the species composition of the infauna and initially result in a lower total standing crop.

2) These effects will be worsened by the application of dispersants with the oil.

Analysis of variance was selected as a test of these hypotheses. Any significant effects of oil or oil plus dispersant on the benthos would be manifested as a significant treatment vs. sampling time (bay x period) interaction term. In other words, temporal change would not be consistent among bays. There exists the possibility of committing two types of errors in these tests. A type I error would cause rejection of the null (no effect) hypothesis when it was true (finding apparent effects when there were none), and a type II error would cause acceptance of the null hypothesis when it was in fact false (not detecting effects that did occur). Occurrence of the latter type of error should have been minimized by the use of spatial and temporal controls and the large number of samples collected (908 samples of infauna and epibenthos, 452 samples of algae, 360 *in situ* counts). Type I errors are of concern because of the large number of statistical analyses carried out.

Decisions to accept or reject the null hypothesis were based on a probability level of 0.05. When a test indicates that the effect is significant, it is actually indicating that there is less than a 1 in 20 chance that differences as large as those observed could occur as a result of chance sampling effects if there were no real differences. However, a total of 212 period x bay interaction tests were performed on the data. Hence we would expect that approximately 11 type I errors would be made if there were no real differences. In fact, a total of 19 significant interactions were found in the 212 tests. This is not many more than the 11 expected by chance. However, based on the above hypotheses, we were testing for specific patterns of period x bay interaction, i.e. temporal change that occurred (1) in bays treated with oil and not in a bay that received no oil, or (2) in a bay contaminated with chemically dispersed oil and not in a bay contaminated by untreated oil. Inspection of the nature of the 19 seemingly significant interactions showed that 16 were consistent with a possible oil effect. Thus, we can be reasonably confident that most of the significant interactions are indicative of real oil effects. These are some, but not all of the types of interaction possible in a design involving four bays and four periods, or three bays and five periods. Hence type I errors appear to have been rare.

The nested analysis design used in the present study produces a conservative test for oil effects. Changes caused by introduction of oil must be greater than natural variability between 50 m transects in order to be detected. This is a reasonable approach in a study of an inherently variable system. However, it may have been possible that oil effects were present but were not detected by the conservative test. To this end, a less conservative analysis of variance design was applied to infaunal data from the 7 m depth.

Table 30 compares results of analyses of variance used in this study (nested design) with those that would be obtained if the nested transect term were ignored. In this new analysis, variation attributable to the period x bay interation was compared with smaller-scale (sample to sample) variability. The resulting increase in denominator degrees of freedom increases the likelihood of showing an oil effect if it exists, but also increases the probability of making a type I error. The new approach also increases the power of the test by reducing the chance of making a type II error. The use of this less conservative technique on 42 univariate and two multivariate analyses of variance did not affect results (Table 30).

4.2 Levels of Contamination

Four bays at Cape Hatt, northern Baffin Island, were selected as experimental bays; oil was released on the surface of Bay 11, dispersed oil was released in the water column of Bay 9 and also contaminated Bay 10, and Bay 7 was used as a reference bay.

On 19 August 1981, 75 drums (15 m^3) of slightly aged Lagomedio crude oil were released on the surface in Bay 11. Approximately half of this amount was recovered on the day following the release. During the 6 h release and

Table 30. Comparisons of results of analyses of variance of density and biomass of major taxa and species using nested and non nested designs. Only the 7 m depth is considered and only the results of the test of the Period x Bay interaction effects are shown.

	Design -> Type of Analysis -> df ->	Nested		Not Nested	
		3 Bay/5 Period	4 Bay/4 Period	3 Bay/5 Period	4 Bay/5 Period
		8,6 or 30	9,8 or 32	8,343	9,381
Biomass (g/m^2)	Total infauna	0.86 ns	0.52 ns	1.05 ns	0.62 ns
	Polychaetes	1.00 ns	0.96 ns	1.27 ns	1.10 ns
	Bivalves	0.89 ns	0.55 ns	1.14 ns	0.78 ns
Density ($no./m^2$)	Total infauna	0.87 ns	1.22 ns	1.05 ns	1.38 ns
	Polychaetes	3.06 *	2.76 *	3.16 **	3.37 ***
	Bivalves	0.23 ns	0.27 ns	0.40 ns	0.40 ns
	Mya truncata	0.61 ns	0.40 ns	0.89 ns	0.51 ns
	Thyasiridae sp.	0.38 ns	0.78 ns	0.53 ns	0.46 ns
	Astarte borealis	0.73 ns	0.70 ns	0.71 ns	0.90 ns
	Astarte montagui	0.49 ns	0.26 ns	1.23 ns	1.26 ns
	Euchone analis	1.41 ns	0.82 ns	1.68 ns	1.03 ns
	Myriotrochus rinkii	0.64 ns	0.87 ns	1.47 ns	1.86 ns
	Factors 1-9	ns	ns	ns	ns
	MANOVA Pillai's Trace	0.55 ns	0.94 ns	1.20 ns	1.15
	df	48,36	81,288	72,2736	81,3294

during the 30 h monitoring period that followed, oil concentrations in the top metre of water were low (<3 ppm) and concentrations below a depth of 1 m were below the detection limit of 0.25 ppm (Green et al. 1982). Approximately one third of the oil was deposited on the sandy beach during the falling tide, and concentrations in the intertidal area reached 36,000 ppm (Green et al. 1982). This oil did not immediately become incorporated into Bay 11 sediments at 3 and 7 m depths (Boehm et al. 1982), but oil concentrations began to rise a few weeks following the spill and were still rising 1 year following the spill (Figure 15; Boehm 1983). Furthermore, this trend of increasing contamination of sediments at 3 and 7 m depth is expected to continue (Boehm 1983). Total exposure of oil in water resulting from the surface oil release was 1.2-2.1 ppm-h in Bay 11 (Green et al. 1982). Mean oil concentrations in the sediment after one year were 7-9 ppm (Boehm 1983).

On 27 August 1981, an additional 15 m^3 of aged Lagomedio crude oil mixed with Corexit 9527 (10%) dispersant and seawater (5:1, water:oil) were introduced into Bay 9 from a diffuser pipe. The released oil was stratified by depth. Surface (0-7 m) oil first circulated to the south and subsequently reached the sampling areas in Bay 9 some 6 h later, while the deep layer (7-15 m) moved north with the current directly into the experimental bay. Concentrations in the water column were high (~50 ppm) following the release. Horizontal diffusion was rapid, and after four days the dispersed oil was found throughout Ragged Channel at concentrations of 30-50 ppb. Total exposure to dispersed oil was 300 $\pm$ 100 ppm-h in Bay 9, approximately 30 ppm-h in Bay 10, and 0.5 ppm-h in Bays 7 and 11 (Green et al. 1982).

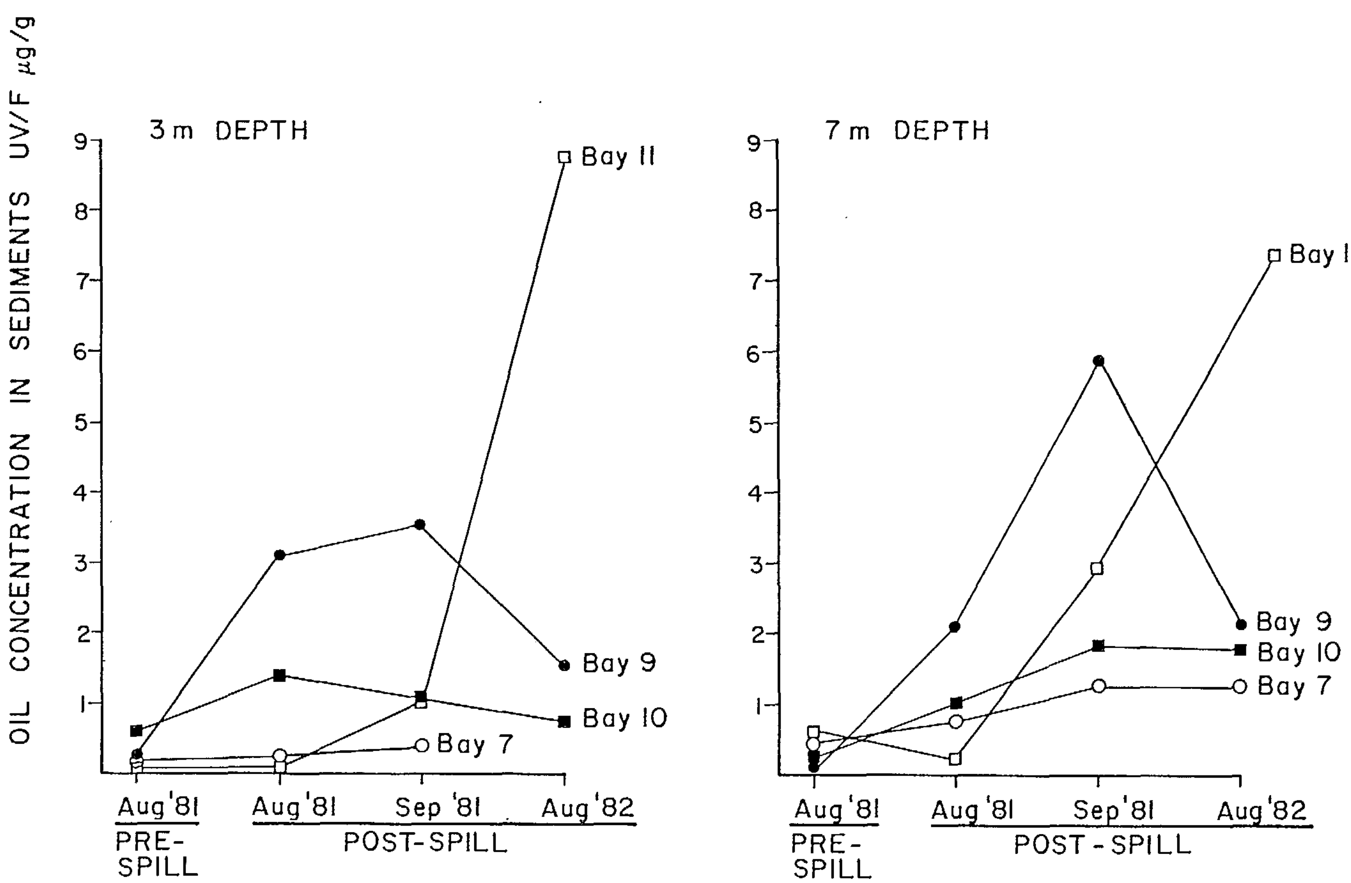


FIGURE 15. Mean oil concentrations (UV/F) in sediments from four bays at Cape Hatt, northern Baffin Island, during pre-spill sampling in August 1981, and during post-spill sampling in August and September 1981 and August 1982. Values shown are means of all samples taken on benthic transects and tissue plots for the indicated depth, bay and period. Data are shown from Boehm et al. (1982) and Boehm (1983).

Oil was quickly incorporated into the sediments in Bay 9 and, to a lesser degree, in Bay 10 (Figure 15; Boehm et al. 1982; Boehm 1983). Concentrations in Bay 9 sediments reached a maximum of 4-6 ppm a few weeks (or later) following the release and were considerably lower one year later (Figure 15).

The oil levels in the sediment at Cape Hatt are relatively low (< 10 ppm on a dry sediment weight basis) when compared with values reported in the literature. Following an oil spill in Chedabucto Bay, N.S., Scarratt and Zitco (1972) reported that sediment hydrocarbon concentrations (based on wet sediment weight) were 10-20 ppm at lightly oiled stations, and 160-1240 ppm at heavily oiled stations. Sanders et al. (1980) found 10-20 ppm hydrocarbon content (based on dry sediment weight) in lightly oiled stations, and 1300-12400 ppm (dry sediment) in heavily oiled stations after an oil spill in Buzzards Bay, Mass. Chronically oiled areas can contain similar sediment hydrocarbon concentrations: 4-60 ppm in lightly oiled areas and 820-6000 ppm in heavily oiled areas (Farrington and Quinn 1973; Koons and Thomas 1979; both based on dry sediment weight).

4.3 Oil Effects

The effects of oil on benthos in the study bays at Cape Hatt fall under three categories: sublethal effects, decreased abundance in some organisms, and enhancement of growth or recruitment in other organisms.

Sublethal effects caused by the release of dispersed oil included immediate post-spill stress in a variety of organisms, particulary *Serripes groenlandicus* (Cross and Thomson 1982), temporary relocation of urchins, changes in the weight-length relationship of Serripes groenlandicus, and in the mean weight of Macoma calcarea. All three of these species accumulated considerable quantities of oil (Boehm 1983). The first two of these sublethal effects were transitory in nature, whereas changes in weight length relationships may persist.

Mortality of individuals was caused by both the surface oil and dispersed oil releases. A post-spill decrease in density of Macoma juveniles occurred in the dispersed oil release bay, and a post-spill decrease in density of polychaetes was associated with the surface oil release.

Enhancement of growth or recruitment in some organisms was associated with both surface and dispersed oil releases. The surface oil release appears to have stimulated growth of the filamentous brown alga Pilayella littoralis in the month following the oil release and decreased growth in the following summer. The post-spill increase in Astarte juveniles at 3 m depth in the two dispersed oil bays, and increases in calliopiid amphipods and Anonyx sp at 3 m depth in the surface oil release bay are all events that did not occur in the reference bay and must be considered to be possible oil effects. These changes are, however, difficult to interpret in the context of what is known about the effects of oil. Increases in the densities of the two amphipod taxa in the surface oil release bay may have been the result of increased food availability associated with increases in algal standing crop in that bay.

Oil and dispersed oil released at Cape Hatt did not cause large-scale immediate mortality of benthic animals, probably because rather low concentrations entered the sediments. Experimental studies have shown that benthic animals are killed or begin to die after 1 to 8 weeks exposure to 250-1000 ppm of crude oil in sediments (Gordon et al. 1978; Roesijadi et al. 1978; Roesijadi and Anderson 1979; Augenfeld 1980; Augenfeld et al. 1980). The above authors found a range of response from no mortality to total mortality depending on the species. With longer exposures, lower concentrations can cause mortality. Twenty-five weeks exposure to 109 ppm in sediment caused a significant decline in density of macrofauna in experimental ecosystems (Grassle et al. 1980).

Oil and dispersed oil released at Cape Hatt did cause immediate sublethal effects on some benthic animals. Sublethal effects occur at concentrations much lower than those causing lethal effects. Concentrations of less than 1 ppm in water may cause decreased activity and decreased growth rates (Keck et al. 1978; Stekoll et al. 1980).

The criterion for recognizing an oil effect was decided, before the experiments began, to be the occurrence of a significant period x bay interaction in the multivariate analyses of variance. No such interaction was found. Inspection of Tables 4 and 6 and Figures 3, 4, 12 and 13 shows that, in most cases, temporal trends in biomass and density were quite consistent among bays. Oil-related interactions were found in only 16 of 212 analyses performed, and results were similar using a less conservative analysis design. Within the framework of published literature, our results are consistent with the low quantity of oil to which the animals were exposed.

An important objective of this project is to compare oil effects in the dispersed oil release bay with those in the surface release bay and to make inferences about the effects of dispersing oil with chemical agents. To this end, it is possible to say that the effects of dispersed oil have occurred and that they were minor. Immediate post-spill effects were obvious but only short-lived, and appear to have had no permanent effect (Cross and Thomson 1982). Medium term effects did not change community composition and affected only a few species. It is too early to be certain, but it appears that there will be little or no long-term effect.

Oil levels in the sediment of the bay where there was a surface oil release have not yet reached maximum levels (Boehm 1983) and resultant effects on the benthic community (if any) have yet to be manifested. The increasing concentrations of oil recorded in the sediment of the surface oil release bay may be sufficient to cause a change in the condition, reproductive status and mortality rates of benthic animals in the next year or two.

SECTION FIVE

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APPENDIX A. Dates and locations (depth, bay, transect, and number of metres from N to S along the transect line) of each airlift sample collected at Cape Hatt, northern Baffin Island in 1980 (Pre-spill Period 1), 1981 (Pre-spill Period 2 and Post-spill Period 1) and 1982 (Post-spill Periods 2 and 3).

				Replicate								
Depth	Bay	Transect	Period	1	2	3	4	5	6	7	8	Date(s)
7 m	7	1	Pre-2	2	6*	24	29	31*	36	39*	45	16 Aug
			Post-1	1*	4	11*	15	24*	33*	40*	42	3 Sept
			Post-2	5	7*	22	30	33	38*	40	46*	13 Aug
			Post-3	10	10*	26	35	36*	37	37*	42*	6 Sept
		2	Pre-2	0	19	30	31*	35	37	38*	49*	16 Aug
			Post-1	4*	10*	12*	26	28	36	46	48*	3 Sept
			Post-2	1	2	10	11*	14*	17*	31	42	13 Aug
			Post-3	4	8	12	16*	26*	42*	43*	47	6 Sept
		3	Pre-2	5*	9	11*	15	20	22	27	36*	17 Aug
			Post-1	0	5	14	17*	25	25*	29*	48	3 Sept
			Post-2	2	4	4*	15*	19*	33	34	42	13 Aug
			Post-3	11	21*	22*	23*	24	28	36	44	6 Sept
	9	1	Pre-1	2	8*	20*	23*	31	35	36	43	1 Sept
			Pre-2	13	14	14*	18*	33	36	45*	48*	6 Aug
			Post-1	10*	16	20	24*	27*	37*	38	45	5 Sept
			Post-2	1	10	28	31*	34*	41*	43	47	11 Aug
			Post-3	4	9*	12	17*	29*	34	35*	37	5 Sept
		2	Pre-1	6	24*	25	32*	37	43*	43	48	31 Aug, 1 Sept
			Pre-2	2*	8*	10	18*	27*	41	44	49	6, 7 Aug
			Post-1	3*	7	10*	12*	24	26	26*	42*	5 Sept
			Post-2	5	28	28*	30*	37*	40	46	46*	11 Aug
			Post-3	1*	4*	4	8	14*	16*	39	42	5 Sept
		3	Pre-1	2	8*	20*	23*	31	35*	36*	43	31 Aug
			Pre-2	5*	10*	13*	14	17	20	34*	42	7 Aug
			Post-1	2*	7	18	19	25*	45*	46	47	5 Sept
			Post-2	0*	4*	21*	22*	23	25	44	49	11 Aug
			Post-3	0	1*	14*	16	18*	32*	44*	48	5 Sept
	10	1	Pre-1	1	2*	7*	13*	14	16	29*	31	3 Sept
			Pre-2	6	9*	15	27	30	33	41*	48	13 Aug
			Post-1	19*	26	33*	39	40*	42	48*	50	6 Sept
			Post-2	11*	23*	25*	28	35*	36	45*	49*	10 Aug
			Post-3	14	16	23*	25	28	35*	40*	48*	4 Sept
		2	Pre-1	5*	8	11	16*	20*	24	33*	41*	3 Sept
			Pre-2	4	10	13*	22	25	27	32	39*	13 Aug
			Post-1	5	15	15*	22*	24*	25*	26*	30*	6 Sept
			Post-2	8*	17	18	29	31	37	37*	46	10 Aug
			Post-3	0*	20	20*	35*	42	43	46*	49	4 Sept

Continued...

APPENDIX A Continued.

Depth	Bay	Transect	Period	Replicate 1	2	3	4	5	6	7	8	Date(s)
7 m		3	Pre-1	5	9*	16*	20	24*	25	38*	44	3 Sept
			Pre-2	3	4*	10*	13*	31	39	45	48*	14 Aug
			Post-1	1	2*	10	18	24	39*	41*	43	6 Sept
			Post-2	1*	6	19*	23	27	32	34*	43*	10 Aug
			Post-3	1	9	10*	11*	17*	18	26*	41	4 Sept
	11	1	Pre-1	1	5*	12*	23*	24	33	39*	40*	4, 5 Sept
			Pre-2	3	8	8*	12*	29*	35*	35*	39*	10 Aug
			Post-1	15	19	25	26	27*	30*	38*	42	1 Sept
			Post-2	0	2	4	7	11*	19*	22	35	8 Aug
			Post-3	6	6*	16	20*	23	38	46	49*	3 Sept
		2	Pre-1	6	12*	14*	16*	27*	29	40*	41	5, 6 Sept
			Pre-2	3*	6*	14	35	40	45	47*	48	12 Aug
			Post-1	3	3*	13*	18*	20	22*	30*	47*	1, 2 Sept
			Post-2	4*	10*	11*	15	19	24*	32*	49	8, 15 Aug
			Post-3	0	8	9*	20*	28	28*	31*	37	3 Sept
		3	Pre-1	4*	20	25*	27	28	40	43*	45*	6 Sept
			Pre-2	4	6*	8*	14*	34*	35	36	48*	12 Aug
			Post-1	6	8	11	12*	13*	28	30	44	2 Sept
			Post-2	1*	7*	16*	18	23	30*	38	43	15 Aug
			Post-3	1	3	12*	25	31*	41	44*	45	3 Sept
3m	7	1	Pre-2	12	15*	24	27	33*	36	44	45	17 Aug
			Post-1	8	9	20	26*	34	39	39*	48*	5 Sept
			Post-2	16*	26	29*	33	40*	41	46*	47*	14 Aug
			Post-3	1*	3	5*	21*	22*	24*	29	31*	7 Sept
		2	Pre-2	11	11*	16*	20	26	27	41	44	17 Aug
			Post-1	2*	3	6*	7*	33	36	37	49*	5 Sept
			Post-2	1	3*	4	9*	14	15	41*	46*	14 Aug
			Post-3	1*	5*	10*	19*	21*	27*	28	37*	7 Sept
		3	Pre-2	9	15*	17*	19	38	38*	39*	40*	17 Aug
			Post-1	2*	3	8*	10	16	20	27*	42*	5 Sept
			Post-2	0	2	11*	18*	24*	26	31	45*	14 Aug
			Post-3	18	21	28*	30	32*	33	40	48	7 Sept
	9	1	Pre-1	2*	5	10	11*	14	20	33	39*	10 Sept
			Pre-2	1	3	9	17	18*	23	32	39	7 Aug
			Post-1	4*	21	24*	29	32*	35*	43	49	6 Sept
			Post-2	4	18	22*	24	27*	35	37*	42	10 Aug
			Post-3	8	14	17	18	18*	19*	28*	33	5 Sept

Continued...

APPENDIX A Concluded.

Depth	Bay	Transect	Period	Replicate 1	2	3	4	5	6	7	8	Date(s)
3 m		2	Pre-1	1*	9	10	17	24*	30	36	44	10 Sept
			Pre-2	7*	17*	23	24	32	38	45*	46	7, 8 Aug
			Post-1	14*	19	31*	38*	39	39*	40*	44	6 Sept
			Post-2	4	5	10*	18*	27	28	36*	46*	10, 11 Aug
			Post-3	1*	16	21*	28*	34	37	40	46	5 Sept
		3	Pre-1	6*	16*	21	27	30*	33	38	45	10 Sept
			Pre-2	2*	5	8	12	15	45	45	48	7, 8 Aug
			Post-1	3*	8*	14	20*	23	40*	46	47	6 Sept
			Post-2	10*	17	21*	25	25*	32	36	42	11 Aug
			Post-3	11*	12	20	23*	27	37	38	43*	5 Sept
	10	1	Pre-1	4*	11	30	33*	37*	43	45	46*	7 Sept
			Pre-2	1	5	12	13*	33	39*	42*	45*	14 Aug
			Post-1	0	7	14*	16*	17*	33*	34*	46	7 Sept
			Post-2	3*	12*	13	20	22*	41	44*	49	9 Aug
			Post-3	14	16	23*	25	25*	35*	40*	48*	6 Sept
		2	Pre-1	3*	6*	11	13	17*	32*	44	46	7 Sept
			Pre-2	2*	9*	10*	12*	13*	21*	24*	27*	14 Aug
			Post-1	3	4	11*	14	15	22*	34	37	7 Sept
			Post-2	9	18*	23	26	33*	35	41*	47	9 Aug
			Post-3	0*	20	20*	35*	42	43	46*	49	6 Sept
		3	Pre-1	2*	5*	8	13*	14	30	31	37*	8 Sept
			Pre-2	10	18*	20*	25	39	42	43	46	14 Aug
			Post-1	3	15	16*	24*	25*	27	38	41*	7 Sept
			Post-2	6	10*	19*	28*	36*	46*	47*	49	9 Aug
			Post-3	1	9	10*	11*	17*	18	26*	41	6 Sept
	11	1	Pre-1	0*	6*	12	16*	21	41	44	45*	9 Sept
			Pre-2	4	4*	8	11	18	20*	22*	33	12 Aug
			Post-1	6	15	23*	26	27*	36	37	42	2 Sept
			Post-2	0	1*	3	5	11*	25	35	45	9 Aug
			Post-3	5*	9	20	31*	40	41*	42	49*	3 Sept
		2	Pre-1	1*	12*	19*	26	27	30	39*	47	9 Sept
			Pre-2	17	18	22	29*	31	32	33	40	12 Aug
			Post-1	10	25	30*	31*	37*	40	47*	48*	2 Sept
			Post-2	8	13	24	25	29	33*	35*	46*	9 Aug
			Post-3	1	9*	11	27*	28*	30*	32*	42*	3 Sept
		3	Pre-1	0	1*	6	7	14*	16*	18	42*	9 Sept
			Pre-2	1	9*	11*	25	26	30*	31	32	12 Aug
			Post-1	4	8	13*	17	19	23	35	39*	2 Sept
			Post-2	2*	3*	5*	10	11	13	29	37	9 Aug
			Post-3	4*	14	17*	21*	24	33	38*	43*	3 Sept

* Indicates sample taken seaward of transect line.

APPENDIX B. List of species of benthic fauna collected by airlift at Cape Hatt, northern Baffin Island, during August 1980 and August and September 1981 and 1982.

ANTHOZOA

Unidentified Anthozoa

NEMERTINEA

Unidentified Nemertinea

NEMATODA

Unidentified Nematoda

POLYCHAETA

Ampharete arctica

Ampharete actuifrons

Ampharete sp.

Amphicteis sundevalli

Amphitrite cirrata

Antinoella sarsi

Apistobranchus tullbergi

Aricidea hartmanae

Asabellides sibirica

Axiothella catenata

Brada granulata

Capitella capitata

Chaetozone setosa

Chone infundibuliformis

Cirratulidae spp.

Cossura longicirrata

Diplocirrus hirsutus

Diplocirrus longisetosus

Dysponetus pygmaeus

Eteone barbata

Eteone longa

Euchone analis

Exogone verrugera

Gattyana cirrhosa

Glycera capitata

Harmothoe extenuata

Harmothoe imbricata

Lanassa venusta

Laonome kroyeri

Laphania boecki

Lumbrinereis impatiens

Lumbrinereis minuta

Maldane sarsi

Mediomastus sp.

Melaenis loveni

Myriochele oculata

Nephtys ciliata

Nereimyra punctata

Nereis zonata

Nicolea sp.

Nicomache lumbricalis

Ophelia limacina

Ophelina accuminata

Ophryotrocha puerilis

Oriopsis crenicollis

Owenia fusiformis

Pectinaria granulata

Pectinaria hyperborea

Petaloproctus tenuis

Pholoe minuta

Pholoe longa

Phyllodoce groenlandica

Phyllodoce mucosa

Pista cristata

Pista maculata

Polydora sp.

Continued...

APPENDIX B. Continued.

Polydora quadrilobata
Praxillella praetermissa
Prionospio steenstrupi
Proclea graffi
Pygospio elegans
Rhodine loveni
Scalibregma inflatum
Scoloplos armiger
Scoloplos pugettensis
Sphaerodoropsis biserialis
Sphaerodoropsis minuta
Spio spp.
Spirorbis sp.
Syllides sp.
Terebellides stroemi
Tharyx marioni
Thelepus cincinnatus
Travisia forbesi
Trichobranchus glacialis
Unidentified Polychaeta

GASTROPODA

Acmaea rubella
Acmaea testudinalis
Admete couthouyi
Alvania mighelsi
Alvania sp.
Beringius sp.
Buccinum ciliatum
Buccinum cf. scalariforme
Buccinum cyaneum
Buccinum sericatum
Cingula castanea
Colus islandicus
Colus cf. spitzbergensis
Colus tortuosus
Frigidoalvania cruenta
Lunatia pallida
Margarites helicinus
Margarites umbilicalis
Moelleria costulata
Natica clausa
Oenopota arctica
Oenopota cf. bicarinata
Oenopota cf. cinerea
Oenopota incisula
Oenopota pyramidalis
Oenopota turricula
Oenopota sp.
Onoba aculeus
Philine lima
Propebela turricula
Retusa obtusa
Scaphander punctostriatus
Trichotropis borealis
Unidentified Gastropoda

POLYPLACOPHORA

Tonicella marmorea

BIVALVIA

Astarte borealis
Astarte montagui
Clinocardium ciliatum
Hiatella arctica
Lyonsia arenosa
Macoma calcarea
Macoma moesta
Musculus discors substriatus
Musculus niger

Continued...

APPENDIX B. Continued.

Mya truncata
Mytilus edulis
Nucula belloti
Nuculana minuta
Periploma sp.
Serripes groenlandicus
Thracia sp.
Thyasiridae spp.
Yoldiella sp.
Unidentified Bivalvia

CUMACEA

Brachydiastylis resima
Campylaspis glabra
Diastylis rathkei
Diastylis sculpta
Eudorella sp.
Lamprops fuscata
Leptostylis macrura
Leucon sp.

OSTRACODA

Eucytheridea bradii
Eucytheridae punctillata
Finmarchinella finmarchica
Philomedes globosa
Rabilimis mirabilis

AMPHIPODA

Ampelisca macrocephala
Anonyx laticoxae
Anonyx nugax
Anonyx sarsi
Apherusa glacialis
Apherusa megalops
Atylus carinatus
Bathymedon longimanus
Bathymedon obtusifrons
Bathymedon sp.
Boeckosimus edwardsi
Boeckosimus plautus
Byblis gaimardi
Centromedon pumilus
Corophium clarencense
Gammaracanthus loricatus
Gammarus setosus
Gammarus wilkitzkii
Guernea nordenskioldi
Haploops lavevis
Harpinia serrata
Ischyrocerus sp.
Melita dentata
Metopa sp.
Metopella carinata
Monoculodes borealis
Monoculodes kroyeri
Monoculodes latimanus
Monoculodes longirostris
Monoculodes sp.
Monoculopsis longicornis
Oediceros saginatus
Onisimus glacialis
Onisimus litoralis
Opisa eschrichti
Orchomene minuta
Paramphithoe sp.
Paroediceros lynceus
Phoxocephalus holbolli
Pleusymtes glaber
Pontogeneia inermis

Continued...

APPENDIX B. Concluded.

Pontoporeia femorata
Protomedia fasciata
Stenothoidae spp.
Tmetonyx sp.
Westwoodilla brevicalcar
Westwoodilla megalops
Weyprechtia pinguis
Unidentified Amphipoda

DECOPODA
Argis dentata
Lebbeus microceros
Lebbeus polaris
Pasiphaeidae spp.
Sabinea sarsii
Sclerocrangon boreas
Sclerocrangon ferox
Spirontocaris phippsi

OTHER CRUSTACEA
Unidentified Mysidacea
Unidentified Nebaliacea
Unidentified Tanaidacea
Unidentified Isopoda

ASTEROIDEA
Leptasterias groenlandica
Leptasterias polaris
Stephanasterias albula

OPHIUROIDEA
Amphiura psilopora
Amphiura sundevalli
Ophiocten sericeum
Ophiopus arcticus
Ophiura robusta
Ophiura sarsi

ECHINOIDEA
Strongylocentrotus droebachiensis

HOLOTHUROIDEA
Myriotrochus rinkii

ASCIDIACEA
Rhizomolgula globularis
Unidentified Ascidiacea

OTHER PHYLA
Priapulus bicaudatus
Priapulus caudatus
Unidentified Echiura
Unidentified Sipuncula

PISCES
Artediellis uncinatus
Boreogadus saida
Eumesogrammus praecius
Eumicrotremus spinosus
Eumicrotremus sp.
Gadus ogac
Gymnelis viridis
Gymnocanthus tricuspis
Icelus spatula
Leptoclinus maculatus
Liparis tunicatus
Lycodes mucosus
Myoxocephalus quadricornis
Myoxocephalus scorpiodes
Myoxocephalus scorpius
Triglops pingelii

APPENDIX C. Mean density (no./m2) of selected species of infauna and epifauna at 3 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Data are expressed as mean ± standard deviation and are based on 8 replicate 0.06252 airlift samples on each of three transects for each period and experimental bay.

Taxon	Period	Bay 7		Bay 9		Bay 10		Bay 11	
		Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD
Pholoe minuta									
	PRE-SPILL 1	.	.	514.7	258.1	276.7	251.7	222.7	224.3
	PRE-SPILL 2	298.0	343.5	813.3	649.7	290.7	155.0	158.7	161.5
	POST-SPILL 1	308.0	277.9	776.0	452.1	330.0	224.3	198.0	225.6
	POST-SPILL 2	459.4	267.8	822.7	397.3	367.4	226.3	171.5	119.1
	POST-SPILL 3	444.0	342.0	840.0	416.8	302.9	239.7	196.4	233.7
Nereimyra punctata									
	PRE-SPILL 1	.	.	271.3	347.7	558.7	348.9	282.0	266.0
	PRE-SPILL 2	218.7	178.5	180.0	192.3	472.8	368.6	276.1	245.9
	POST-SPILL 1	202.0	229.6	126.7	152.8	371.3	316.0	230.7	179.1
	POST-SPILL 2	318.8	150.3	207.3	178.4	344.9	224.6	206.5	105.6
	POST-SPILL 3	326.0	166.7	230.7	157.3	209.8	125.1	266.7	227.3
Eteone longa									
	PRE-SPILL 1	.	.	82.0	73.0	92.7	79.2	91.3	82.9
	PRE-SPILL 2	52.0	47.7	41.3	28.7	132.0	195.5	98.8	62.4
	POST-SPILL 1	68.7	64.1	69.3	68.6	73.3	60.6	196.3	189.0
	POST-SPILL 2	76.0	59.5	62.7	40.8	96.7	91.1	118.0	118.1
	POST-SPILL 3	82.0	68.3	71.3	49.3	85.4	60.8	137.3	136.0
Astarte juveniles									
	PRE-SPILL 1	.	.	90.0	82.5	110.7	109.8	6.0	13.2
	PRE-SPILL 2	9.3	19.4	20.7	35.8	53.6	53.0	0.0	0.0
	POST-SPILL 1	3.3	9.4	78.7	161.3	17.3	39.2	4.2	12.0
	POST-SPILL 2	26.0	29.8	269.3	373.6	141.3	163.0	4.0	10.8
	POST-SPILL 3	22.0	31.2	124.0	158.0	96.0	72.0	2.0	7.2

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

APPENDIX C. Continued.

Taxon	Period	Bay 7 Mean	Bay 7 ± SD	Bay 9 Mean	Bay 9 ± SD	Bay 10 Mean	Bay 10 ± SD	Bay 11 Mean	Bay 11 ± SD
Musculus discors									
	PRE-SPILL 1	.	.	1.3	6.5	172.0	220.5	62.7	104.6
	PRE-SPILL 2	22.0	27.4	4.0	13.6	87.6	105.3	40.0	78.8
	POST-SPILL 1	8.0	14.2	4.7	12.0	80.0	124.4	78.7	116.9
	POST-SPILL 2	22.0	35.6	14.7	23.6	97.3	116.9	42.7	62.7
	POST-SPILL 3	22.0	41.9	18.0	23.7	96.7	148.8	63.0	164.1
Musculus juveniles									
	PRE-SPILL 1	.	.	0.0	0.0	70.0	119.2	79.3	135.8
	PRE-SPILL 2	24.0	25.0	10.7	36.1	25.7	34.0	35.3	81.7
	POST-SPILL 1	12.7	22.1	14.0	42.5	29.3	46.1	66.2	105.3
	POST-SPILL 2	30.7	39.7	5.3	9.0	82.8	107.6	73.3	134.1
	POST-SPILL 3	32.0	38.0	6.7	13.3	112.5	142.0	66.9	171.1
Cingula castanea									
	PRE-SPILL 1	.	.	150.7	131.9	104.0	81.9	10.0	18.2
	PRE-SPILL 2	236.7	181.4	175.3	152.8	60.5	54.6	4.2	11.5
	POST-SPILL 1	230.7	198.8	367.3	484.6	77.3	77.9	3.5	16.7
	POST-SPILL 2	380.8	221.8	490.7	352.1	184.9	173.4	8.0	15.6
	POST-SPILL 3	413.3	270.3	424.0	352.2	181.3	146.9	6.7	14.9
Retusa obtusa									
	PRE-SPILL 1	.	.	79.3	49.1	30.7	40.6	24.7	28.3
	PRE-SPILL 2	20.7	24.3	72.7	62.4	23.7	32.7	12.2	18.8
	POST-SPILL 1	26.7	27.4	89.3	63.8	26.0	31.2	6.3	11.6
	POST-SPILL 2	52.7	37.9	142.0	71.0	54.7	52.1	31.3	51.4
	POST-SPILL 3	44.7	55.8	144.7	119.1	65.3	72.9	8.0	17.0

APPENDIX C. Continued.

Taxon	Period	Bay 7 Mean	Bay 7 + SD	Bay 9 Mean	Bay 9 + SD	Bay 10 Mean	Bay 10 + SD	Bay 11 Mean	Bay 11 + SD
Orchmene minuta									
	PRE-SPILL 1	.	.	5.3	9.0	20.7	49.4	8.7	10.5
	PRE-SPILL 2	17.3	29.4	29.3	44.2	70.7	219.2	5.3	19.8
	POST-SPILL 1	10.7	25.3	27.3	47.5	50.0	214.6	3.8	6.8
	POST-SPILL 2	16.7	16.0	28.7	65.7	73.3	173.9	15.3	45.6
	POST-SPILL 3	16.7	23.3	9.3	15.6	60.7	81.3	12.0	21.7
Protomedia fasciata									
	PRE-SPILL 1	.	.	58.7	86.7	4.7	13.7	8.0	21.6
	PRE-SPILL 2	0.7	3.3	62.0	163.1	11.1	19.0	9.3	18.2
	POST-SPILL 1	0.0	0.0	146.7	245.1	18.7	30.1	11.1	25.3
	POST-SPILL 2	0.7	3.3	69.3	200.6	26.9	37.6	21.3	35.5
	POST-SPILL 3	0.0	0.0	36.7	71.6	15.3	27.0	16.7	33.9
Guernea sp.									
	PRE-SPILL 1	.	.	72.0	63.8	41.3	63.3	14.0	25.5
	PRE-SPILL 2	12.7	17.0	96.7	122.4	47.9	33.6	10.7	18.7
	POST-SPILL 1	36.7	47.8	206.0	143.4	76.7	81.7	12.5	15.2
	POST-SPILL 2	34.7	35.2	116.7	79.7	88.6	100.2	24.7	39.2
	POST-SPILL 3	32.7	64.8	138.0	56.0	35.8	54.2	10.0	19.2
Anonyx spp.									
	PRE-SPILL 1	.	.	7.3	11.5	17.3	40.3	40.7	94.1
	PRE-SPILL 2	5.3	10.2	2.0	7.2	2.8	6.2	6.0	14.0
	POST-SPILL 1	23.3	29.1	11.3	17.3	6.7	10.5	5.6	10.4
	POST-SPILL 2	2.7	6.1	1.3	4.5	4.0	9.7	66.0	150.7
	POST-SPILL 3	72.0	202.7	74.0	75.9	157.3	342.5	31.3	38.5
Lamprops fuscata									
	PRE-SPILL 1	.	.	24.0	36.2	22.7	62.4	10.7	27.8
	PRE-SPILL 2	18.7	30.8	138.0	376.4	20.8	33.0	22.7	46.4
	POST-SPILL 1	34.0	41.2	87.3	91.1	114.7	176.9	4.2	8.7
	POST-SPILL 2	15.3	21.9	189.3	290.3	64.0	112.0	50.7	102.5
	POST-SPILL 3	21.3	63.1	69.3	73.8	56.0	170.0	11.3	23.8

APPENDIX C. Concluded.

Taxon	Period	Bay 7 Mean	± SD	Bay 9 Mean	± SD	Bay 10 Mean	± SD	Bay 11 Mean	± SD
Oedicerotidae spp.									
	PRE-SPILL 1	.	.	22.7	39.5	106.0	143.3	97.3	113.7
	PRE-SPILL 2	30.0	44.3	10.7	17.4	61.2	87.9	60.0	78.0
	POST-SPILL 1	59.3	70.4	12.7	18.3	76.7	61.0	29.9	48.3
	POST-SPILL 2	78.7	77.1	9.3	12.4	192.0	200.3	61.3	106.7
	POST-SPILL 3	83.3	91.0	16.0	15.6	114.9	147.3	107.3	111.2
Calliopiidae spp.									
	PRE-SPILL 1	.	.	10.7	24.4	38.0	146.4	14.0	33.8
	PRE-SPILL 2	0.7	3.3	0.0	0.0	1.4	4.6	2.0	7.2
	POST-SPILL 1	6.7	9.3	2.7	7.7	14.0	26.0	56.1	105.5
	POST-SPILL 2	17.3	37.7	2.0	5.4	18.1	24.7	14.6	33.2
	POST-SPILL 3	73.3	149.2	26.7	39.1	206.0	240.4	71.0	90.8
Lysianassidae spp.									
	PRE-SPILL 1	.	.	28.0	39.8	72.7	104.7	63.3	96.6
	PRE-SPILL 2	48.0	66.7	44.7	47.4	86.0	217.6	20.0	41.7
	POST-SPILL 1	40.0	44.3	50.0	75.2	69.3	215.2	16.0	22.6
	POST-SPILL 2	37.3	49.6	72.0	103.0	111.3	222.1	112.7	201.3
	POST-SPILL 3	107.3	230.6	104.7	98.6	243.9	426.9	64.0	70.1
Paroediceros lynceus									
	PRE-SPILL 1	.	.	4.7	11.0	34.0	72.4	11.3	13.7
	PRE-SPILL 2	2.7	6.1	1.3	4.5	18.1	25.7	19.3	35.0
	POST-SPILL 1	3.3	9.4	2.7	7.7	30.0	42.3	13.6	34.2
	POST-SPILL 2	17.3	61.9	0.7	3.3	69.3	115.6	15.3	32.2
	POST-SPILL 3	18.7	52.7	2.0	5.4	59.0	108.0	38.4	54.6

APPENDIX D. Mean density (no./m^2) of selected species of infauna and epifauna at 7 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Data are expressed as mean ± standard deviation and are based on 8 replicate 0.0625^2 airlift samples on each of three transects for each period and experimental bay.

Taxon	Period	Bay 7		Bay 9		Bay 10		Bay 11	
		Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD
Pholoe minuta									
	PRE-SPILL 1	.	.	402.7	235.5	384.0	233.5	264.0	206.7
	PRE-SPILL 2	330.0	158.4	438.7	244.3	304.0	163.2	247.3	144.1
	POST-SPILL 1	359.3	181.9	518.0	196.4	493.9	304.4	242.4	130.4
	POST-SPILL 2	330.1	183.6	583.3	256.3	687.9	417.6	347.8	204.9
	POST-SPILL 3	394.0	227.0	714.7	335.4	514.6	230.6	396.7	130.1
Praxillella praetermissa									
	PRE-SPILL 1	.	.	39.3	30.9	36.0	29.2	50.7	42.9
	PRE-SPILL 2	14.0	19.1	38.0	38.6	24.3	17.3	39.3	32.7
	POST-SPILL 1	18.7	19.8	32.7	24.3	38.0	34.3	56.0	44.0
	POST-SPILL 2	24.0	14.2	58.7	46.6	51.3	52.3	60.7	42.5
	POST-SPILL 3	48.0	30.6	60.0	46.0	60.0	38.7	94.7	68.2
Pectinaria granulata									
	PRE-SPILL 1	.	.	45.3	39.7	88.7	41.1	61.3	37.6
	PRE-SPILL 2	60.7	44.8	62.7	37.1	68.2	47.8	48.7	29.3
	POST-SPILL 1	50.7	35.2	55.3	34.0	66.0	46.5	54.6	47.7
	POST-SPILL 2	42.7	38.8	43.3	34.2	66.7	41.8	67.3	95.6
	POST-SPILL 3	48.7	37.3	56.7	34.0	68.0	49.1	60.7	32.0
Maldane sarsi									
	PRE-SPILL 1	.	.	32.7	80.7	22.0	37.7	85.3	111.4
	PRE-SPILL 2	30.0	53.9	26.0	36.8	13.9	17.6	110.7	127.5
	POST-SPILL 1	22.0	30.1	16.7	27.7	26.7	38.2	65.7	71.5
	POST-SPILL 2	30.0	38.7	21.3	31.2	35.3	54.2	82.7	96.4
	POST-SPILL 3	49.3	108.2	32.7	43.6	13.3	32.9	58.7	66.7

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

APPENDIX D. Continued.

Taxon	Period	Bay 7 Mean	± SD	Bay 9 Mean	± SD	Bay 10 Mean	± SD	Bay 11 Mean	± SD
Astarte juveniles									
	PRE-SPILL 1	.	.	136.0	125.7	198.7	250.9	196.7	129.6
	PRE-SPILL 2	9.3	18.8	42.7	67.7	27.1	67.3	50.7	65.8
	POST-SPILL 1	11.3	27.7	34.0	52.8	22.7	42.4	56.3	68.2
	POST-SPILL 2	49.3	45.0	152.7	114.9	86.0	67.2	272.0	215.0
	POST-SPILL 3	72.7	96.7	152.0	104.1	131.0	96.7	248.7	173.0
Macoma calcarea									
	PRE-SPILL 1	.	.	172.0	75.1	99.3	57.0	60.7	27.1
	PRE-SPILL 2	227.3	135.3	174.0	90.2	92.5	65.3	64.0	44.3
	POST-SPILL 1	223.3	123.1	180.0	90.3	108.0	43.8	60.5	39.5
	POST-SPILL 2	253.3	143.9	219.3	79.0	146.0	65.8	74.7	45.9
	POST-SPILL 3	248.0	152.5	197.3	100.2	128.7	59.2	108.7	54.8
Macoma juveniles									
	PRE-SPILL 1	.	.	79.3	54.1	67.3	56.0	62.7	49.9
	PRE-SPILL 2	40.0	38.3	54.7	41.6	22.5	34.9	17.3	24.9
	POST-SPILL 1	62.7	80.2	28.7	38.3	38.7	40.3	15.3	29.9
	POST-SPILL 2	114.7	88.9	96.0	65.0	96.0	71.7	63.3	48.7
	POST-SPILL 3	124.0	104.3	110.0	82.8	87.3	53.0	98.0	64.4
Musculus juveniles									
	PRE-SPILL 1	.	.	48.0	68.7	16.7	46.3	12.7	23.1
	PRE-SPILL 2	32.7	54.3	40.0	45.0	5.6	10.4	8.7	15.6
	POST-SPILL 1	32.0	58.7	28.7	33.4	11.3	22.4	9.4	19.7
	POST-SPILL 2	153.3	275.3	106.7	71.7	20.7	19.7	22.7	24.9
	POST-SPILL 3	134.7	216.4	120.0	111.7	44.7	42.2	31.3	35.8

APPENDIX D. Continued.

Taxon	Period	Bay 7 Mean	± SD	Bay 9 Mean	± SD	Bay 10 Mean	± SD	Bay 11 Mean	± SD
Nuculana minuta									
	PRE-SPILL 1	.	.	117.3	68.5	66.7	52.3	76.7	33.4
	PRE-SPILL 2	62.0	41.8	140.0	64.9	38.3	20.3	68.0	35.7
	POST-SPILL 1	82.0	63.7	120.7	57.0	44.7	36.2	85.6	40.5
	POST-SPILL 2	101.3	102.4	161.3	74.6	71.3	60.2	130.0	74.0
	POST-SPILL 3	90.0	60.2	158.7	79.9	77.3	39.9	132.7	81.6
Cingula castanea									
	PRE-SPILL 1	.	.	73.3	87.4	28.0	30.7	20.7	26.9
	PRE-SPILL 2	94.0	103.7	83.3	80.2	25.7	28.0	15.3	25.6
	POST-SPILL 1	71.3	42.5	42.7	39.1	20.7	26.9	32.0	33.1
	POST-SPILL 2	131.3	151.9	132.0	130.6	48.0	80.9	56.5	63.8
	POST-SPILL 3	133.3	80.9	78.7	85.4	50.6	40.4	68.0	61.2
Trichotropis borealis									
	PRE-SPILL 1	.	.	28.0	24.6	47.3	38.8	110.0	78.6
	PRE-SPILL 2	54.7	39.5	31.3	23.8	31.3	25.7	66.0	48.4
	POST-SPILL 1	50.7	42.1	33.3	33.3	32.0	31.7	76.2	75.6
	POST-SPILL 2	62.0	43.1	38.0	40.3	56.0	53.6	125.3	88.6
	POST-SPILL 3	60.7	59.5	38.7	36.5	45.3	37.1	113.3	81.3

APPENDIX D. Continued.

Taxon	Period	Bay 7 Mean	Bay 7 + SD	Bay 9 Mean	Bay 9 + SD	Bay 10 Mean	Bay 10 + SD	Bay 11 Mean	Bay 11 + SD
Guernea sp.									
	PRE-SPILL 1	.	.	91.3	64.6	112.7	78.9	152.0	97.0
	PRE-SPILL 2	117.3	48.7	172.7	110.0	119.7	70.2	169.3	147.5
	POST-SPILL 1	95.3	67.5	148.0	76.8	187.3	109.2	145.3	87.0
	POST-SPILL 2	139.4	86.5	250.0	145.4	285.0	214.5	285.2	170.1
	POST-SPILL 3	179.3	122.2	253.3	108.1	255.0	132.0	260.7	125.2
Pontoporeia femorata									
	PRE-SPILL 1	.	.	10.0	16.2	2.7	6.1	70.7	87.5
	PRE-SPILL 2	71.3	58.2	19.3	26.7	9.7	15.1	28.0	83.4
	POST-SPILL 1	106.7	71.7	36.7	48.7	14.0	17.8	82.8	110.8
	POST-SPILL 2	136.0	107.2	25.3	33.3	22.0	30.9	100.0	137.1
	POST-SPILL 3	214.7	151.9	57.3	48.3	23.3	35.9	172.0	299.4
Lamprops fuscata									
	PRE-SPILL 1	.	.	108.7	98.4	110.0	84.0	184.0	137.5
	PRE-SPILL 2	58.0	62.4	82.7	91.9	39.7	34.7	90.0	88.0
	POST-SPILL 1	24.7	29.5	115.3	75.2	28.7	25.8	90.8	82.3
	POST-SPILL 2	84.0	79.7	146.0	162.2	82.7	93.9	165.3	126.3
	POST-SPILL 3	72.0	51.0	96.7	103.0	89.3	90.5	142.0	102.4
Myodocopid ostracods									
	PRE-SPILL 1	.	.	955.3	738.7	1713.3	873.0	1069.3	747.9
	PRE-SPILL 2	2046.7	988.5	1719.3	733.6	1543.7	620.3	1284.0	974.4
	POST-SPILL 1	2236.7	675.5	1815.3	1209.5	1774.1	782.0	1030.9	911.4
	POST-SPILL 2	2673.9	1137.4	2247.3	923.0	2268.7	1399.4	1727.7	1285.8
	POST-SPILL 3	2905.3	1450.9	2615.3	1293.0	2250.5	1064.3	1620.7	968.2

APPENDIX D. Concluded.

Taxon	Period	Bay 7 Mean	± SD	Bay 9 Mean	± SD	Bay 10 Mean	± SD	Bay 11 Mean	± SD
Oedicerotidae spp.									
	PRE-SPILL 1	.	.	12.7	15.6	106.0	129.0	108.7	115.1
	PRE-SPILL 2	99.3	132.3	40.7	38.0	55.7	34.1	69.3	58.7
	POST-SPILL 1	75.3	75.9	29.3	26.1	84.0	70.8	75.4	58.3
	POST-SPILL 2	73.5	94.8	43.3	29.7	118.7	95.2	78.9	62.0
	POST-SPILL 3	89.3	83.3	56.7	39.7	125.0	146.8	128.7	73.9
Lysianassidae spp.									
	PRE-SPILL 1	.	.	96.7	222.7	324.0	322.5	125.3	106.1
	PRE-SPILL 2	13.3	21.4	41.3	65.9	43.1	45.6	57.3	61.9
	POST-SPILL 1	32.7	63.9	11.3	12.9	58.0	51.0	85.6	73.7
	POST-SPILL 2	25.3	32.3	203.3	793.1	2012.7	9417.6	69.9	54.3
	POST-SPILL 3	21.3	32.2	67.3	84.5	142.0	147.0	96.0	62.6
Anonyx spp.									
	PRE-SPILL 1	.	.	91.3	220.1	298.7	308.0	95.3	81.8
	PRE-SPILL 2	7.3	14.9	29.3	56.9	11.8	19.4	25.3	30.9
	POST-SPILL 1	30.7	62.4	7.3	10.5	33.3	33.3	47.7	50.4
	POST-SPILL 2	12.7	24.5	62.0	202.7	194.0	855.3	35.2	44.4
	POST-SPILL 3	16.7	28.1	60.7	76.8	124.0	138.3	52.7	56.1
Monoculodes spp.									
	PRE-SPILL 1	.	.	0.7	3.3	15.3	32.9	16.7	19.2
	PRE-SPILL 2	0.0	0.0	4.0	8.5	16.7	27.1	10.0	19.9
	POST-SPILL 1	0.0	0.0	0.7	3.3	19.3	27.1	19.5	29.3
	POST-SPILL 2	0.7	3.3	4.0	10.8	24.0	32.3	14.0	17.2
	POST-SPILL 3	0.7	3.3	0.7	3.3	13.3	28.6	26.0	24.0