NOAA Technical Memorandum NOS ORCA 110

Evaluation of the Condition of Prince William Sound Shorelines Following the Exxon Valdez Oil Spill and Subsequent Shoreline Treatment:

Volume I 1995 Biological Monitoring Survey

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noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

National Ocean Service

Office of Ocean Resources Conservation and Assessment
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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CHAPTER 1
INTRODUCTION

GENERAL

This document is the sixth annual progress report on studies designed to investigate the ecological implications of shoreline treatments on intertidal and shallow subtidal marine life of Prince William Sound, Alaska, following the March 1989 spill from the tank vessel *Exxon Valdez*. This program addresses two areas of great uncertainty and concern about the effect of oil on shorelines:

1. The length of time required for oil-damaged ecosystems to recover.
2. The effects of shoreline treatment methods on marine life and the extent to which treatment affects recovery.

It is imperative that information regarding shoreline recovery from the *Exxon Valdez* spill and the various treatments applied be made available to decision makers before the next such incident occurs. This need to obtain and disseminate information is the general rationale for the present study initiated by the National Oceanic and Atmospheric Administration (NOAA) under Contract No.50ABNC-2-00050. Funding in 1995 was provided by NOAA and the Restitution Fund established as part of the settlement between the *Exxon Valdez* Oil Spill Trustees Council and Exxon.

Several studies conducted shortly after the spill demonstrated the effects of high-pressure hot-water treatment on shoreline marine life. Exxon-sponsored studies of the short-term effects of two different beach cleaning methods employed in 1989; the July 1989 Omni-Barge test and the Corexit 9580 test (Lees et al. 1993), provide data that allow inference of the short-term effects of oiling and describe the short-term impact of hydraulic beach treatments. Both of these high-pressure hot-water washes clearly had significant, similar impacts on intertidal assemblages that had survived extended exposure to heavy oiling.

The 1990 NOAA biological studies in Prince William Sound (Houghton et al. 1991a,b) report conditions on rocky, boulder/cobble, and mixed-soft beaches and in adjacent eelgrass beds in portions of the sound that were oiled, or oiled and high-pressure hot-water washed in 1989. Biological conditions on these beaches were compared to those on unoiled beaches of similar habitats. The conclusions were:

- the effects of high-pressure hot-water washing remained evident in the biological assemblages 16 to 18 months after the spill, and
- oiled beaches not treated in this manner were well on their way to recovery.

Results of the 1991 and 1992 NOAA biological studies in Prince William Sound (Houghton et al. 1993a,b) show that

- infaunal and epibiotal assemblages that were not high-pressure hot-water washed, in most respects, resembled communities on beaches that were not oiled, and
- effects of high-pressure hot-water washing were still evident in some intertidal assemblages 40 months after the spill.

Additional conclusions in 1991 were that oiling and subsequent treatment may have altered the spawning cycle of mussels and the reproductive strategy of eelgrass. Continued bioavailability of hydrocarbons was shown in the bioaccumulation of polycyclic aromatic hydrocarbons (PAHs) in transplanted mollusks. PAH levels in mussels had declined by an order of magnitude in 1991 from those seen in 1990, however, and generally continued to decline in 1992.

By 1993 (Houghton et al. 1994) most epibiota had rebounded at the oiled sites; abundances in many cases were higher on oiled sites than on unoiled sites. This was attributed to continued instability in populations of biological control species. The infauna at hot-water washed lower intertidal stations continued to display lower density, richness, and diversity than those at reference stations and at oiled but unwashed stations. This continued difference raised a concern that the hot-water washed stations are fundamentally different from the other station categories and may never support similar infaunal communities.

In 1994 (Houghton et al. 1995) the mature rockweed community at the oiled rocky intertidal sites declined from its 1993 peak. The general reduction in the cover of *Fucus* at the oiled sites was not seen in the rockweed communities at the unoiled reference sites and appeared to reflect the widespread senescence of a single cohort of plants. Some components of the community showed a trend toward increased stability (littorines). Other groups such as the limpets continued to increase in 1994, probably in response to the abundance of weakened rockweed plants. A major predator/prey association at the middle intertidal stations is that of the drill (*Nucella* spp.) and its prey (barnacles and mussels). Abundances of drills, barnacles, and mussels have shown wide fluctuations and cycling of abundance from year to year. Increased abundance of drills at certain stations in 1994 was expected to result in decreased abundances of barnacles and mussels in 1995.

SAMPLING OBJECTIVE AND APPROACH

Objectives

The overall objectives of this study are:

- To assess and compare the impacts of oiling and shoreline treatment activities (specifically, effects of high-pressure hot-water washing) in important littoral (intertidal and shallow subtidal) habitats in the sixth year following the spill.
- To evaluate rates of recovery over several years in areas receiving differing levels of oiling and treatment.

For purposes of this study, "recovery" is defined as the return of the ecosystem to a state within the limits of natural variability (Ganning et al. 1984). Detailed information was obtained on the dynamics and ecological forces driving recovery at a relatively small number of carefully selected sites. Data reported herein were gathered in July 1995, more than six years after the initial spill. It is anticipated that similar studies in the future will continue to document long-term recovery processes.

Funding levels in 1995 allowed only limited field sampling and limited interpretation of data generated.

Approach and Fieldwork Accomplished

The field approach in 1995 involved examination of a limited spectrum of variables representative of the status of and trends in intertidal infaunal and epibiotal assemblages and species. The intent was to continue the collection of data covering potential responses of a range of biological indicators to hydrocarbon contamination and to various disturbances caused by shoreline treatment. The data were used to compare the effects of hydrocarbon contamination and shoreline treatment and to compare rates and patterns of recovery in treated and untreated areas. The components examined in 1995 were:

- Quantitative studies of epibiota (those species living on the substratum surface) abundance and relative cover at selected rocky intertidal sites.
- Collection of core samples for archiving and later analysis of intertidal infaunal assemblage characteristics for comparisons with data from previous years.
- Continuation of photographic record at selected sites.
- Retrieval of experiments started in 1994 designed to investigate factors influencing littleneck clam (*Protothaca staminea*) recruitment, growth, survival, and bioavailability of hydrocarbons. Experiments involved a coordinated series of mark/recapture transplant experiments and a settling experiment involving selected sediment treatments.
- Collection of samples for analyses of grain size, total organic carbon (TOC), total Kjeldahl nitrogen (TKN), and PAHs in surficial sediments and PAHs in *Protothaca staminea* and *Mytilus* cf. *trossulus*.

Intertidal sampling was conducted from July 11 to July 16, 1995, with a single vessel and crew. About 36 person-days were expended in collecting 274 samples of all types.

Epibiotic quadrats were examined at 18 rocky stations (Table 1-1). Ten sediment cores were collected at nine lower intertidal mixed-soft stations; five samples were archived for later infaunal analyses, and the remaining five samples were analyzed for grain size distribution. TOC/TKN analyses were conducted on samples composited from the area sampled for grain size. At contaminated lower mixed-soft sites, 17 sediment PAH samples were collected. Mussel tissue samples were collected at 16 stations for tissue hydrocarbon analyses.

Specimens of individually tagged *Nucella*, originally released in 1991, were collected and measured on an as-time-allowed basis. Tagged *Nucella* were recovered at Bass Harbor, Outside Bay, Crab Bay, and Northwest Bay Rocky Islet.

Table 1-1. Intertidal rocky stations sampled in 1989-95 by oiling/treatment category. *

Elevation	Category/Station	Degree of oiling	Apr-89	May-89	Jul-89	Sep-89	Jul-90	Sep-90	May-91	Jul-91	Sep-91	Jul-92	Jul-93	Jun-94	Jul-95
Upper	**Category 1**														
	Bass Harbor	None				x	x	x	x	x		x		x	x
	Eshamy Bay	None				x	x	x		x		x	x	x	x
	Hogg Bay	None				x	x	x	x	x		x		x	
	Category 2														
	Herring Bay	Heavy				x	x	x	x	x		x	x	x	x
	Outside Bay	Light				x	x	x	x	x		x	x	x	x
	Snug Harbor	Heavy				x	x	x	x	x		x	x	x	x
	Category 3														
	Mussel Beach S	Heavy				x	x	x	x	x		x	x	x	x
	NW Bay Islet	Heavy				x	x	x	x	x		x		x	x
	Block Island	Heavy							x	x		x	x	x	x
	Elrington East	Heavy										x			
	Mussel Beach N	Heavy										x	x	x	
	Elrington Islet - N	Heavy										x		x	
	Elrington Islet - W	Heavy										x		x	
	Elrington Islet - E	Heavy										x		x	
Middle	**Category 1**														
	Crab Bay	None	x		x	x	x	x	x	x		x	x	x	x
	Eshamy Bay	None	x	x	x	x	x	x		x		x	x	x	x
	Hogg Bay	None	x		x	x	x	x	x	x		x		x	
	Category 2														
	Herring Bay	Heavy	x	x	x	x	x	x	x	x		x	x	x	x
	Outside Bay	Light	x		x	x	x	x	x	x		x	x	x	x
	Snug Harbor	Heavy		x	x	x	x	x	x	x		x	x	x	x
	Bay of Isles	Light	x		x	x	x	x		x					
	NW Bay W. Arm	Moderate				x				x		x	x	x	x
	Category 3														
	Block Island	Heavy					x	x	x	x		x	x	x	x
	NW Bay Islet	Heavy	x	x	x	x	x	x	x	x		x	x	x	x
	NW Bay W. Arm	Moderate				x	x			x		x	x	x	x
	Elrington East	Heavy				x						x		x	
	Elrington West	Heavy				x						x		x	
	Mussel Beach N	Heavy										x	x	x	
Lower	**Category 1**														
	Crab Bay	None	x		x		x	x		x		x	x	x	
	Hogg Bay	None	x		x		x	x		x		x		x	
	Eshamy Bay	None	x	x	x			x			x	x	x	x	
	Category 2														
	Snug Harbor	Light		x	x		x	x		x		x	x	x	
	Outside Bay	Light	x		x		x	x	x	x		x	x	x	
	Category 3														
	NW Bay Islet	Heavy		x	x	x	x	x	x	x		x	x	x	x
	Elrington East	Moderate										x		x	
	Elrington West	Moderate										x		x	
	Mussel Beach N	Moderate										x	x	x	

* Category 1 = Unoiled; Category 2 = Oiled, untreated; Category 3 = Oiled, treated with hot water. Note: Sta categorized as oiled and treated are known to have been treated with some form of hot-water washing.

** There is uncertainty regarding treatment history at this site; thus it was not included in any category analyse

Containers for the clam recruitment experiment were recovered at three sites. There were 44 cores collected from the experimental pots. Each core was sorted and the infauna, except littleneck clams, identified to major taxonomic group (phylum or class) and counted. Young-of-the-year littleneck clams were counted and measured. Grain size samples were analyzed from each experimental unit, and a TOC/TKN sample was analyzed from each of the three lots of sediments used at a site.

Tagged and untagged clams were recovered from six buried wooden quadrats at Block Island for age and growth analyses. At the Outside Bay reference site, two of the three quadrats were disturbed or lost as a result of a shift in over-the-beach drainage from a nearby lagoon. The area was searched for marked clams and a partial recovery was made. Sediment samples were collected for PAH analysis from each of the quadrats at the Block Island site.

Hypotheses Tested

Three treatment categories were defined at the beginning of the 1990 study: Category 1 (unoiled), Category 2 (oiled, but untreated or moderately treated), and Category 3 (oiled, treated with high-pressure hot-water wash Within each of these treatment categories, multiple sites were sampled in each year to provide replication for statistical testing. Based upon the stated study objectives, several previously formulated null hypotheses were tested to evaluate the continued effects of oiling and shoreline treatment on the intertidal assemblages in selected habitats:

1a. Relative cover of dominant algal taxa does not differ among site categories.

1b. Abundance (density or percent cover) of dominant epifaunal species does not differ among site categories.

2. There is no difference in the nature of (trends in) recovery between site Categories 2 and 3.

SAMPLING DESIGN

A stratified random sampling design was used in all years to assess important intertidal assemblage and population (individual taxa) characteristics. Sampling was structured following Zeh et al. (1981) to obtain statistically reliable estimates of density or cover of macrobiota inhabiting the surface (epibiota) and, where possible, the subsurface (infauna) within important life zones and typical habitats.

The intertidal sampling effort was initially stratified according to three habitat types important in Prince William Sound:

1. Sheltered rocky habitats—Intertidal substratum composed primarily of bedrock or very large boulders (50 centimeters [cm] or larger).
2. Boulder/cobble habitats—Exposed beaches with nearly 100 percent cover by rounded cobbles and boulders ranging from 10 to 50 cm. Some larger materials and/or bedrock outcroppings were occasionally present.
3. Mixed-soft habitats—Typically a mixture of silt, granules, and pebbles with varying amounts of cobbles (5 to 25 cm) or boulders (25 to 50 cm).

Sheltered (low energy) rocky and mixed-soft sites were initially included for two reasons:

1. their biological productivity is high, and
2. their low energy regime reduces the rate of natural weathering of oil (Jahns et al. 1991; Michel et al. 1991).

In 1995 sampling was conducted at 18 rocky sites (Table 1-1) and 9 mixed-soft sites (Table 1-2). None of the exposed boulder/cobble sites sampled in earlier years were revisited in 1995.

To represent important life zones (i.e., to further stratify the sampling), three elevations (stations) were typically sampled for epibiota at each site:

1. near the upper limit of attached macrobiota,
2. in the upper portion of the broad rockweed-dominated zone, and
3. along the lower edge of this rockweed zone.

Table 1-2. Intertidal infauna stations sampled in 1989-95 by oiling/treatment category.

Elevation	Category/Station	Apr-89	May-89	Jul-89	Sep-89	Jul-90	Sep-90	May-91	Jul-91	Sep-91	Jul-92	Jul-93	Jun-94	Jul-95
Upper	**Category 3**													
	Sleepy Bay					x	x							
Middle	**Category 1**													
	Crab Bay					x	x		x		x			
	Sheep Bay				x	x	x		x		x			
	Outside Bay	x			x	x	x		x		x			
	Category 2													
	Snug Harbor					x	x		x		x			
	Mussel Beach South						x		x		x			
	Crafton Island								x					
	Category 3													
	NW Bay W. Arm						x		x		x			
	Shelter Bay				x	x	x		x		x			
	Sleepy Bay					x	x		x		x			
	Block Island						x				x			
Lower	**Category 1**													
	Crab Bay					x	x				x	x	x	x
	Sheep Bay			x		x	x		x		x	x	x	
	Outside Bay	x		x		x	x	x	x		x	x	x	x
	Bainbridge Bight							x	x	x	x	x	x	
	Category 2													
	Herring Bay	x	x	x	x	x	x	x	x		x	x	x	x
	Bay of Isles	x		x	x		x		x					
	Snug Harbor		x	x	x	x	x	x	x		x	x	x	x
	Block Island					x	x	x	x		x	x	x	x
	Mussel Beach South		x	x	x	x			x		x	x	x	x
	Ingot Island						x		x		x	x		
	Crafton Island					x	x		x			x		
	Category 3													
	NW Bay W. Arm		x	x		x	x	x	x		x	x	x	x
	Shelter Bay		x	x	x	x	x	x	x		x	x	x	x
	Sleepy Bay								x		x	x	x	x
	Elrington West										x	x	x	

* Category 1 = Unoiled; Category 2 = Oiled, untreated; Category 3 = Oiled, treated with hot water. Note: Stations categorized as oiled and treated are known to have been treated with some form of hot-water washing.

Thus, in the terminology of this study a "location," such as Snug Harbor, can have both rocky and mixed-soft "sites," and each site can have up to three "stations" to represent different intertidal zones (Figure 1-1). Infauna was typically sampled only at lower elevation stations at mixed-soft sites. At each station, sampling was conducted at points along a transect line laid parallel to the waterline along the beach contour. Detailed descriptions and discussions of the sample design employed have been provided in the 1991 and 1992 reports (Houghton et al. 1993a,b).

SITE CLASSIFICATION, OILING, AND TREATMENT HISTORY

About 570 kilometers (km) of shoreline in Prince William Sound received sufficient oiling to require some form of shoreline cleanup or treatment in 1989 (Harrison 1991). Intensive efforts were made to verify the treatment history for each of the sites in this study (see Appendix Table A-1 in Houghton et al. 1993a). Information used to document the site designations was compiled from Exxon and State of Alaska records of treatments applied to various "beach segments" and from conversations with knowledgeable personnel in the field during 1989 (e.g., the authors, NOAA personnel, and field bosses for specific locations). Each site sampled in the present study typically occupied only about 50 meters (m) along a given beach and represents only a small fraction of the shoreline segment in question, which could range from a few hundred meters to several kilometers long.

For statistical testing and qualitative discussion purposes, sites or stations within each habitat type were assigned to one of three categories to represent the range of possible stresses experienced in 1989. Stations at a given site may or may not be classified in the same category, depending on the site's known treatment history. Stations were classified as Category 1, 2, or 3 based on available information about habitat disturbance from oiling and high-pressure hot-water treatment. Replicate stations were assigned to the following three site categories:

- Category 1: Unoiled in 1989—No significant oiling or treatment reported; considered reference stations.
- Category 2: Oiled in 1989—Untreated (set aside) or treated with cool-water flushes in 1989 and/or bioremediation in 1989, 1990, or 1991.
- Category 3: Oiled in 1989—Treated with high-pressure hot-water wash(es), most, if not all, were also bioremediated in 1989, 1990, and/or 1991.

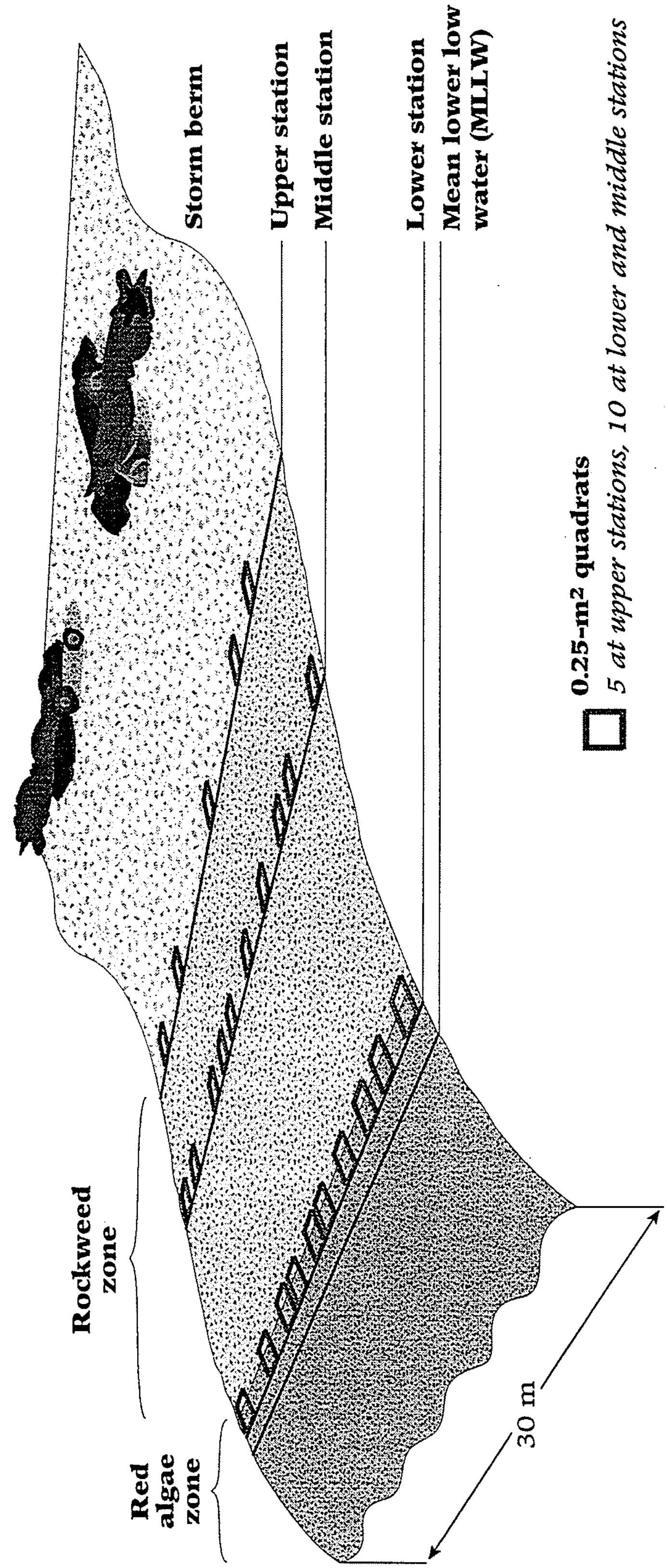


Figure 1-1. Typical site layout.

Some sites or stations (Northwest Bay Islet and West Arm mixed-soft) were sampled in 1989 before and after treatment and thus effectively moved from Category 2 to Category 3. These instances are noted in the appropriate data presentations.

Each intertidal station was classified as to the degree of oiling experienced in 1989. Because oiling was typically very uneven vertically over the intertidal zone and upper elevations were much more heavily oiled, there is little point in mandating the same oiling classification for all stations (elevations) at a site. Moreover, the width of the oiled band on a shoreline has little effect on the specific intertidal assemblage at a station; what is important is the specific degree of oiling to which the plants and animals at that station are actually exposed (cf. Page et al. 1995).

The following oiling classifications were used in this study:

- Unoiled—No area of continuous oiling present at any time in 1989. Some sheens may have been present on adjacent waters. In 1990 no oiling was present except for possible widely scattered tarballs or spots of indeterminate origin.

- Lightly oiled—Patches of oiling in 1989 with fresh oil, mousse, or tar; cover generally less than 50 percent, or large areas of continuous sheen present on the beach. Little if any oil was visible in 1990. All stations at a site reported to have been oiled were considered to have been at least lightly oiled, even if no evidence of oil was gathered from that elevation.

- Moderately oiled—Near-continuous oiling in 1989 with fresh oil, mousse, or tar; cover often exceeding 50 percent and approaching 100 percent in some areas but with relatively thin sheens; few areas of thick deposition (i.e., several millimeters (mm) or more). Usually some oil remained in these areas in 1990 in the form of dry tar crusts on upper rock surfaces or light sheens within soft sediments.

- Heavily oiled—Continuous oiling in 1989 with fresh oil, mousse, or tar; cover approaching or reaching 100 percent; some thick deposits (i.e., several mm or more). Considerable oil generally remained in these areas in 1990 in the form of dry tar crusts on upper rocks or sheens and moist tar spots within soft sediments.

THE STUDY AREA

Prince William Sound is a protected fjord and estuary system located on the south-central coast of Alaska (Figure 1-2). Wave action from North Pacific storms is blocked by the outer line of islands. The winds, however, are only minimally abated by the low-lying peaks of those islands. This topography generates storm seas and chop that strike exposed shorelines with high-intensity wave action during storm events. Within embayments, wave energy may be minimal despite high wind forces because of limited fetch and frequent shifts in wind direction (Bascom 1964; Lethcoe and Lethcoe 1989). Fetch at specific locations within Prince William Sound, including several sites in this study, is provided by Michel and Hayes (1991). Tides are of the mixed semi-diurnal type; mean tide level is about 1.8 m, and extreme range is more than 5 m.

The study area encompassed most of central and southern Prince William Sound from Sheep Bay on the eastern mainland to Eshamy Bay and Bainbridge Passage on the western mainland (Figure 1-2). The sampling focused on the chain of islands stretching from Naked Island (in the central sound), south-southwest through the Knight Island group, to the islands protecting the southwest entrances to the sound. This portion of the sound lay in the path of movement of oil from the *Exxon Valdez* and many beaches on these islands were oiled.

Unoiled beaches in Prince William Sound support biological communities relatively specific to and characteristic of a given habitat type and range of tidal elevation. Within these communities there are usually several species that, because of their abundance and/or ecological roles (e.g., as an effective grazer or predator), exert a strong influence on other kinds of organisms found in the community. Throughout this report these taxa are termed community or assemblage "dominants."

REPORT ORGANIZATION

This report is organized into several chapters, each of which reports on methods used and results of specific aspects of the study. Because this is considered a data report rather than an interpretive report, emphasis is placed on tabular and graphical data presentations and narrative discussion of the data is limited. Chapter 2 reports on intertidal epibiota and associated physical and water quality measurements; Chapter 3 contains results of mollusk studies; Chapter 4 briefly discusses major findings and conclusions; and Chapter 5 provides references for literature cited and acronym identification.

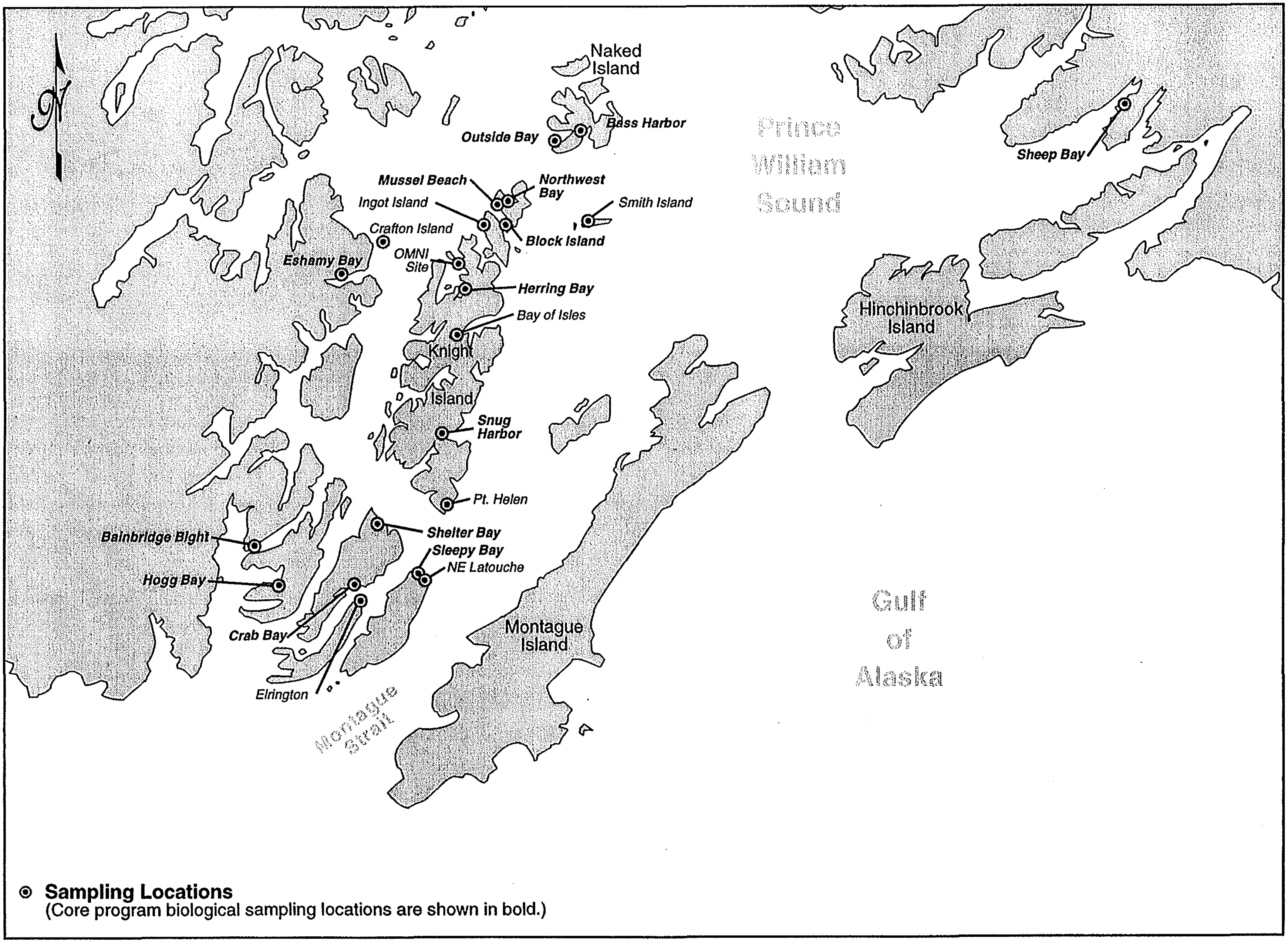


Figure 1-2. Prince William Sound study areas and sampling locations (asterisks). Sampling locations for 1994 are shown in bold.

CHAPTER 2
INTERTIDAL EPIBIOTA

INTRODUCTION

Intertidal epibiota (the assemblage of plants and animals living on or attached to the substratum) was sampled in July 1995 at one or more elevations at ten rocky sites. A summary of selected 1989-95 intertidal sampling tasks and months of collection is shown in Appendix Table A-1; only sampling activities for 1995 are shown. A complete listing of sampling tasks completed in other years may be found in Appendix Table A-1 in Houghton et al. (1993b). Latitude and longitude coordinates from a global positioning system (GPS) for each of the study sites are found in Appendix Table A-2 in Houghton et al. (1993b). Tidal elevations of stations at each study site are located in Appendix Table A-3 in Houghton et al. (1993b).

Field sampling of epibiota was conducted by intertidal ecologists with many years of experience in the taxonomy and natural history of Alaskan intertidal organisms. Some qualitative observations of trends or patterns observed during field surveys are reported on the basis of this experience without quantitative measurements or without demonstration of statistical significance.

METHODS

Field

Water Quality

Water temperature and salinity were measured with a YSI33 meter at six locations visited in July 1995 (Appendix Table A-2). The probe was gently lowered to about 0.3, 1.8, or 2.4 m, below the surface of the water. Water temperature (±0.1°C) and salinity (parts per thousand [ppt]) were read directly off the meter.

Epibiota

The abundance of epibiota was measured in July 1995 at one, two, or three elevations on rocky substrata (Table 1-1). Five or ten 0.25-m^2 quadrats were sampled on 30-m sampling lines (transects) oriented along the beach contour. Quadrats were repositioned at the same orientation as those previously sampled with the aid of previously placed rebar stakes, spikes, or epoxy markers. Where possible, the position of a quadrat was adjusted by referring to photographs taken during previous surveys.

Prior to sampling, each quadrat was photographed with a label showing the site, date, and quadrat number. Most taxa were identified by biologists in the field. Problematic taxa were collected (from outside the sample area, if possible) for cross-comparison among investigators or for identification on board the support vessel or in the laboratory. Biological variables measured or estimated included algal cover (percent by taxon) and numbers or percent cover of major epibenthic fauna. Relative cover estimates for biota, substratum type, and oiling were based on visual examination of the tops, sides, and overhangs within a quadrat, but rocks fist-size and larger were not overturned. Whenever oil was found, a subjective description of oiling in each quadrat and the percentage of oil cover found within the quadrat was recorded.

Field QA/QC

All members of the field sampling team discussed procedures for field sampling at a mobilization meeting aboard each vessel before sampling to ensure that everyone understood the field methods to be used and that these methods were followed consistently. This common understanding, along with the use of the same personnel, maximized consistency with procedures used in previous years.

Several checks were made prior to data collection in the field. Quadrats sampled at each location were checked against a master list of stations, dates of previous sampling, and quadrats that had previously been sampled destructively and nondestructively since 1989. This check precluded resampling an area previously sampled destructively. Notes on the orientation of the station line and any deviations in the previous samplings were also checked.

Some of the header information required on the data sheets (including location, elevation, date, foot marker numbers of quadrats to be sampled, and sample identification [ID]) was filled out onboard the support vessel prior to sampling. The sample ID numbers consisted of an eight-digit designation composed of the year, month, day, and a unique sample serial number. The principal investigator checked these numbers against the computer logs to ensure that numbers were not duplicated. Members of the field team noted these numbers, along with the type of sample to which each was assigned, in their field notebooks for reference in the field. Filling out the computer sample ID log before sampling ensured that all desired sampling activities were accomplished at each location.

On the beach, data sheets were checked to be sure header information was correct. The time sampling began was entered, and the data recorder checked quadrat numbers against the master station list to be sure that the quadrat numbers sampled were correct for the elevation. One person laid the tape in the appropriate direction from the station origin stake and checked with the recorder to see if permanent quadrat locations lined up with markers. Deviations from previous samplings were noted on the data sheet. The initials of the recorder were placed at the top of the data sheet, and the initials of the quadrat enumerator were placed at the top of each data column.

There was frequent cross-checking of taxonomic identifications and estimates of percent cover between quadrat enumerators.

Invertebrate nomenclature generally followed Kozloff (1987), and algal nomenclature followed Gabrielson et al. (1989). Problematic species and unique fauna and flora were placed in plastic bags, labeled, and returned to the support vessel for identification or for preservation as reference or voucher specimens. When sampling was finished, the recorder checked to make sure that all header information was entered on the data sheet, and another person checked that all information was complete. A final review of the data sheets was made later onboard the support vessel and included checking of the sample ID numbers against those previously assigned.

Statistical Analyses

Inferential Statistics

Various statistical analyses were applied to quantitatively describe the data (number of species, number of individuals, and percent cover by species) and evaluate the significance of the findings. Parametric and nonparametric tests were applied as appropriate to evaluate the significance of differences observed between station categories. In these tests the mean of all subsamples (replicates) at a given station was used to represent each variable; thus, n= the number of stations within that category where the variable in question was measured.

For tests of category effects and site-to-site differences in intertidal epibiota and environmental variables, a critical value (alpha) of $p = 0.1$ was used. Eberhardt and Thomas (1991) note that the alpha of 0.05 "automatically" selected by most ecologists may be inappropriate in some cases. Use of 0.1 allows that there is a 1-in-10 chance of falsely rejecting the null hypothesis ("no difference between site categories"—Type I error). If there is a greater concern for falsely accepting a null hypothesis that is in fact false (i.e., failure to identify significant effects of oiling or treatment when they exist—Type I error), then a lower critical value may be justified.

Eberhardt and Thomas (1991) note further that a disparity commonly occurs about probability values between analysts on opposing sides of a controversial environmental issue. Those wishing to show "no effect" may ignore Type II error and opt for a critical p value of 0.05 or even 0.01; those concerned with not missing an impact choose a higher probability value to reduce the Type II error. Therefore, the authors have considered probability levels of 0.1 or less to represent significant differences (i.e., to reject the null hypothesis) in most aspects of this study. Use of the randomization approach to analysis of variance (ANOVA) and t-testing (see below) allows computation of exact p values.

Many trends are noted as differences in mean values where no probability value is given. These differences are considered biologically relevant even though they are not statistically significant, often because of the limited replication of stations within site categories. Differences described between site categories also have been tested between pairs of stations representing those categories, often with significant results because of the greater sample size available.

Randomization Tests

Enumeration data were first tested for significant category effects using a randomization ANOVA and then tested for significant differences between pairs of site categories with a 2-tailed randomization t-test (Edgington 1987). Randomization tests are distribution-free statistical tests in which the data are repeatedly reassigned among and between treatment groups. First, a test statistic (e.g., t or F statistic) is computed for the initial data set. The data set is then randomly shuffled and the test statistic recalculated. Following a thousand or more passes of this iterative process, the proportion of random test statistics greater than or equal to the initial test value represents the exact significance of the results. All assumptions of normality, homogeneity of variance, and other characteristics of randomly sampled populations are not relevant, with one exception: that the data set truly represents the population of interest (i.e., is sampled randomly; Edgington 1987).

Randomization ANOVA tests performed on epibiota (middle rocky stations) data collected in 1990 indicated that, for certain dominant taxa, there were significant category effects—that is, abundance varied significantly among treatment categories. Multiple comparison tests using the 1990 data (Houghton et al. 1991a) identified significant ($p < 0.1$)

differences in abundances of certain taxa between various permutation pairs of site categories. The same approach, ANOVA for category effects followed by t-tests for significance of differences between pairs of site categories, was applied in 1991 through 1994. Because a main purpose of this study is to assess the degree of recovery occurring over time, it was considered important to continue to test for differences between pairs of site categories, even for taxa for which no experiment-wise category effect remained in 1991 through 1995. It is recognized that such multiple comparisons have a statistical penalty in the true experiment-wise alpha (Type I error term): differences calculated to have an alpha of 0.1 in the multiple comparison randomization t-tests in fact represent differences that have a greater than 1-in-10 chance of occurring randomly.

For epibiota, detailed abundance data (Appendix B) were used in calculations of total algal cover and total taxa present. Certain taxa were subsequently combined into higher taxonomic groups (e.g., all species of limpets into the Family Lottiidae) for ease of presentation (e.g., Tables 2-1 through 2-4) and for statistical testing. A randomization ANOVA was used to determine if a significant category effect existed and was followed by randomization t-tests for differences among station categories for dominant taxonomic groups.

RESULTS AND DISCUSSION

Physical Measurements

Water temperature and salinity were measured at six locations. Lowest surface water temperature (10.1°C) was recorded at Northwest Bay Rocky Islet. Highest surface water temperature was found at Eshamy Bay (13°C). Lowest subsurface water temperatures were found at Block Island and Northwest Bay Rocky Islet (10.3 and 10.4°C, respectively). Highest subsurface water temperatures were found at Eshamy Bay and Snug Harbor (12.8°C). Highest salinity (29.6 ppt at 1.8-m depth) was measured at Outside Bay. Northwest Bay Rocky Islet had surface salinity of 29.0 ppt and the highest subsurface salinity (1.8-m depth) of 29.2 ppt. Lowest surface salinity (8.0 ppt at 0.3-m depth) was found at Snug Harbor. The low surface salinity was the result of the development of a freshwater lens during heavy rains. Subsurface salinity in Snug Harbor (1.8-m depth) was 25.5 ppt. Oil cover remained at or near zero at all stations at all elevations in 1995.

Table 2-1. Mean abundance (% or no./0.25 m2) of important epibiota at upper rocky stations, July 1995 (*p ≤ 0.10; **p ≤ 0.05).

	Catagory 1		Catagory 2		Catagory 3			t-test		
Lumped taxon	**Mean**	**S.E.**	**Mean**	**S.E.**	**Mean**	**S.E.**	**ANOVA**	**1 vs 2**	**1 vs 3**	**2 vs 3**
Plants (% cover)										
Encrusting brown algae	0.00	0.00	0.00	0.00	0.70	0.38				
Encrusting red algae	0.35	0.15	2.33	1.99	1.17	0.92				
Endocladiaceae	0.75	0.75	2.30	2.05	0.10	0.06				
Flagelliform brown algae	0.05	0.05	0.00	0.00	0.07	0.07				
Fucus gardneri	2.60	1.80	16.47	12.49	4.07	3.34				
Fucus gardneri (germlings)	0.90	0.70	0.83	0.28	0.60	0.45				
Total Fucus	3.50	2.50	17.30	12.38	4.67	3.78				
Misc. Chlorophyta	0.45	0.25	0.37	0.19	0.07	0.03				
Misc. Cyanophyta	0.30	0.30	0.00	0.00	0.00	0.00				
Rhodomelaceae/Cryptosiphonia	0.20	0.20	0.00	0.00	0.40	0.40				
Verrucaria spp.	4.95	4.95	11.53	9.31	4.53	2.81				
Total plant cover (%)	**10.80**	**0.50**	**33.83**	**16.27**	**11.77**	**8.25**				
No. of plant taxa/quadrat	**4.40**	**3.03**	**3.27**	**1.02**	**1.40**	**1.18**				
No. plant taxa/site	**9.00**	**5.66**	**5.33**	**1.08**	**6.67**	**2.16**				
Animals (% cover)										
Balanus glandula	3.20	2.80	0.90	0.31	0.43	0.19				
Balanus/Semibalanus spp.	0.00	0.00	0.00	0.00	0.40	0.40				
Balanus/Semibalanus spp. (set)	3.90	3.50	0.93	0.58	0.27	0.18				
Chthamalus dalli	2.15	1.85	1.33	1.08	0.47	0.07				
Mytilidae (spat)	0.40	0.40	0.13	0.09	0.07	0.03				
Mytilus cf. trossulus	0.20	0.20	0.33	0.28	0.13	0.13				
Semibalanus balanoides	25.65	25.15	2.83	2.58	0.10	0.06				
Semibalanus cariosus	0.30	0.30	0.00	0.00	0.00	0.00				
Total barnacles	35.20	33.60	6.00	4.03	1.67	0.82				
Total animal cover (%)	**35.80**	**33.80**	**6.47**	**3.85**	**2.03**	**1.13**				
No. of animal taxa/quadrat	**3.00**	**1.49**	**2.53**	**0.80**	**1.20**	**0.92**				
No. animal taxa/site	**4.50**	**0.71**	**4.33**	**0.41**	**3.67**	**0.82**				
Animals (No./0.25 m2)										
Ligia sp.	0.00	0.00	0.33	0.33	0.00	0.00				
Littorina scutulata	135.70	102.30	148.13	123.82	37.00	33.27				
Littorina sitkana	35.20	15.20	46.80	27.26	16.27	8.67				
Littorina spp. (juv.)	0.00	0.00	0.00	0.00	26.60	26.60				
Lottiidae	18.70	11.50	5.60	2.58	3.07	1.54				
Lottiidae (juv.)	0.00	0.00	0.00	0.00	0.40	0.23				
Nucella lima	0.20	0.20	0.00	0.00	0.00	0.00				
Pagurus hirsutiusculus	0.10	0.10	1.33	1.33	0.93	0.93				
No. of animals/quadrat	**190.00**	**99.00**	**202.27**	**117.07**	**84.33**	**23.39**				
No. animal taxa/quadrat	**3.20**	**1.55**	**3.80**	**0.67**	**2.80**	**0.92**				
No. animal taxa/site	**5.50**	**2.12**	**5.67**	**1.08**	**4.67**	**0.41**				
Dead organisms (% cover or no./0.25 m2)										
Balanus glandula (dead)	0.00	0.00	0.03	0.07	0.07	0.07				
Mytilus sp. (dead)	0.20	0.20	0.13	0.07	1.40	1.03				
Semibalanus balanoides (dead)	1.85	1.85	0.20	0.15	0.03	0.03				
Other (% cover)										
Rock	90.00	10.00	66.67	33.33	79.87	20.13				
Boulder/Cobble	9.55	9.45	30.80	30.80	18.20	18.20				
Gravel/Sand	0.50	0.50	2.53	2.53	1.93	1.93				
Oil cover	0.00	0.00	0.30	0.21	0.00	0.00				
Oil scale	0.00	0.00	2.00	1.44	0.00	0.00				
Water	0.25	0.05	0.07	0.07	1.40	1.40				
Number of stations	**2**		**3**		**3**					

Note: animals w/ means < 0.15 were hidden.

Table 2-2. Mean abundance (% or no./0.25 m2) of important epibiota at middle rocky stations, July 1995 (*p ≤ 0.10).

	Category 1		Category 2		Catagory 3			t-test		
Lumped taxon	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**ANOVA**	**1 vs 2**	**1 vs 3**	**2 vs 3**
Plants (% cover)										
Elachista spp.	0.78	0.78	2.15	1.74	0.88	0.28				
Encrusting brown algae	0.00	0.00	0.03	0.03	0.47	0.26				
Encrusting coralline algae	0.00	0.00	0.12	0.12	0.30	0.25				
Encrusting red algae	0.03	0.03	2.23	1.59	2.70	2.03				
Endocladiaceae	0.95	0.40	0.88	0.52	0.63	0.13				
Filamentous brown algae	0.40	0.10	1.62	0.81	0.75	0.13				
Filamentous green algae	2.98	2.58	1.88	0.78	1.35	0.42				
Flagelliform brown algae	0.03	0.03	0.32	0.16	0.42	0.08				
Fucus gardneri	33.25	11.25	39.23	14.06	19.13	4.54				
Fucus gardneri (germlings)	1.65	0.35	4.43	3.25	1.85	0.51				
Total Fucus	34.90	11.60	43.67	15.09	20.98	4.97				
Gigartinaceae	0.08	0.03	1.30	1.20	0.02	0.02				
Halosaccion glandiforme	0.00	0.00	0.57	0.54	0.08	0.02				
Misc. Chlorophyta	0.43	0.28	0.62	0.32	0.30	0.13				
Misc. Cyanophyta	0.03	0.03	0.25	0.23	0.22	0.11				
Misc. Phaeophyta	0.15	0.10	0.02	0.02	0.34	0.24				
Rhodomelaceae/Cryptosiphonia	1.88	0.93	0.97	0.51	2.85	1.17				
Soranthera ulvoidea	0.03	0.03	0.00	0.00	0.48	0.27				
Total plant cover (%)	**42.65**	**7.80**	**57.07**	**21.31**	**32.88**	**5.73**				
No. of plant taxa/quadrat	**4.35**	**1.46**	**7.03**	**2.85**	**7.08**	**2.69**				
No. plant taxa/site	**12.00**	**2.83**	**19.67**	**6.98**	**18.00**	**1.87**				
Animals (% cover)										
Balanus glandula	1.60	0.85	0.58	0.30	2.18	0.73				
Balanus/Semibalanus spp. (set)	2.90	2.35	9.60	4.01	5.10	3.33				
Chthamalus dalli	1.08	0.02	4.30	3.70	3.83	3.03				
Mytilidae (spat)	0.38	0.18	1.25	0.71	0.63	0.13				
Mytilus cf. trossulus	3.78	2.78	1.18	0.76	3.98	2.52				
Semibalanus balanoides	2.55	1.60	13.07	12.37	4.65	1.65				
Semibalanus cariosus	0.08	0.03	0.73	0.73	0.07	0.07				
Siphonaria thersites, eggs	0.13	0.13	0.18	0.18	0.03	0.03				
Total barnacles	8.20	3.15	28.28	13.53	15.83	4.70				
Total animal cover (%)	**12.50**	**0.10**	**31.00**	**13.07**	**20.68**	**3.55**				
No. of animal taxa/quadrat	**3.50**	**1.05**	**3.73**	**0.72**	**4.16**	**0.53**				
No. animal taxa/site	**6.50**	**0.71**	**6.00**	**1.87**	**5.33**	**1.08**				
Animals (No./0.25 m2)										
Gnorimosphaeroma oregonensis	0.00	0.00	0.13	0.13	0.20	0.20				
Lacuna spp.	0.25	0.25	0.10	0.10	0.00	0.00				
Littorina scutulata	58.30	50.70	17.50	10.52	105.73	69.69				
Littorina sitkana	79.90	48.40	23.73	17.32	24.47	9.77				
Littorina spp. (juv.)	0.00	0.00	5.83	5.83	1.60	1.60				
Lottiidae	28.10	6.40	30.37	8.85	50.23	6.43				
Lottiidae (juv.)	0.00	0.00	5.30	3.16	4.13	3.50				
Nemertea	0.05	0.05	0.17	0.17	0.03	0.03				
Nucella lamellosa	1.50	0.10	2.27	2.17	0.33	0.33				
Nucella lima	0.00	0.00	0.40	0.40	0.00	0.00				
Onchidella borealis	0.00	0.00	0.63	0.63	0.00	0.00				
Pagurus hirsutiusculus	7.30	1.50	3.30	1.21	9.43	5.08				
Siphonaria thersites	1.45	1.45	5.63	5.63	0.97	0.65				
No. of animals/0.25m2	**176.95**	**4.15**	**95.77**	**33.01**	**197.30**	**83.67**				
No. animal taxa/quadrat	**5.45**	**1.43**	**5.77**	**1.26**	**5.24**	**1.23**				
No. animal taxa/site	**10.50**	**2.12**	**11.67**	**3.56**	**10.33**	**1.08**				
Dead organisms (% cover or no./0.25 m2)										
Fucus gardneri (dead)	0.20	0.05	0.20	0.06	2.33	1.93				
Balanus glandula (dead)	0.25	0.05	0.22	0.17	0.25	0.03				
Balanus/Semibalanus spp. (dead)	0.03	0.03	0.17	0.08	0.02	0.02				
Chthamalus dalli (dead)	0.05	0.05	0.40	0.35	0.30	0.20				
Mytilus sp. (dead)	4.40	1.70	3.07	0.55	2.63	1.32				
Semibalanus balanoides (dead)	0.43	0.33	0.75	0.51	0.37	0.07				
Other (% cover)										
Rock	41.00	13.50	29.63	29.63	98.40	1.45				
Boulder/Cobble	47.45	16.65	66.22	28.85	0.87	0.82				
Gravel/Sand	8.55	6.15	3.98	3.02	0.73	0.64				
Mud	0.00	0.00	0.17	0.17	0.00	0.00				
Water	0.80	0.70	0.30	0.30	3.85	0.87				
Number of stations	**2**		**3**		**3**					

Note: animals w/ means < 0.15 were hidden.

Table 2-3. Mean abundance (% or no./0.25 m2) of important epibiota at Northwest Bay West Arm middle rocky stations; September 1989 (n = 4,4), July 1991 (n = 5,5), July 1992 (n = 5,5), July 1993 (n = 5,5), June 1994 (n = 5,5), and July 1995 (n = 5,5) (*p ≤ 0.10; **p ≤ 0.05; ***p ≤ 0.01).

	1989				1991				1992				1993				1994				1995			
		Category	Difference			Category	Difference			Category	Difference			Category	Difference			Category	Difference			Category	Difference	
Lumped taxon	Reference	3	(%)	t-test	Reference	3	(%)	t-test	Reference	3	(%)	t-test	Reference	3	(%)	t-test	Reference	3	(%)	t-test	Reference	3	(%)	t-test
Plants (% cover)																								
Elachista fucicola	a	a	b		3.8	0.1	-97	**	0.4	0	-100		0	0.2	b		0.7	1.0	43		0.2	1.4	600	
Encrusting coralline algae	1.4	0	-100		4.6	0.2	-96		2.7	0.2	-93		1.3	1.0	-23		1.2	0.9	-25		2.2	0.8	-64	
Encrusting non-coralline algae	9.5	12.0	26		18.0	9.4	-48		10.2	1.1	-89	**	14.1	7.5	-47		17.8	8.3	-53		7.8	7.6	-3	
Filamentous Chlorophyta	1.3	1.5	15		1.2	2.0	67		1.5	0.5	-67		6.6	0.9	-86	**	9.5	1.3	-86	**	3.1	2.1	-32	
Fucus gardneri	87.5	7.0	-92	**	88.0	34.4	-61	***	85.0	63.0	-26		74.0	65.4	-12		40.6	34.0	-16		45.8	13.0	-72	
Fucus gardneri (germlings)	a	a	b		2.4	2.4	0		0.8	0.2	-75	*	1.8	0.4	-78	**	3.8	0.6	-84		3.2	1.7	-47	
Gloiopeltis furcata	a	a	b		0.7	7.2	929	**	2.5	4.6	84		3.3	2.0	-39		2.2	0.3	-86	*	4.0	0.9	-78	*
Halosaccion glandiforme	0.4	0	-100		2.1	0	-100	**	1.0	0	-100	***	3.4	0	-100	**	4.2	0.1	-98	***	3.5	0.1	-97	**
Mastocarpus papillatus	0.9	0.6	-33		1.4	0	-100	**	1.0	0	-100		0	0	0		0.2	0	-100		0.9	0	-100	
Neorhodomela larix	6.3	0	-100		5.6	0.1	-98		6.1	0	-100		2.4	3.3	38		2.0	1.0	-50		3.2	3.0	-6	
Neorhodomela oregona	8.3	4.0	-52		11.4	3.4	-70	*	5.2	2.4	-54		5.6	2.2	-61		4.4	6.5	48		1.0	2.9	190	
Pilayella littoralis	a	a	a		8.4	0.1	-99	**	1.4	0.8	-43		2.2	1.0	-55		6.6	0.4	-94	**	6.6	1.0	-85	**
Total plant cover (%)	116.8	25.1	-79	**	149.40	61.8	-59	***	121.2	74.1	-39	***	124.0	88.4	-29	**	101.5	55.9	-45	**	85.0	35.0	-59	*
Number of plant taxa	7.0	3.5	-50	*	10.6	7.0	-34		12.2	4.8	-61		14.0	7.0	-50	**	15.2	8.2	-46	**	13.0	8.6	-34	**
Animals (% cover or no./0.25 m2)																								
Chthamalus dalli (%)	9.3	3.8	-59		23.6	15.5	-34		9.2	12.6	37		12.9	15.0	16		14.3	11.5	-20		9.6	9.9	3	
Littorina scutulata (#)	0.3	12.3	4000	**	10.2	312.8	2967	**	12.2	433.6	3454	***	2.0	16.2	710		10.2	52.2	412		14.4	51.8	260	*
Littorina sitkana (#)	1.8	1.8	0		62.6	11.6	-81	*	6.2	83.8	1252		0.6	1.6	167		19.2	2.4	-88		21.8	12.4	-43	
Lottiidae (#)	22.3	0.8	-96	**	47.0	22.4	-52		45.0	42.2	-6		60.4	31.8	-47		60.4	47.6	-21		62.8	38.6	-39	**
Mytilus cf. trossulus (%)	0	0.1	b		0.4	0.5	25		2.5	0.9	-64		0	0.1	b		0.1	0	-100		0	0	0	
Nucella lamellosa (#)	10.8	3.3	-69		7.0	0.6	-91	***	7.2	14.6	103		10.4	10.2	-2		8.4	3.8	-55		7.2	1.0	-86	*
Pagurus hirsutiusculus (#)	3.0	5.0	67		11.2	1.8	-84	**	7.8	2.8	-64	*	9.4	16.8	79		3.8	6.8	79		4.4	4.4	0	
Semibalanus balanoides (%)	0	0.1	b		0.7	18.9	2600		0.9	11.4	1167	**	0	0.4	b		0.1	0.1	0		0.5	1.7	240	
Siphonaria thersites (#)	3.8	0	-100	**	21.2	0.2	-99	***	63.2	3.2	-95	***	21.4	2.8	-87	**	36.4	10.2	-72	***	18.6	2.2	-88	**
Number of animal taxa	6.8	6.0	-12		7.8	6.6	-15		12.6	9.8	-22	**	11.2	16.0	43	*	11.6	10.0	-14		12.0	10.8	-10	
Dead plants (% cover)																								
Encrusting coralline algae	0.3	8.0	2567	**	0	0	0		0	0	0		0	0	0		0.6	0	-100		0.8	0	-100	
Fucus gardneri	1.5	7.6	407		0.2	0.3	50		0.2	0	-100		0	0.2	b		0.5	0.3	-40		0.4	6.2	1450	
Oil cover (%)	0	22.5	b	**	0	0	0		0	0	0		0	0	0		0	0	0		0	0	0	

a Abundance not documented.

b Percent change not calculable.

Table 2.4. Mean abundance (% or no./0.25 m2) of important epibiota at Northwest Bay Islet lower rocky station, July 1995.

Lumped taxon	Category 3 Mean
Plants (% cover)	
Elachista spp.	1.50
Encrusting brown algae	5.70
Encrusting coralline algae	1.40
Encrusting red algae	7.90
Endocladiaceae	0.30
Filamentous brown algae	2.55
Filamentous green algae	5.05
Filamentous red algae	0.70
Flagelliform brown algae	0.60
Foliose green algae	1.75
Fucus gardneri	57.10
Fucus gardneri (germlings)	1.30
Total Fucus	58.40
Gigartinaceae	2.55
Halosaccion glandiforme	1.20
Misc. Chlorophyta	0.15
Misc. Cyanophyta	0.15
Misc. Phaeophyta	0.15
Palmaria spp.	0.20
Rhodomelaceae/Cryptosiphonia	9.85
Total plant cover (%)	**100.35**
No. of plant taxaa/quadrat	**32.00**
No. of plant taxa/site	**22.00**
Animals (% cover)	
Balanus glandula	0.30
Balanus rostratus	0.30
Balanus/Semibalanus spp. (set)	0.75
Chthamalus dalli	0.90
Encrusting bryozoan	0.30
Mytilidae (spat)	0.40
Total barnacles	2.40
Total animal cover (%)	**3.30**
No. of animal taxa/quadrat	**3.10**
No. of animal taxa/site	**9.00**
Animals (no./0.25m2)	
Spirorbidae	0.30
Lacuna spp.	0.50
Littorina scutulata	3.10
Littorina sitkana	0.40
Littorina spp. (juv.)	0.70
Lottiidae (juv.)	105.20
Margarites spp.	0.40
Nemertea	0.40
Pagurus hirsutiusculus	14.50
Pisaster ochraceus	0.20
Pycnopodia helianthoides	0.20
No. of animals/quadrat	**126.35**
No. of animal taxa/quadrat	**6.00**
No. of animal taxa/site	**15.00**
Dead organisms (% cover or no./0.25 m2)	
Fucus gardneri (dead)	0.15
Balanus/Semibalanus spp. (dead)	0.55
Chthamalus dalli (dead)	0.15
Hiatella arctica (dead)	0.40
Mytilus sp. (dead)	1.80
Other (% cover)	
Rock	97.50
Boulder/Cobble	0.60
Gravel/Sand	1.70
Mud	0.20
Number of stations	**1**

Biological Conditions

Ten rocky sites were sampled at one or more elevations in July 1995 (see Table 1-1). The rocky sites included three Category 1, four Category 2, and four Category 3 sites. Detailed data on taxon abundances by individual station are provided in Appendix Tables B-1 through B-3.

Upper Rocky Stations

Upper rocky stations were examined at eight sites in July 1995. These included two Category 1 sites (Bass Harbor and Eshamy Bay) and three each at Category 2 (Herring Bay, Outside Bay, and Snug Harbor) and Category 3 (Block Island, Mussel Beach, and Northwest Bay Rocky Islet) sites. The dominant plants at upper rocky stations in all three categories of sites were rockweed and the lichen *Verrucaria*. The dominant animals were barnacles, especially *Semibalanus balanoides* and littorine snails, especially *Littorina scutulata*. Plant and animal cover was sparse.

Significant category effects were found in two biological variables at upper rocky stations in 1995 (Table 2-1). The barnacle *Semibalanus balanoides* and limpets (Lottiidae) were both more abundant at Category 1 sites than at Category 3 sites. Littorines were more than two times as abundant, on average, at Category 1 and 2 upper stations than at Category 3 upper stations but variability was relatively high and the differences were not significant.

At upper rocky stations, rockweed (*Fucus gardneri*) was found at low abundance at all categories through 1991 (Figure 2-1, upper) reflecting the initial selection in 1989 of upper stations at the top of the obvious zone of attached macrobiota. By 1992 the mean percent cover of *Fucus* at oiled upper stations (both Category 2 and 3) began to increase markedly compared with Category 1 stations (Figure 2-1). *Fucus* cover at the Category 2 and 3 upper stations increased through 1993 (to 15.4 and 8.7 mean percent cover, respectively) then declined slightly in 1994 and 1995. The natural variation in cover for rockweed at the upper elevation in the study area from 1989 to 1995 ranged from 0.3 to 2.5 percent. This range of natural variation is defined as ±3 standard errors around the mean for the annual means of the reference sites over the duration of the program and is shown on Figure 2-1. Average cover for rockweed at Category 1 upper stations demonstrated an increase above this range in 1995 as it returned to near the cover observed for the reference sites in 1989. Rockweed cover at Category 2 and 3 sites has averaged above the natural range of cover observed at

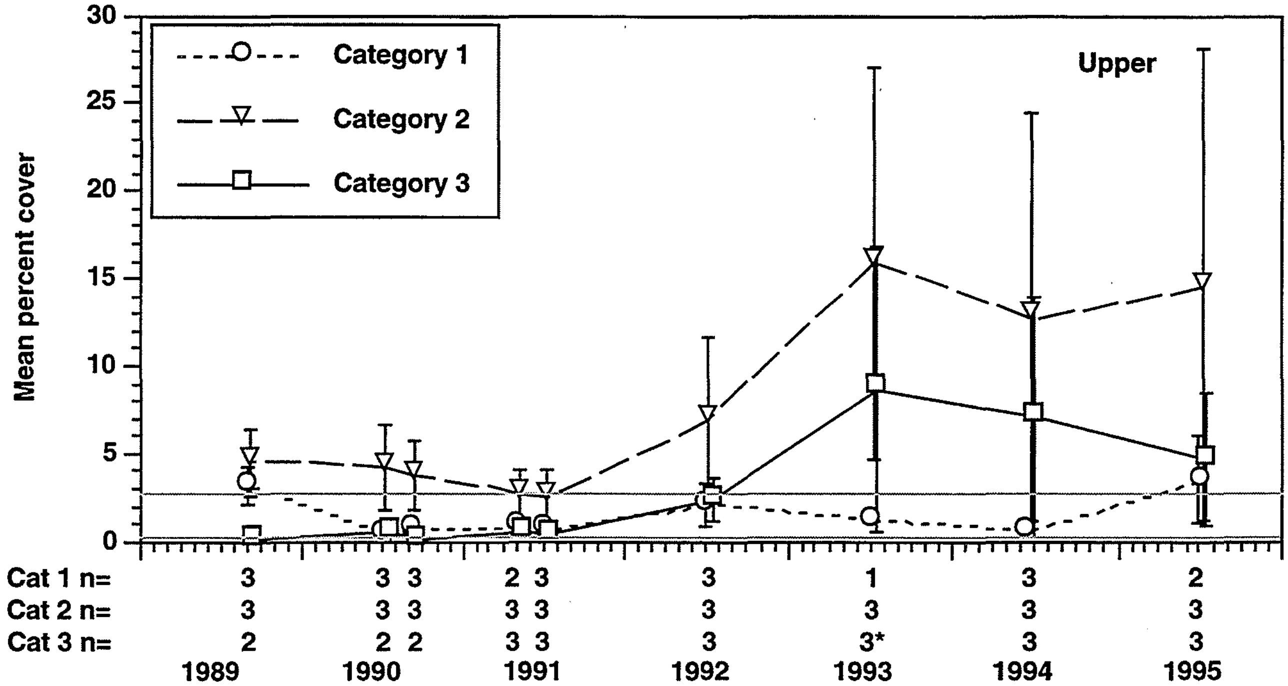
Category 1 sites continuously since 1992, demonstrating that the initial selection of the upper elevation stations was inconsistent.

Fauna associated with the *Fucus* community, such as the periwinkles *Littorina scutulata* and *L. sitkana*, showed somewhat similar changes in abundance to rockweed during this period but generally demonstrated greater similarity among categories than rockweed and relatively high consistency in temporal patterns for abundance between species. Both species have exhibited substantial variability in abundance over the duration of the program (Figure 2-2). The apparent upper limit of attached macrobiota had been influenced (lowered) by oiling and treatment effects in 1989.

The mean density of Lottiidae (limpets) at Category 1 sites was consistently greater than the density at the oiled sites through 1992 (Figure 2-3). The sharp decline in abundance for Category 1 in 1993 reflects, at least partially, that the single upper Category 1 station (Eshamy Bay) sampled that year has consistently had lower densities of Lottiidae than the other Category 1 upper stations. Lottiidae abundance at Category 2 and 3 sites exhibited strong similarity from 1989 through 1995 except for a slight divergence in 1995. Only after 1993 did average abundance for lottiids rise to within the normal range of abundance observed at the Category 1 upper stations. Average abundance at Category 1 upper stations was considerably more variable than in the other upper stations, both among stations during a survey and over the duration of the program (Figure 2-3).

Middle Rocky Stations

Middle rocky stations were examined at eight sites in July 1995. These included two Category 1 sites (Crab Harbor and Eshamy Bay) and three each at Category 2 (Herring Bay, Outside Bay, and Snug Harbor) and Category 3 (Block Island, Northwest Bay Rocky Islet, and Northwest Bay West Arm) treated sites. Plant cover at middle rocky stations in all three site categories was strongly dominated by rockweed. The dominant animals were barnacles, especially *Semibalanus balanoides*; limpets; littorine snails, especially *Littorina sitkana*; and the hermit crab *Pagurus hirsutiusculus*. Plant cover was moderate but animal cover was sparse. The primary predators at the middle rocky stations, the drills *Nucella lima* and *N. lamellosa*, feed mainly on barnacles and mussels; of these two species, the latter is more abundant.



* Includes estimated *Fucus* cover for NW Bay Rocky Islet determined from quadrat photographs.

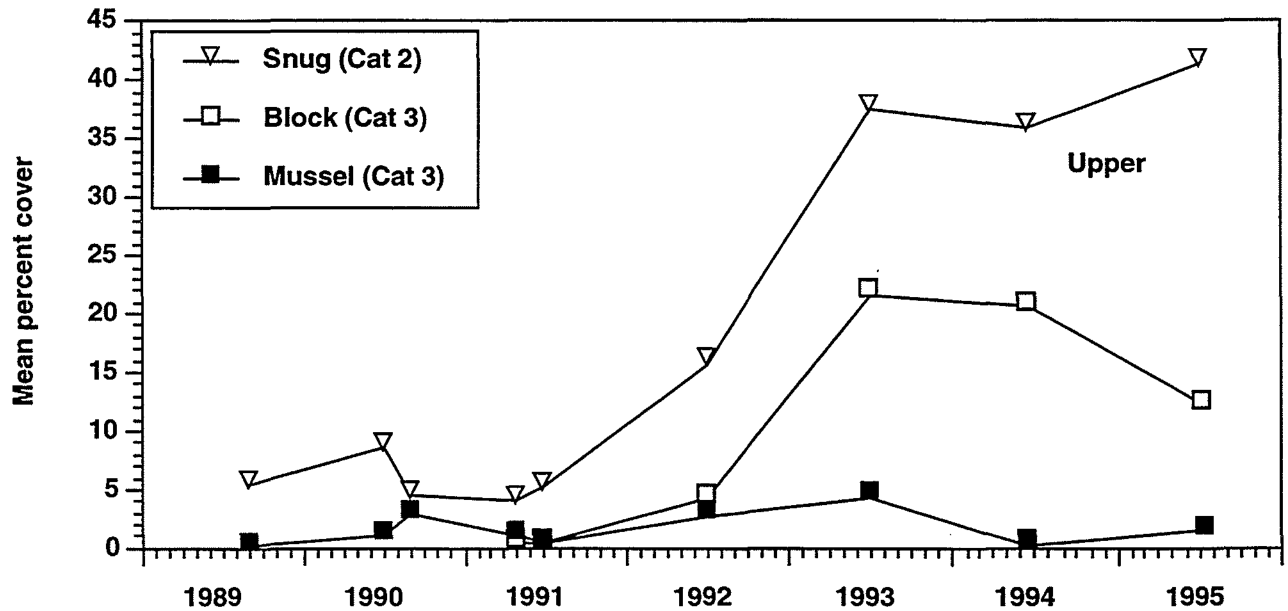


Figure 2-1. Mean percent cover (±1 SE) of Fucus from upper rocky stations, by category and from selected upper rocky stations 1989-95. Number of stations sampled (n) for each category shown below axis. Gray dashed lines represent range of natural variation (±3 SE around mean of annual means(of reference site.)

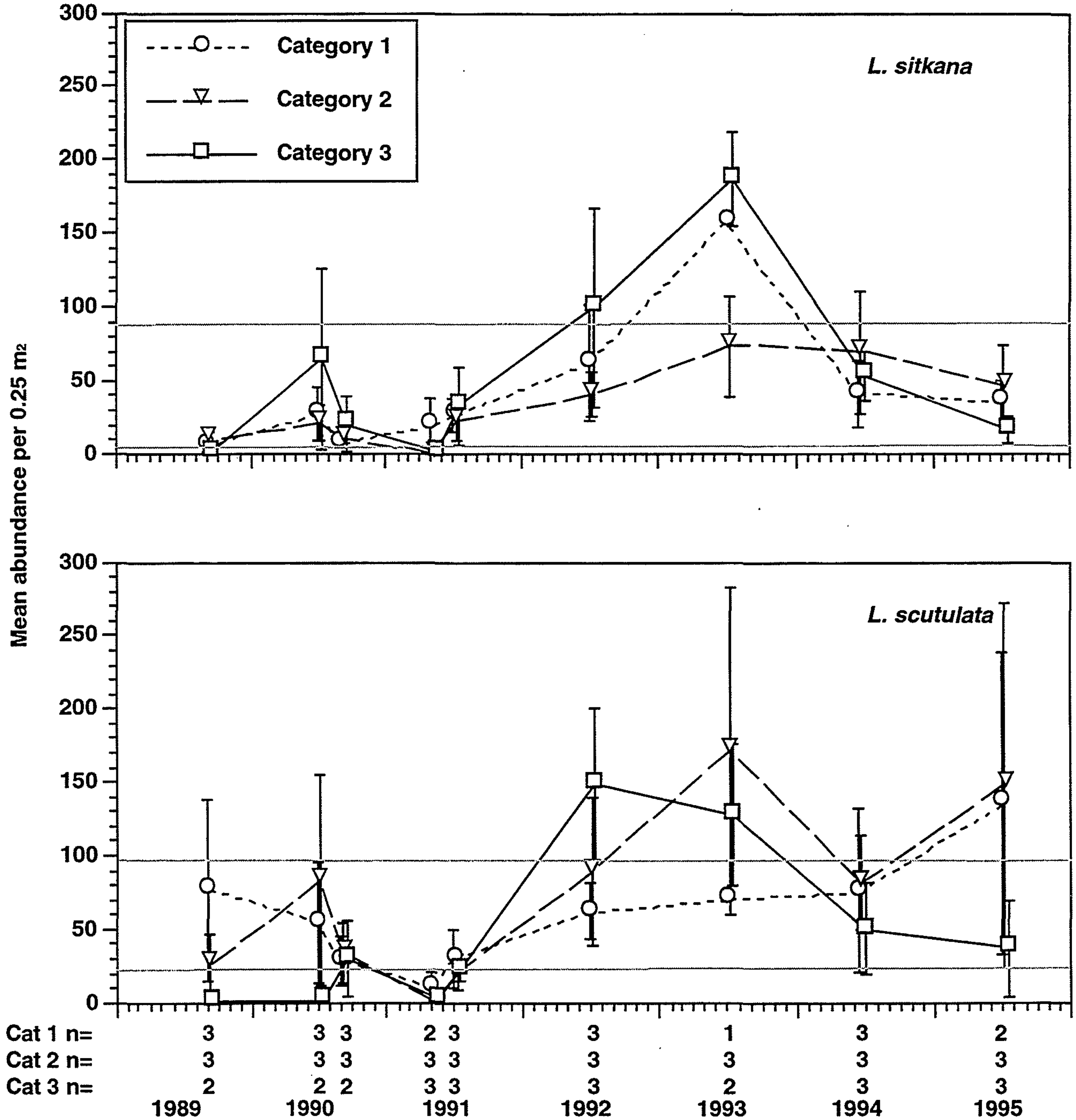


Figure 2-2 Mean abundance (±1 SE) of littorine snails from upper rocky stations, by category 1989-1995.

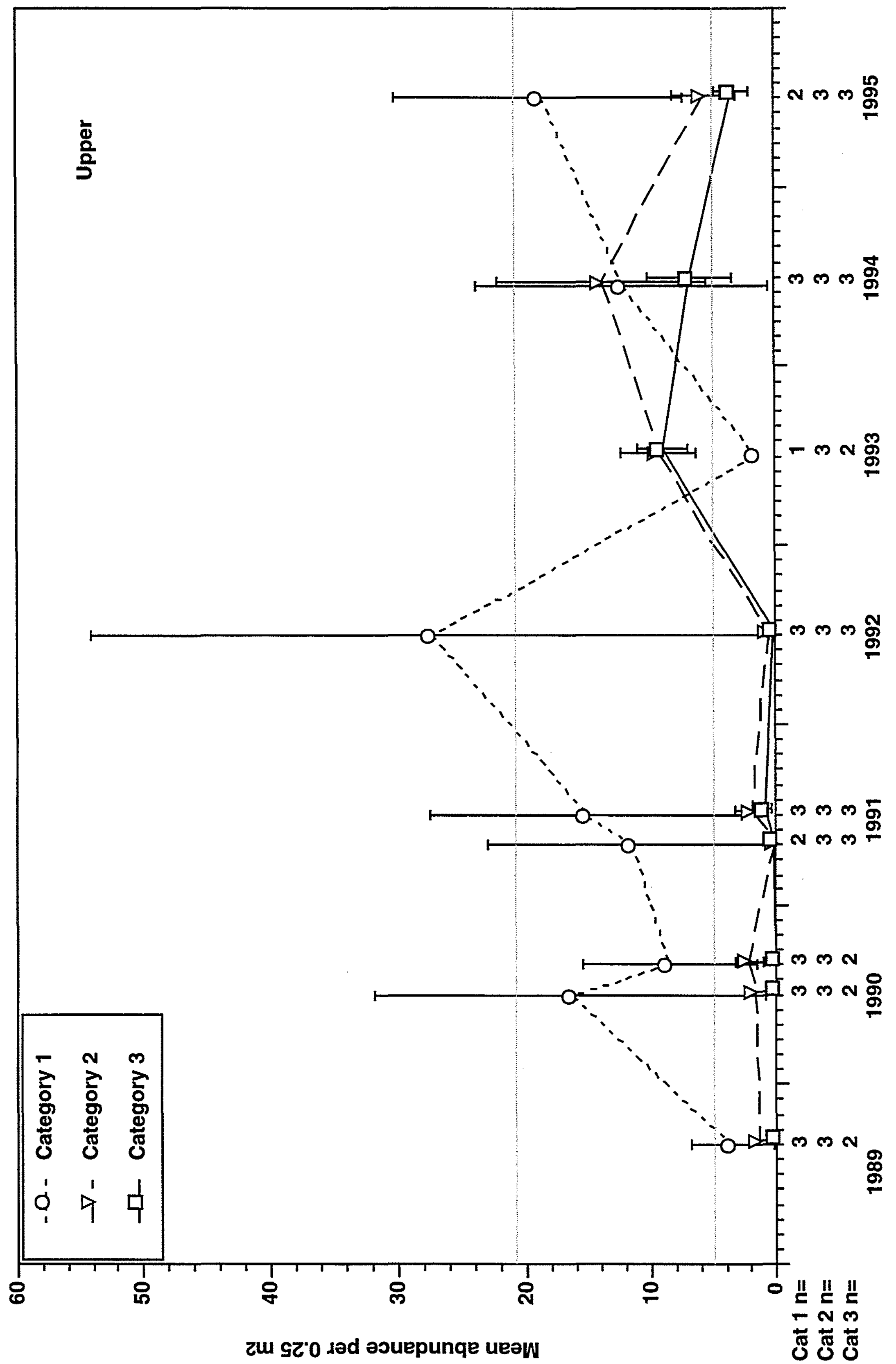


Figure 2-3. Mean abundance (±1 SE) of Lottiidae from upper rocky stations, by category 1989-95.

Only one biologically and statistically significant category effect was observed at the middle stations. Numbers of plant taxa were significantly lower at Category 1 sites than at Category 3 sites (Table 2-2), a difference not seen in prior years.

In 1995, rockweed continued a trend predicted in 1990 and first observed in 1994. Mean cover of *Fucus* declined in all three categories from the cover seen in the original surveys in 1989 until at least 1991 or 1992 (Figure 2-4). Lowest cover was observed in July 1990 at Category 3 sites and in May 1991 at Category 2 sites. Starting in 1991, *Fucus* cover at the oiled middle stations increased through 1993 until mean percent cover exceeded the mean for the Category 1 sites. Rockweed apparently lives four to five years. Because of the severity of the shoreline treatment, rockweed populations at Category 3 sites were severely damaged, leaving a considerable amount of rock surface available for recruit–ment (Figure 2-5). As a consequence, recruitment of germlings was heavy in 1990 at all Category 3 sites and some Category 2 sites. At those sites, the rockweed populations became dominated by a single year class. Thus, four to five years later, starting in 1994, *Fucus* cover decreased at Category 2 and 3 sites, probably reflecting a general senescence of the mature rockweed community at these stations (Figure 2-4). *Fucus* cover at the unoiled Category 1 sites fluctuated moderately over that period, but the long-term trend appears to be relatively stable compared to the trends found at the oiled sites. *Fucus* germling recruitment at the Category 1 middle stations has varied over time but has averaged approximately one percent cover during the seven years of the study (Figure 2-5). The higher cover by mature *Fucus* at the oiled sites in 1993 is attributed to the greater recruitment and increased survival of *Fucus* germlings at Category 2 and 3 sites in 1990 and 1991. Abundance of *Fucus* germlings achieved a hiatus in 1992, but since then cover has increased continuously, most notably at Category 2 sites in 1995. Variability in cover by *Fucus* germlings has been substantially less at Category 1 sites than at Category 2 and 3 sites, where annual averages have been outside the normal range for Category 1 sites the majority of the time (Figure 2-5).

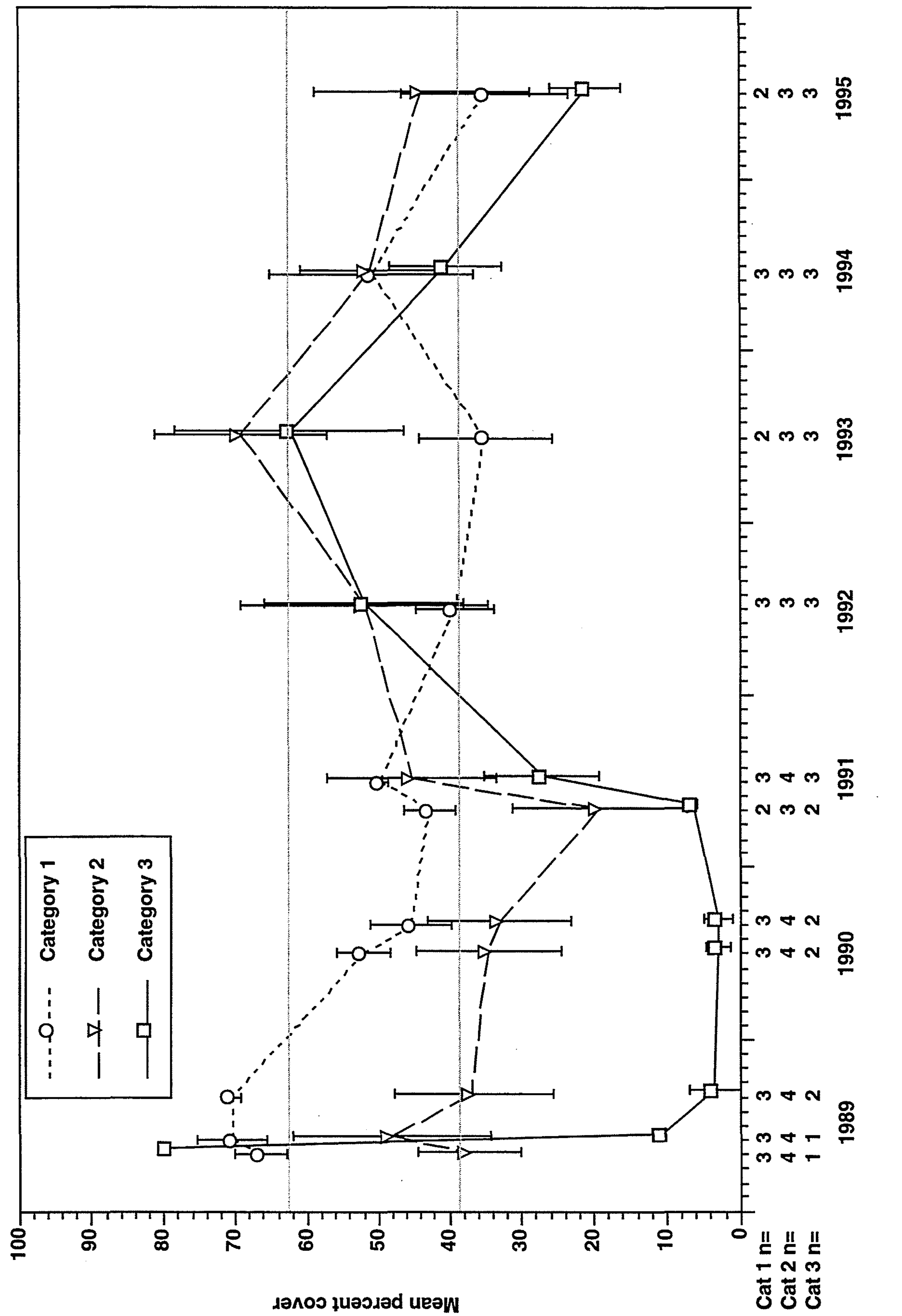


Figure 2-4. **Mean percent cover (±1 SE) of *Fucus* from middle rocky stations, by category 1989-95.**

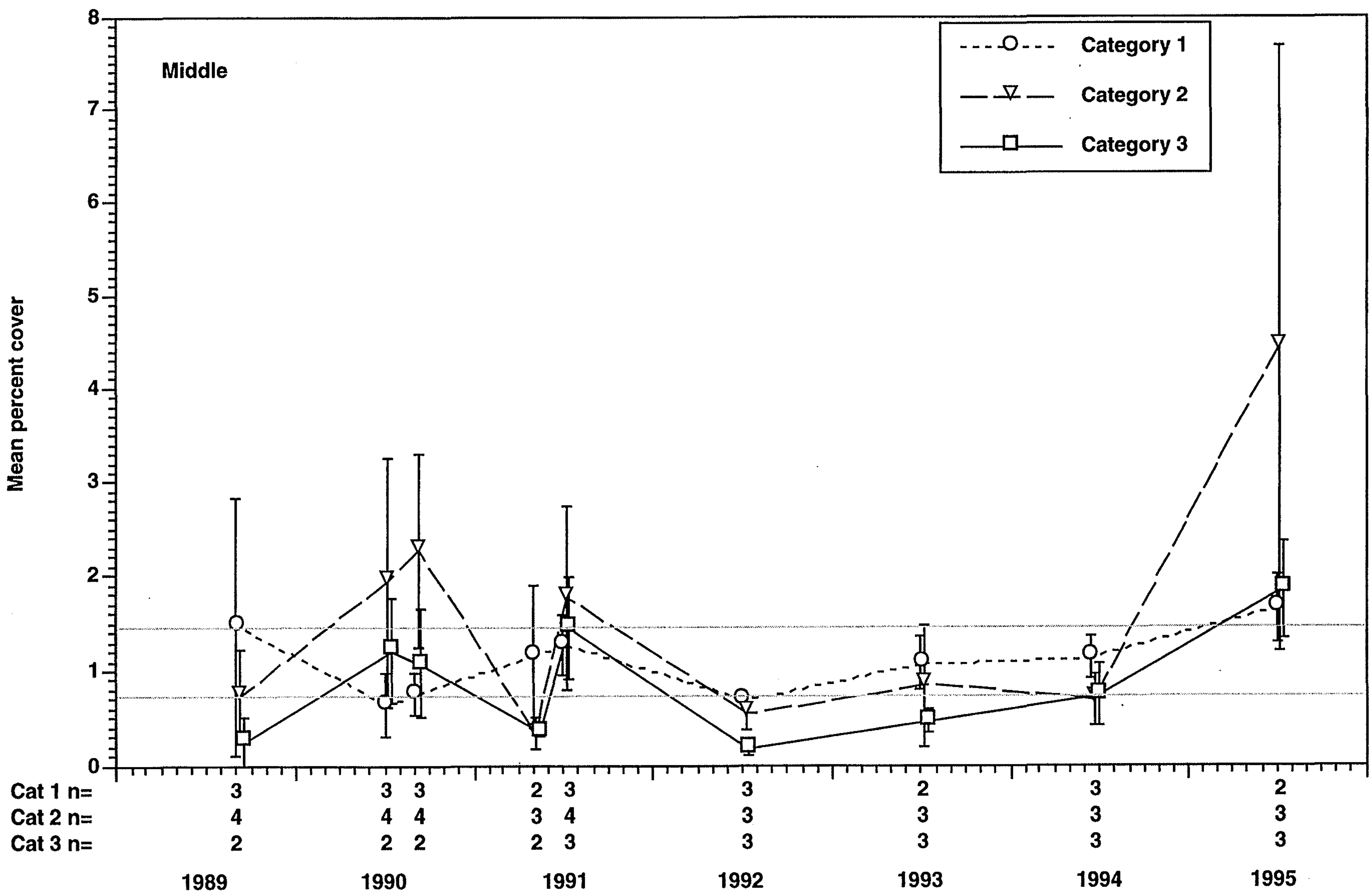


Figure 2-5. Mean percent cover (±1 SE) of *Fucus* germlings from middle rocky stations, by category 1989-95.

Average abundance for both species of littorines decreased at Category 1 middle stations in 1990 and 1991; minimum density observed for the program was observed in 1991 (Figure 2-6). Since then, fluctuations in density have generally remained within the normal range of variation observed for the entire program for the respective species. In the case of *Littorina sitkana,* fluctuations for all three treatment categories have been quite similar since 1991. For *L. scutulata,* fluctuations for Category 2 and 3 sites have been similar since 1991, but abundance at Category 3 sites has been substantially higher than at the other sites and varied dramatically. Littorines have been declining slightly at Category 2 and 3 sites since 1993 (Figure 2-6).

Average abundance of limpets (adults and juveniles) has increased appreciably since 1989 in all treatment categories. Limpets at Category 1 middle stations have gradually increased by nearly 100 percent since 1989; this increase appears to define the range of natural variation for the reference sites. Limpet abundance at Category 2 middle stations approximated these changes very closely until 1992. Since then limpet abundance at these stations has exceeded abundance at Category 1 sites by about 30 percent. Average limpet abundance at Category 3 middle stations has increased from virtually none in 1989 to over $50/m^2$ in 1995. In 1995, Category 3 middle stations had higher densities than Category 1 or 2 sites, a complete turnaround in the situation from 1989 through 1991 (Figure 2-7).

With the exception of Category 3 middle stations in June and September 1989, mussel cover at mid intertidal rocky sites has been relatively well synchronized (Figure 2-8). Moreover, average densities have fallen within the normal range for the Category 1 sites. In relative terms, densities have oscillated across a range of 300 to 400 percent over the course of the program but, except for the very low densities at Category 3 stations in 1989, cover has remained fairly stable at about 1 to 8 percent. The period of the oscillation appears to exceed seven years. Exceptions to this pattern were found at Outside Bay (Category 2; Appendix Table B-2) and Northwest Bay West Arm (Category 3; Table 2-3) where mussel populations have remained low since 1989.

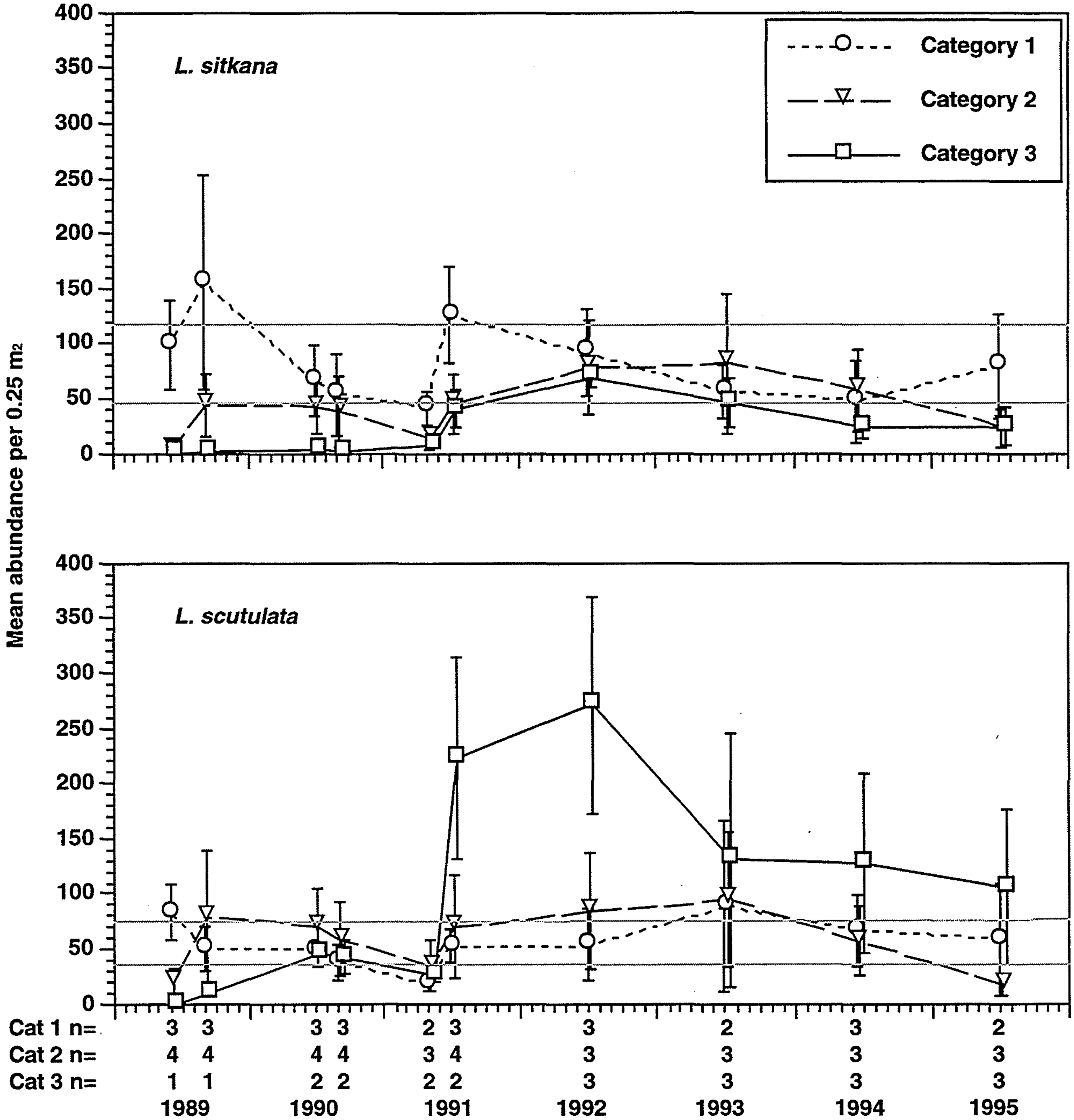


Figure 2-6. Mean abundance (±1 SE) of littorine snails from middle rocky stations, by category 1989-95.

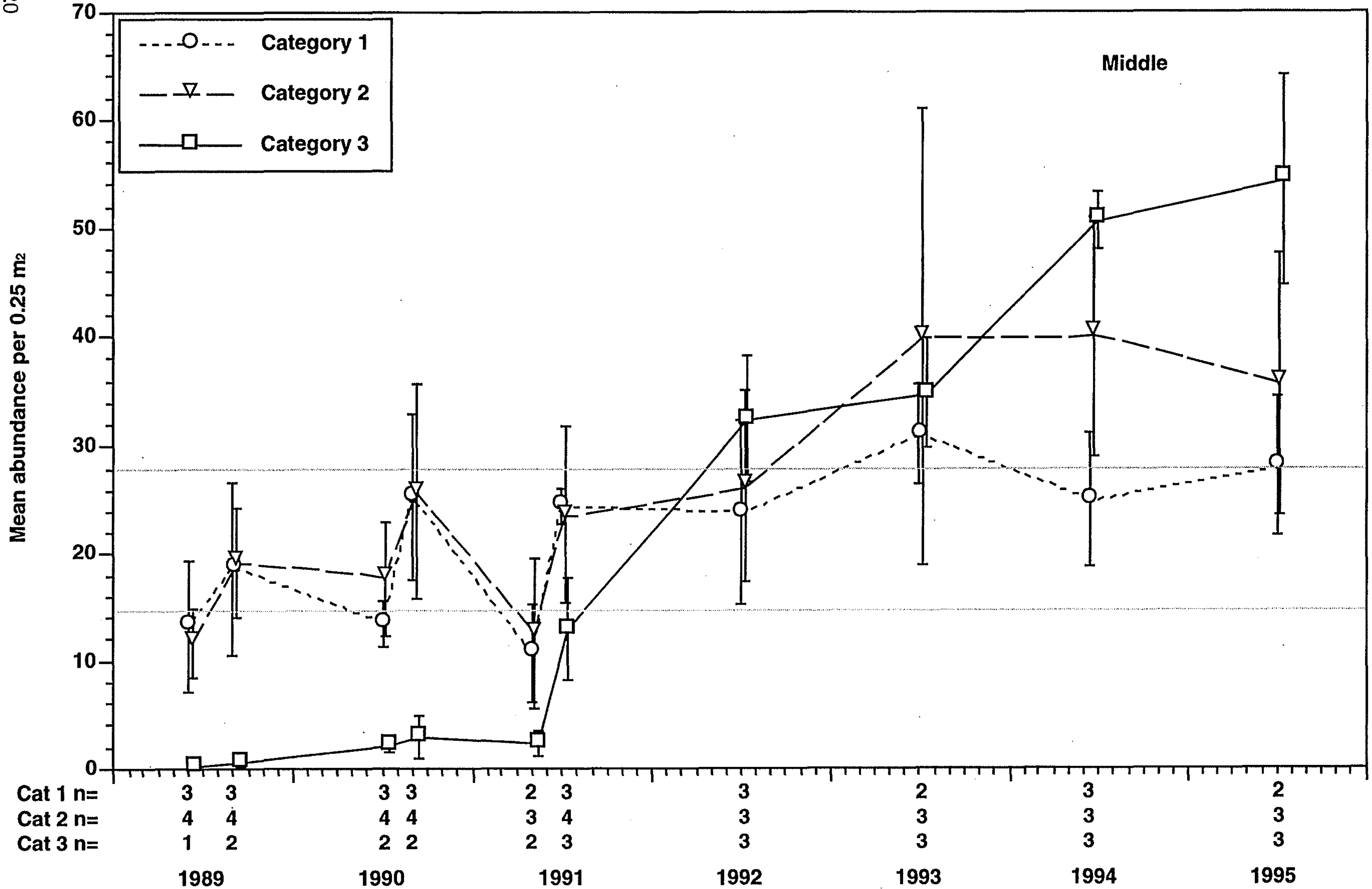


Figure 2-7. Mean abundance (±1 SE) of Lottiidae from middle rocky stations, by category 1989-95.

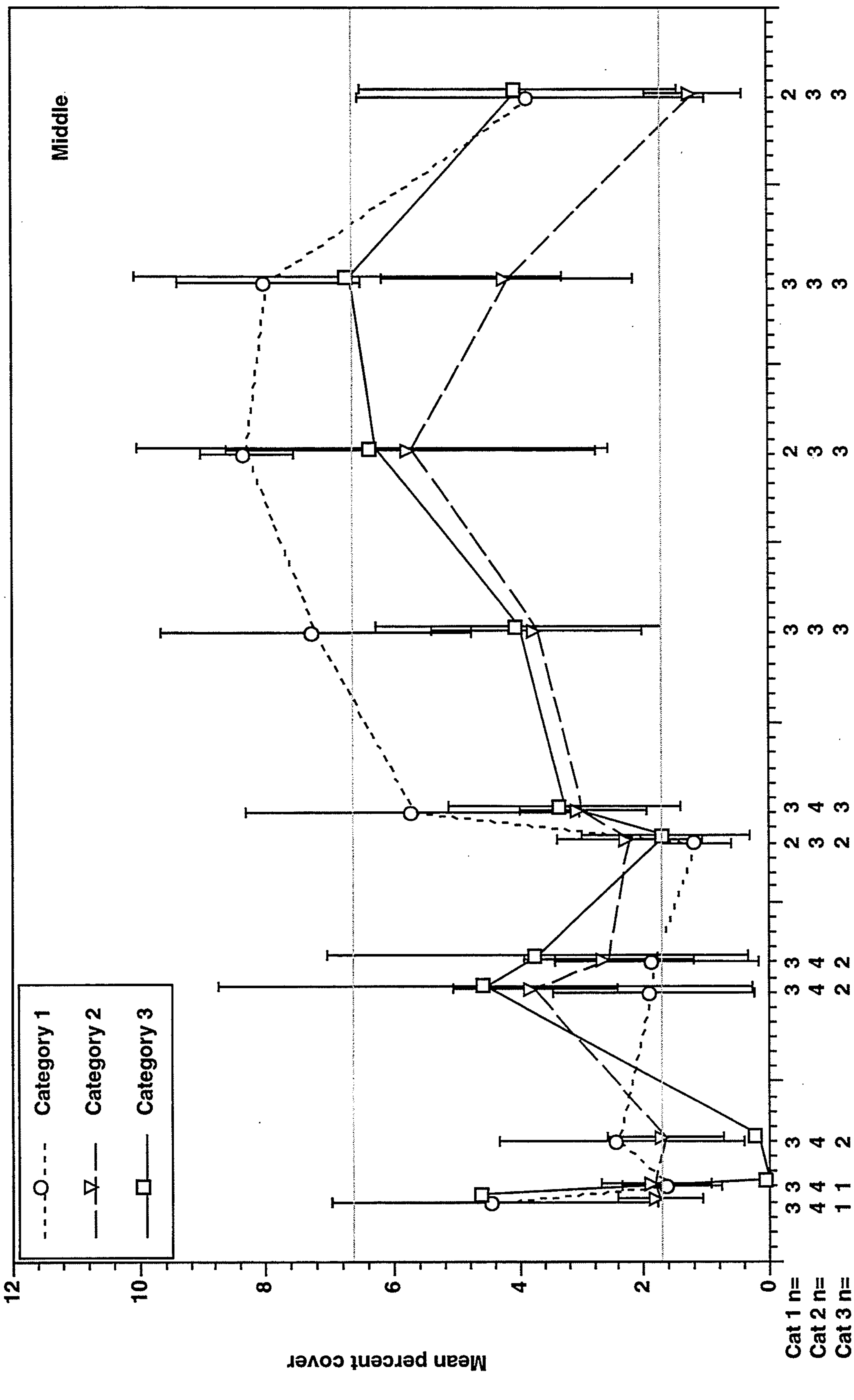


Figure 2-8. Mean percent cover (±1 SE) of mussels from middle rocky stations, by category 1989-95.

With the exception of very low cover at Category 3 middle stations from 1989 through May 1991, barnacle cover has remained generally within the normal range observed for the Category 1 middle stations (Figure 2-9). Fluctuations in barnacle cover do not appear to be synchronized, however. Barnacle cover at Category 2 middle stations has been somewhat more stable than at Category 1 middle stations that, in later years, has fluctuated about 400 percent. Since 1991, barnacle cover at Category 2 middle stations has consistently increased, whereas, it has decreased at Category 3 stations. Barnacle populations, severely impacted at Category 3 sites during treatment in 1989, rebounded in the summer of 1991 when a large set of the opportunistic barnacle *Semibalanus balanoides* contributed to a higher cover at Category 3 sites than at the Category 1 or 2 sites.

Density of the drill *Nucella* at Category 1 middle stations has exhibited long-term cycles with a period of about five years during this program. It declined from 1989 to 1991 at the Category 1 sites, increased considerably from 1991 through 1994, and then declined substantially in 1995 (Figure 2-10). This cycle probably reflects a response to combined changes in cover of mussels and barnacles, the favored prey of both species of *Nucella*. *Nucella* abundance at Category 2 sites increased from 1991 through 1993 and declined in 1994, following a pattern similar to that shown by mussels (Figure 2-8). *Nucella* abundance at Category 3 sites peaked in 1992 and has then declined continuously through 1995. Over that period, barnacle cover (Figure 2-9) has declined consistently whereas mussel cover increased until 1994 and then declined substantially. Generally, *Nucella* density at oiled sites has remained either slightly below or in the lower half of the normal range of density and has been considerably less variable than has been observed at the Category 1 middle stations.

Northwest Bay West Arm Middle Stations

When first sampled in September 1989, the Category 3 middle station at the Northwest Bay West Arm rocky site had significantly greater oil cover and significantly greater cover by dead coralline algae (both $p < 0.05$) than did the adjacent (also oiled) reference site that did not appear to have been hot-water washed (Table 2-3). This, and the other patterns described below, suggest that the treatment was both ineffective at oil removal and immediately damaging to the epibiota.

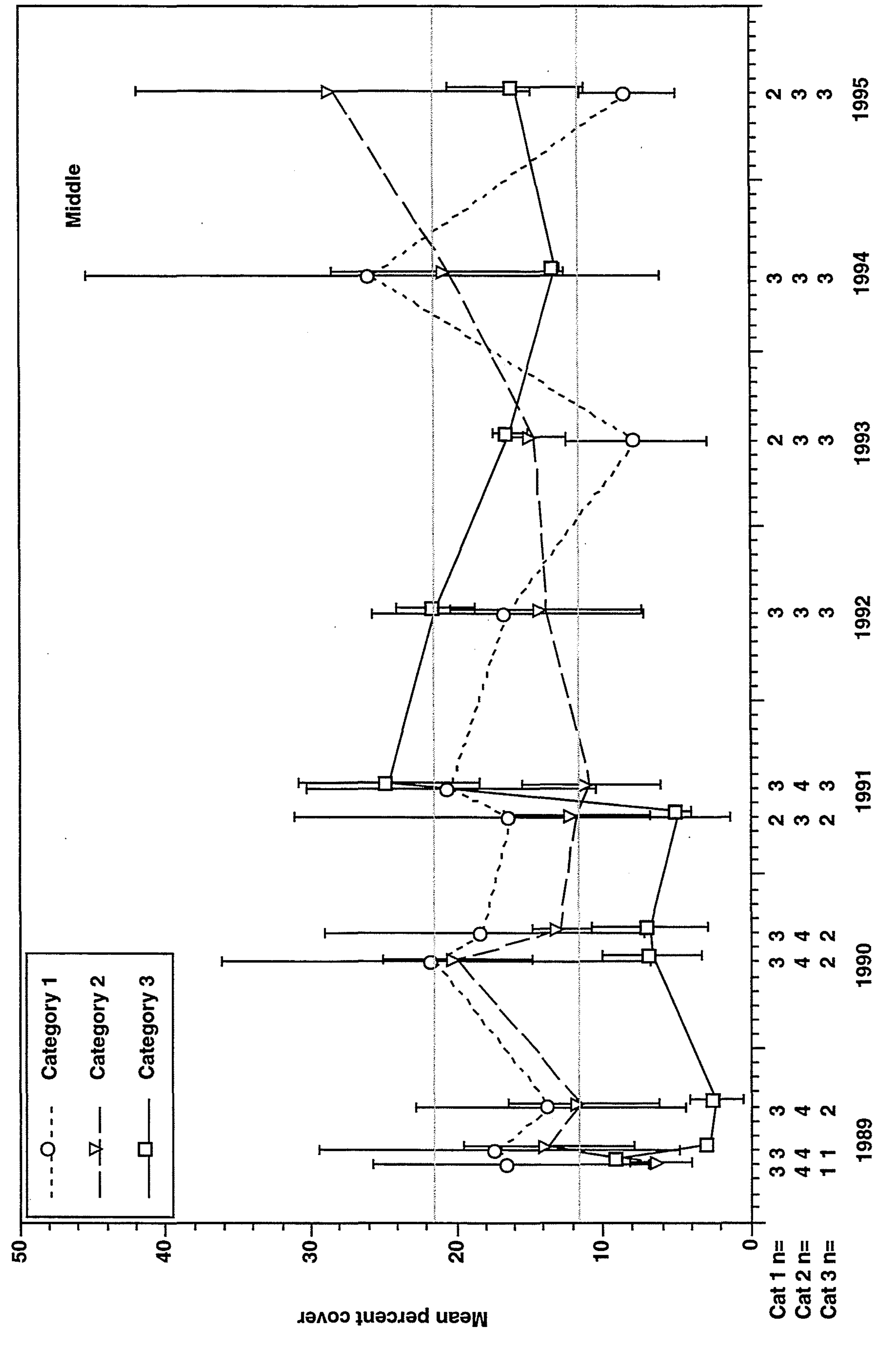


Figure 2-9. Mean percent cover (±1 SE) of Balanomorpha from middle rocky stations, by catgegory 1989-95.

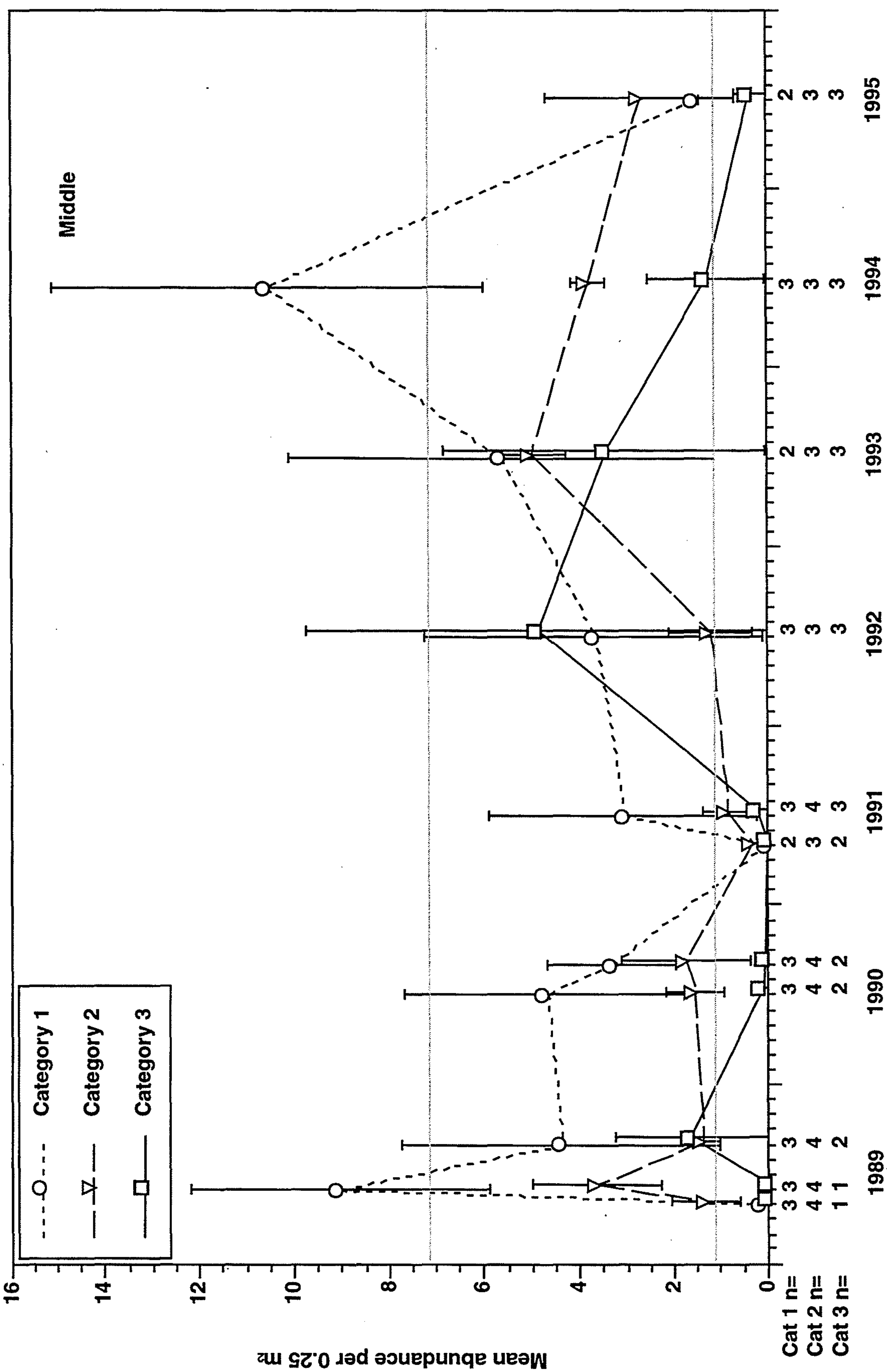


Figure 2-10. Mean abundance (±1 SE) of *Nucella* from middle rocky stations, by category 1989-95.

In an apparent reversal of previous trends, the number of significant differences between the two stations, which had decreased through 1993, increased in 1995 (Table 2-3). This reversal suggests some destabilization of the normal biological controls at the Category 3 station, possibly as a consequence of the senescence of *Fucus*. It appears that full recovery may still be several years away. The degree to which differences are the result of slight differences in wave exposure at the two sites is uncertain but will become clearer over time.

Algal cover has been dominated by rockweed (*Fucus*) since 1989 at the reference station and since 1990 at the Category 3 station. Total cover by algae and *Fucus* at the reference station remained relatively constant from 1989 through 1993 (Table 2-3; Figures 2-11 and 2-12). The slight decline in *Fucus* cover that began in 1993 led to a sharp die-off in 1994 (Figure 2-12); *Fucus* cover seemed to stabilize in 1995. Total cover by algae and *Fucus* at the Category 3 middle station increased steadily after 1989 (based on photo documentation) and showed substantial recovery by July 1993 relative to the adjacent middle reference station. However, total algal cover has never been more than 65 percent of that observed at the reference station. *Fucus* cover at the Category 3 station declined consistently from 65 percent in 1993 to 13 percent in 1995 because of the senescence of the dominant year class that had set as germlings in 1989 following treatment.

The mean number of algal taxa at the reference station increased from 1989 through 1993, possibly showing some recovery from effects of oiling but more probably associated with increasing taxonomic sophistication of the investigators (Figure 2-11). The number of algal taxa declined at the Category 3 station from 1991 to 1992 but increased again in 1993 and stabilized until 1995. The difference in mean total number of algal taxa between the two stations had increased in 1992, a trend contrary to the recovery and probably the result of increased *Fucus* dominance that excluded some other species; this difference has diminished consistently since 1993 (Figure 2-11; Table 2-3).

Patterns in cover by the opportunistic red alga *Gloiopeltis furcata* have differed substantially between the two middle stations at the Northwest Bay West Arm rocky site. *Gloiopeltis* was significantly more abundant at the more disturbed Category 3 station in 1991 but declined steadily with the increased *Fucus* cover until 1994. In contrast, cover increased at the reference station such that it was greater at the reference station than at the Category 3 station in 1994 and 1995 (Figure 2-13).

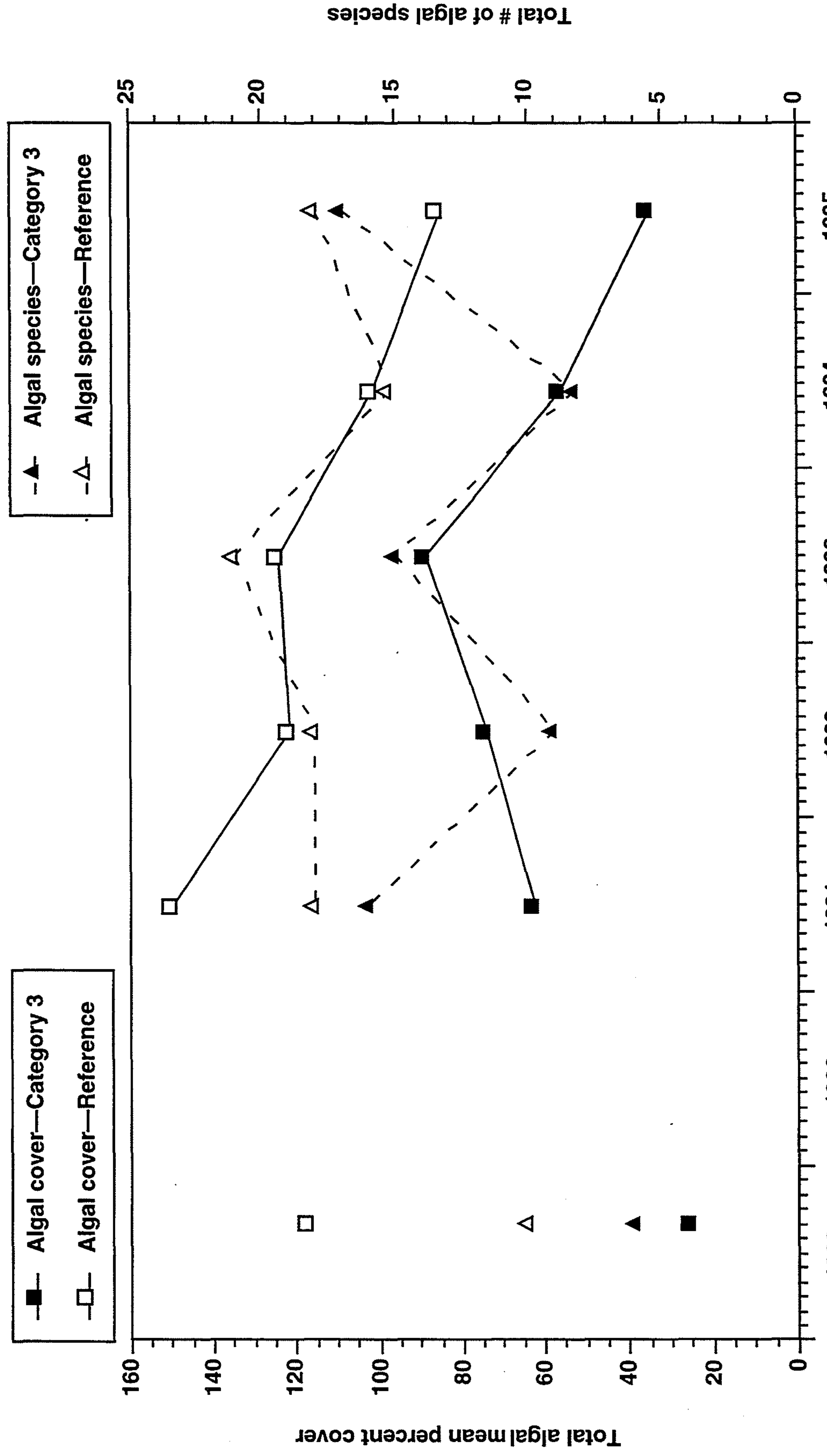


Figure 2-11. Mean percent total algal cover and total number of algal species' site from the Northwest Bay West Arm middle rocky stations, 1989-95.

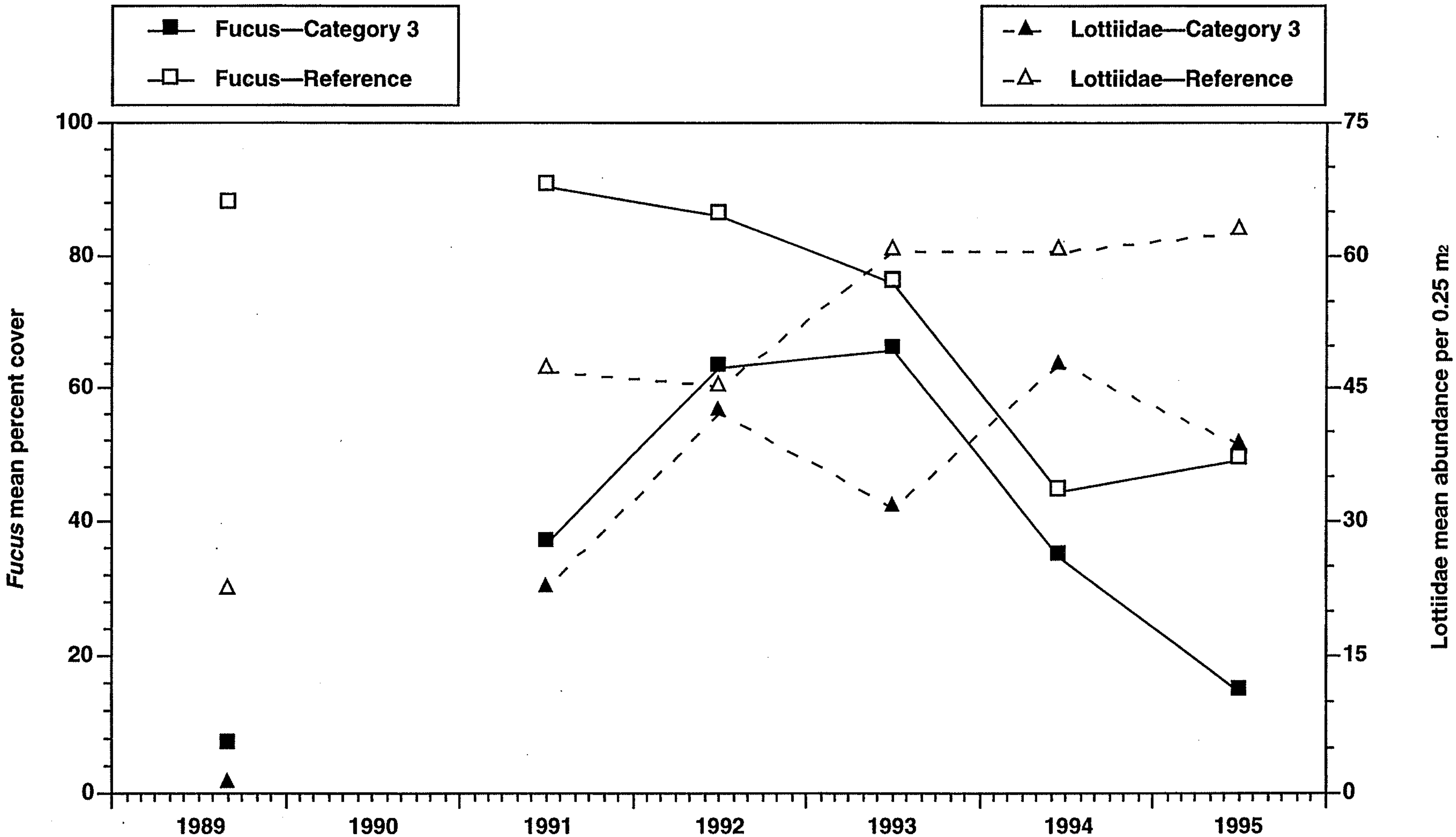


Figure 2-12. Mean percent cover of *Fucus* and mean abundance of Lattiidae from Northwest Bay West Arm middle rocky stations, 1989-95.

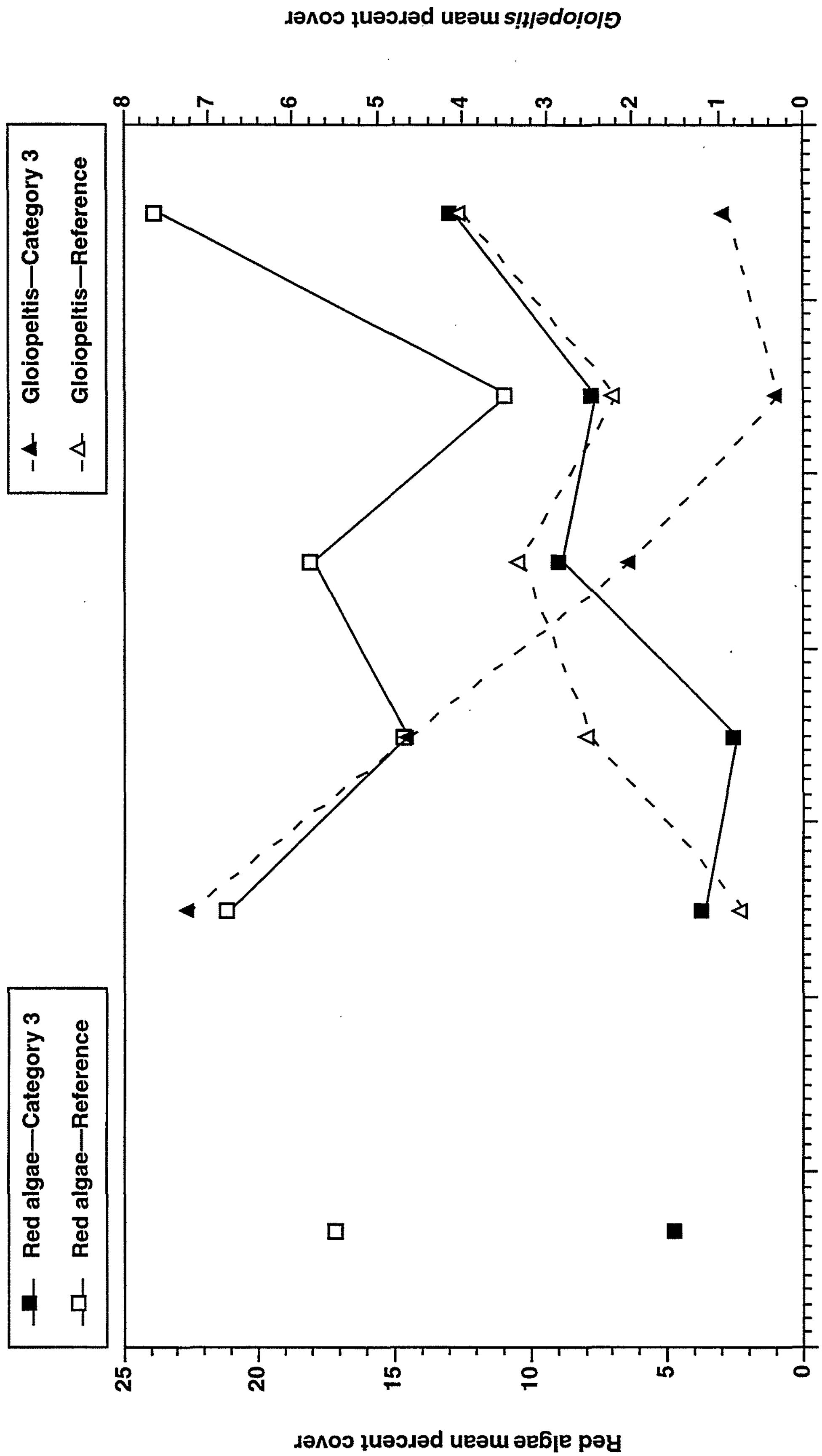


Figure 2-13. Mean percent cover of total erect red algae and *Gloiopeltis* from the Northwest Bay West Arm middle rocky stations, 1989-95.

The cover of erect red algae other than *Gloiopeltis* has varied between 11 and 24 percent at the reference station since 1989 (Figure 2-13). Until 1992, red algal cover was low (less than 5 percent) at the Category 3 station following treatment, but has climbed to about 12 percent in 1995. The saccate red *Halosaccion glandiforme* first appeared at the Category 3 station in 1994 and still remains significantly less abundant ($p < 0.01$) than at the reference station.

Some of the dominant animals have shown signs of recovery at the Category 3 middle stations between 1991 and 1995, but the patterns are not consistent or persistent. Densities of limpets at the two stations have consecutively converged and diverged since 1991, but both have increased about 30 percent over that period (Figure 2-12). The opportunistic barnacle *S. balanoides* remained essentially absent through 1994 at the reference site. Cover of *S. balanoides* precipitously declined from its 1991 peak at the Category 3 station (Figure 2-14); however, in 1995 cover increased substantially at both stations. The sharp decline in barnacles at the Category 3 station preceded a decline in numbers of the drill *Nucella lamellosa*. The large fluctuations in abundance of this predator and its principal prey at the hot-water washed station contrast sharply with the relative stability of these two species at the reference station, but the relatively low abundance of the barnacle at the reference site suggests that the barnacle is not important there and that the drill is probably targeting a suite of alternative prey (Figure 2-14).

Abundance of both species of littorine snails has fluctuated wildly at both stations except for *Littorina scutulata*, which has remained consistently low throughout the program at the reference site (Figure 2-15). Four animal taxa showed statistically significant differences between the two stations in 1995 (Table 2-3). The periwinkle snail *Littorina scutulata* was significantly more abundant at the Category 3 station, whereas limpets (Lottiidae), the drill *Nucella lamellosa*, and the pulmonate snail *Siphonaria thersites* were significantly more abundant at the reference station. These patterns have been consistent over the period of the study. Since 1989, *Siphonaria* has been significantly more abundant at the reference stations in all six years that this site has been sampled. Limpets have been more abundant at the reference site and *L. scutulata* has been more abundant at the Category 3 site all years.

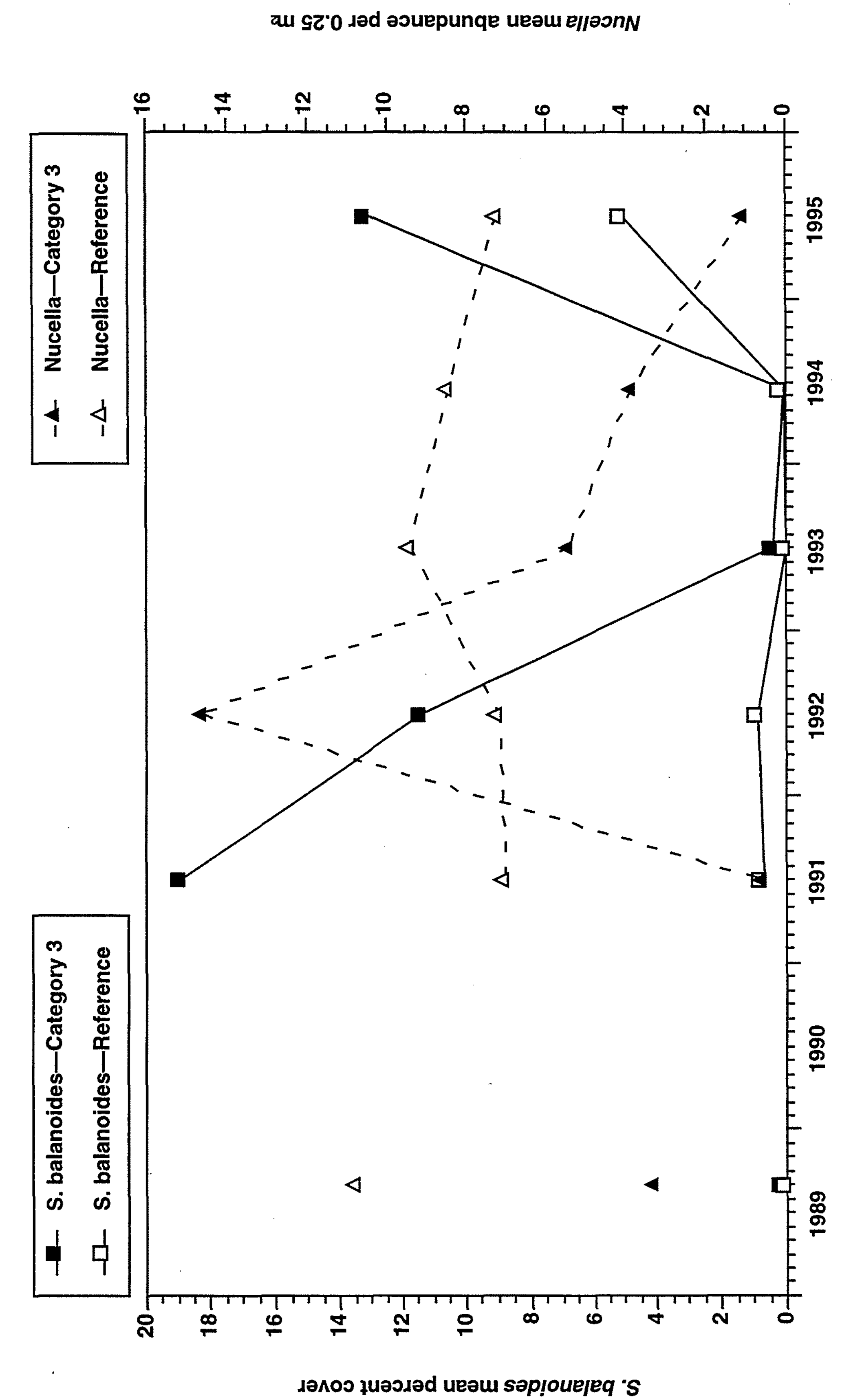


Figure 2-14. Mean percent cover of *Semibalanus balanoides* and mean abundance of *Nucella* from the Northwest Bay West Arm middle rocky stations, 1989-95.

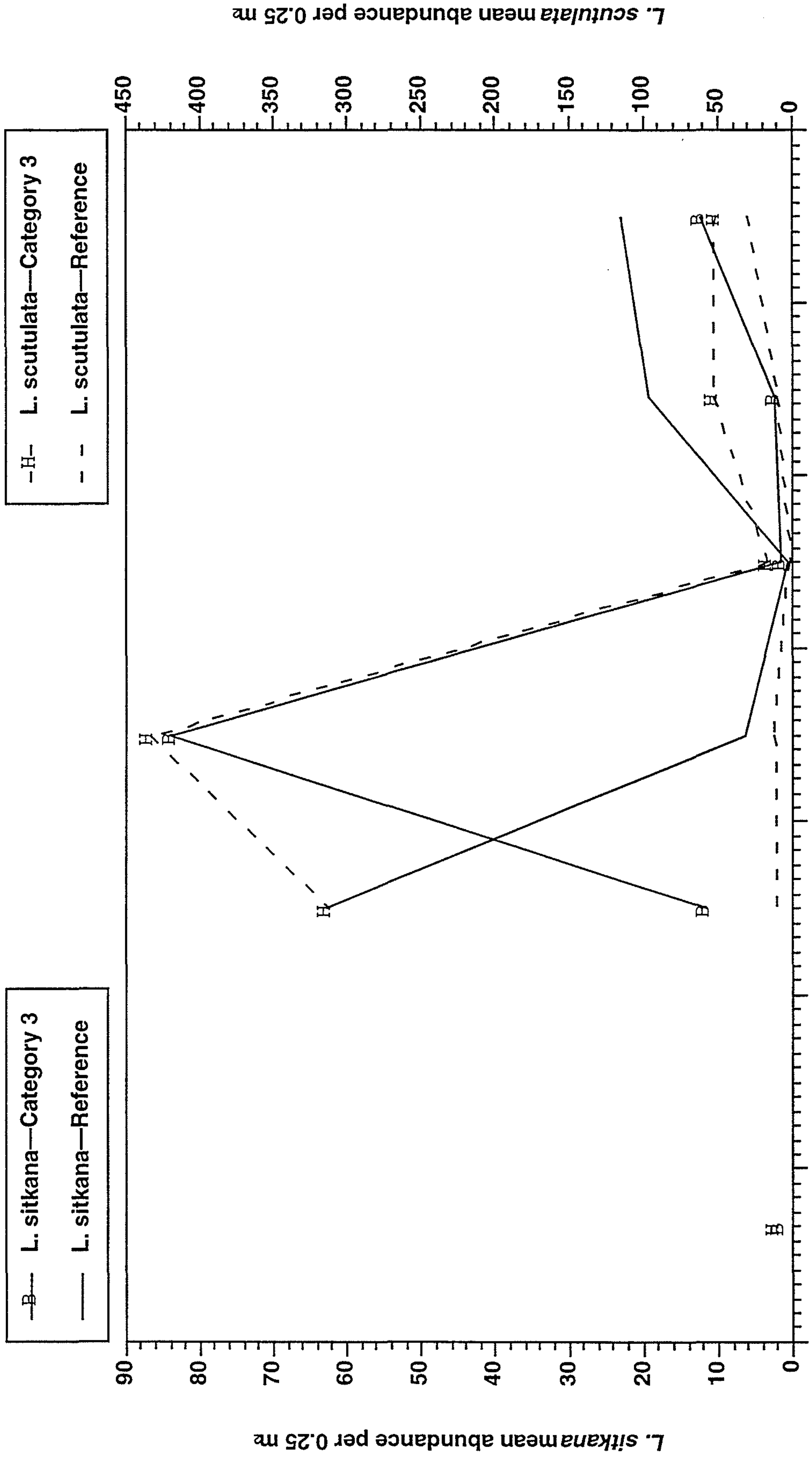


Figure 2-15. Mean abundance of *Littorina sitkana* and *Littorina scutulata* from the Northwest Bay West Arm middle rocky stations, 1989-95.

Lower Rocky Stations

The only lower rocky intertidal station sampled was the Category 3 station at Northwest Bay Islet, which was also the only Category 3 lower station sampled in 1994 (Table 2-4). This limits analysis to only a description of the trends for dominant taxa. *Fucus* cover at the Northwest Bay Islet lower station was about 20 percent higher in 1995 than in 1994. Coverage of the Rhodomelaceae/*Cryptosiphonia* complex remained virtually unchanged. This group of algae has remained severely depressed from its pre-treatment levels. The fauna associated with the *Fucus* community, such as the littorines and Lottiidae, continued to be found at high densities at the Northwest Bay Islet lower station (Table 2-4). Lottiids nearly doubled in density, largely on the strength of juvenile recruitment. Two drills (one *Searlesia dira* and one *Nucella lamellosa*) were observed at this station in 1995.

CHAPTER 3
MOLLUSK STUDIES

INTRODUCTION

The effects of the spill and subsequent shoreline treatments on hardshell clams at lower mixed-soft stations have been investigated over the 1989 to 1995 period using three primary techniques:

1. Excavating randomly placed 0.25-m^2 quadrats each year, except 1993 and 1995, to evaluate densities of larger clams (e.g., > 5 mm) at lower elevation stations.

2. Separating small clams from the infaunal cores at each station to evaluate recruitment.

3. Transplanting clams experimentally in 1991, 1992-93, and 1994-95 to aid our understanding of the survival, growth, and uptake of hydrocarbons by the littleneck clam *Protothaca staminea*.

An experimental clam and infaunal recruitment experiment also was conducted in 1994-95 to investigate causative factors limiting recruitment to treated and untreated beaches.

Analyses were also conducted in 1993 of the histopathology and reproductive maturity of clams and mussels with different exposure histories (Brooks 1994).

METHODS

Field Transplant Experiments

A littleneck clam transplant experiment was initiated in June 1994 to supplement information gained in similar experiments in 1991 to 1993. A total of 611 littleneck clams were collected from near the lower reference station at Outside Bay and approximately 162 clams were collected from near the lower station at Block Island. Tagging with a direct mark was done to permanently identify individual clams (e.g., Houghton 1973) so they could be measured at the beginning and the end of the experiment, increasing the statistical power of the results. Each clam was marked by engraving a number in the side of its shell with a Dremel tool; the number was inked in with a permanent marker and the mark was covered with clear nail polish or marine epoxy. Animals were held in fresh seawater for a maximum of two days following marking before transplanting. During this holding period, water was changed several times a day.

At the transplant site at Block Island, wooden quadrats (0.25-m^2) were dug into the sediment flush with the sediment surface just below the existing lower intertidal transect. Six quadrats were randomly located on a transect established along the beach contour (Figure 3-1). Sediments within each quadrat were hand-dug to a depth of 10 to 15 cm to loosen the material for planting and to remove indigenous clams. Marked Outside Bay clams (a minimum of 80 clams of varying sizes (11.7 to 42.2 mm long)) were transplanted into each quadrat in ten equally spaced rows of eight clams. Use of 80 clams per quadrat made it easy to load clams into the quadrats and provided adequate numbers of clams for growth and survival studies.

Similar marking and transplanting techniques were used to mark and replant 83 Outside Bay clams into one plot and to transplant 80 and 82 Block Island clams to each of two plots at the Outside Bay lower station for cross comparisons.

All littleneck transplant quadrats were left in place over the winter and excavated and hand-sorted to remove tagged clams in July 1995. All marked clams recovered were retained and frozen for length and age analyses.

Clam Aging Conventions

Because erosion in the umbonal region makes identification of the first annulus difficult on older venerid clams, littleneck and butter clams were aged using a modification of the methods and conventions of Houghton (1973). Specifically, rings less than 2.5 mm long were not counted as annuli, and no first annulus was recorded as greater than 8 mm. When the first distinct ring was greater than 8 mm, this ring was assumed to be the second annulus, and the first annulus was recorded as 2.5 mm. In addition, the external sculpture was filed to help distinguish true annuli from disturbance checks. Total length and lengths of the last three annuli were measured to the nearest tenth of a millimeter.

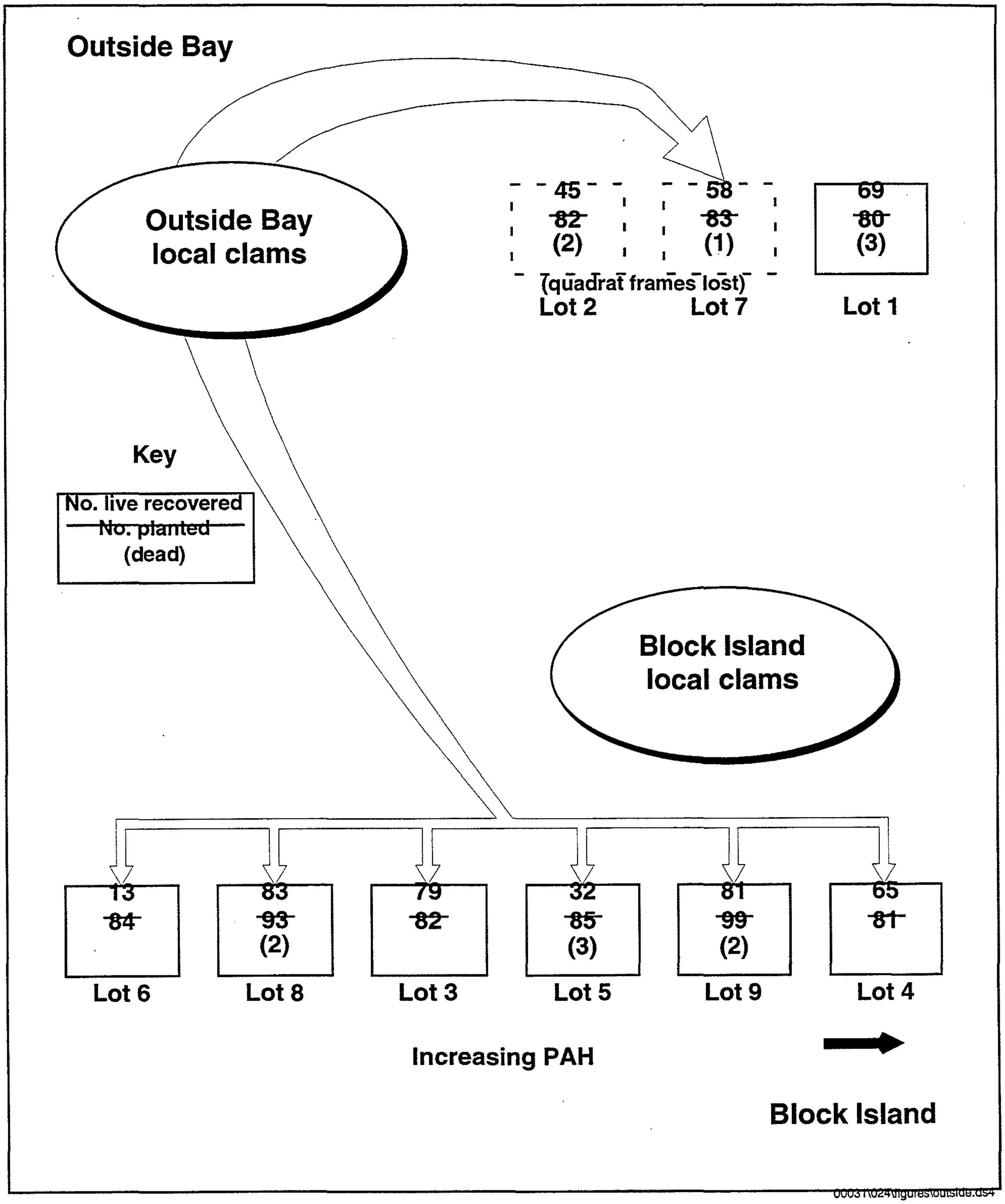


Figure 3-1 **Experimental design and number of clams transplanted and recovered in the 1994-1995 littleneck clam transplant experiment.**

Recruitment Experiment

An experiment was begun in 1994 to test hypotheses regarding factors that appear to be limiting recruitment of littleneck and butter clams, *Saxidomus giganteus*, and infauna to beaches that were hydraulically washed. Experimental units consisted of perforated plastic flower pots filled with specified test sediments and set into the beach in question. Reciprocal sediment exchanges between sites with good and poor recruitment and detailed chemical and physical analyses of sediments were used to enhance our understanding of causative factors. Each experimental treatment was replicated five times at each test site.

The following sediment treatments were established at:

1. Northwest Bay West Arm (local, local with added silt fraction, Outside Bay).
2. Block Island (local, Northwest Bay, Northwest Bay with added silt fraction).
3. Outside Bay (local, Northwest Bay, Northwest Bay with added silt fraction).

Sediment for the "added silt fraction" was obtained at about mean lower low water (MLLW) at the head of the lagoon on the north side of the isthmus separating Eleanor and Block islands. This sediment was a black mud with a high content of organic material. It was mixed about half and half with the Northwest Bay West Arm sediment to make up the material used in the "Northwest Bay with added silt fraction" test sediment.

Test sediments were treated with hot, fresh water to kill existing infauna and each pot was filled and set in the beach at the lower tidal elevation. Samples of each test sediment were retained for analysis of initial grain size (Appendix Table C-1), PAH (Block Island treatments only), TOC, and TKN. The top flange on each pot was set flush with the ambient sediment surface and attached to a rebar stake with a plastic tie wrap. Replicates of different treatments were randomly interspersed at each site to minimize bias.

In 1995 cores were taken of the undisturbed sediments within the recovered test pots (one per treatment) and field-sieved through a 1.0-mm screen. The residue was preserved in a 10 percent buffered formalin solution. Sediment samples from each pot were collected for analysis of grain size distribution (Appendix Table C-2, Figure 3-2).

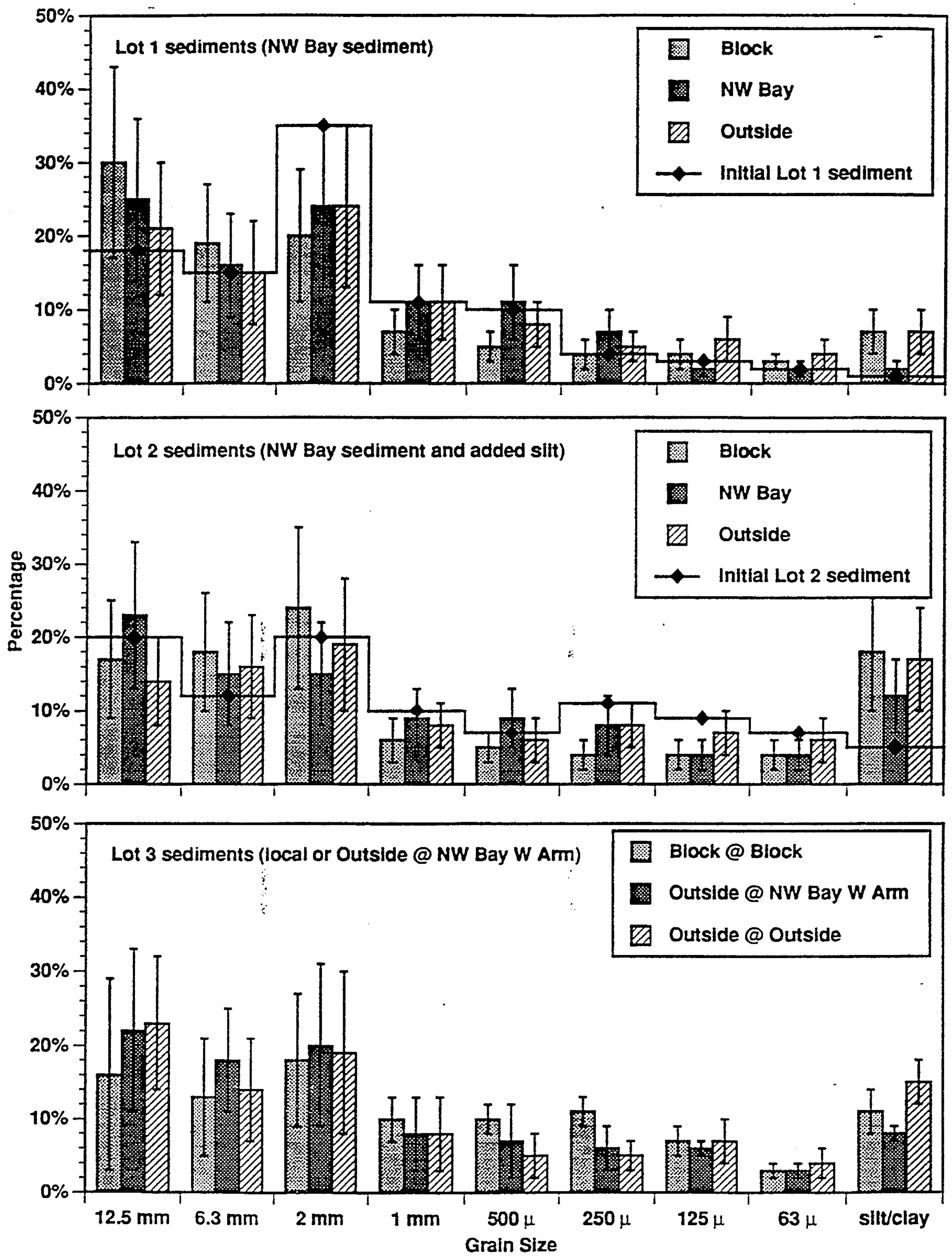


Figure 3-2. Grain size distribution for test sediments used in the littleneck clam recruitment experiment, 1994-95.

Additional sediment was composited from the remaining sediments in each treatment for analysis of TOC and TKN (Appendix Table C-2). At Block Island, samples were taken from each pot for PAH analysis to test the possible influence of a gradient of residual hydrocarbons across this site.

Statistical Analysis

Various statistical analyses were applied to quantitatively describe the abundance data and to evaluate the significance of the findings. Randomization tests were run to determine significant lot or site effects (ANOVA) and differences between lots or sites (t-tests). Only two-tailed t-test results were considered. The randomization routines were adapted from algorithms published by Edgington (1987).

RESULTS

Littleneck Clam Transplant Experiment

Recovery/Survival

The 1994-95 littleneck clam transplant experiment recovery rates are depicted graphically in Figure 3-1. Recovery of marked clams at both sites was 70 percent (Table 3-1; Appendix Table C-3). At Outside Bay two of the three wooden quadrats (Lots 2 and 7) were disturbed by a tidal stream, yet recovery averaged 64 percent (57 and 71 percent). At Block Island recovery ranged from a low of 15 percent (Lot 6) to 96 percent (Lot 3; Figure 3-3). Very low recoveries from Lots 6 and 5 are believed to be artifacts of physical disturbances of the experimental sites, since both are well below the rates of survival and recovery of clams in the same area in the 1991 and 1992 transplant experiments.

Mussel bed cleaning activities were carried out on the beach immediately above the clam transplant experiment location at Block Island in August 1994. Boat and foot traffic associated with this effort may have compromised the results of this experiment. If it is assumed that Lots 5 and 6 were physically disturbed, the mean survival of transplanted clams from the two remaining quadrats on the left side of the experiment (Lots 3 and 8) was higher (92.6 percent) than the survival in the two lots at the more heavily oiled right side of the transect (Lots 4 and 9, 81.1 percent survival). When PAH data are available, a relationship between clam survival and PAH in these four quadrats will be investigated.

Table 3-1. Summary of littleneck clam mark/recovery experiment at Outside Bay and Block Island sites.

	Source	Planted location	# Planted	# Recovered Live	# Recovered Dead	% Live clams recovered
Lot 1	Block Island	Outside Bay	80	69	3	86%
Lot 2	Block Island	Outside Bay	82	45	2	55%
	All Block Island clams		162	114	5	70%
Lot 3	Outside Bay	Block Island	82	79	-	96%
Lot 4	Outside Bay	Block Island	81	65	-	80%
Lot 5	Outside Bay	Block Island	85	32	3	38%
Lot 6	Outside Bay	Block Island	84	13	-	15%
Lot 7	Outside Bay	Outside Bay	83	58	1	70%
Lot 8	Outside Bay	Block Island	93	83	2	89%
Lot 9	Outside Bay	Block Island	99	81	2	82%
	All Outside Bay clams		607	411	8	68%
	Overall		769	525	13	68%

There were 18 marked and recovered clams from all lots excluded from the age analysis: 12 dead clams were recovered; of these, 7 showed little or no growth following planting, 2 were broken and could not be aged, and the remaining 3 showed some growth. Three live clams were broken in recovery and could not be aged. Data from three clams were suspect and not used in the growth analysis. Of the clams used in the growth analysis, 61 (11 percent) appeared to have had no growth in the year following transplanting.

Age and Growth Analysis

Growth data from the clam transplant experiment are provided in Appendix Table C-3. Three age classes of clams (ages 5, 6, and 7) had a sufficient number of clams to allow comparisons among experimental treatments (Figure 3-4). Significant differences were found between clam lots (lot effect) for all three age classes in an ANOVA. For age 6 and 7 clams at Outside Bay, the local clams, marked and replanted at this location, showed significantly greater growth than did Block Island clams transplanted to the site. Overall, Outside Bay clams of ages 5 and 6 showed significantly greater growth, regardless of location, than did Block Island clams.

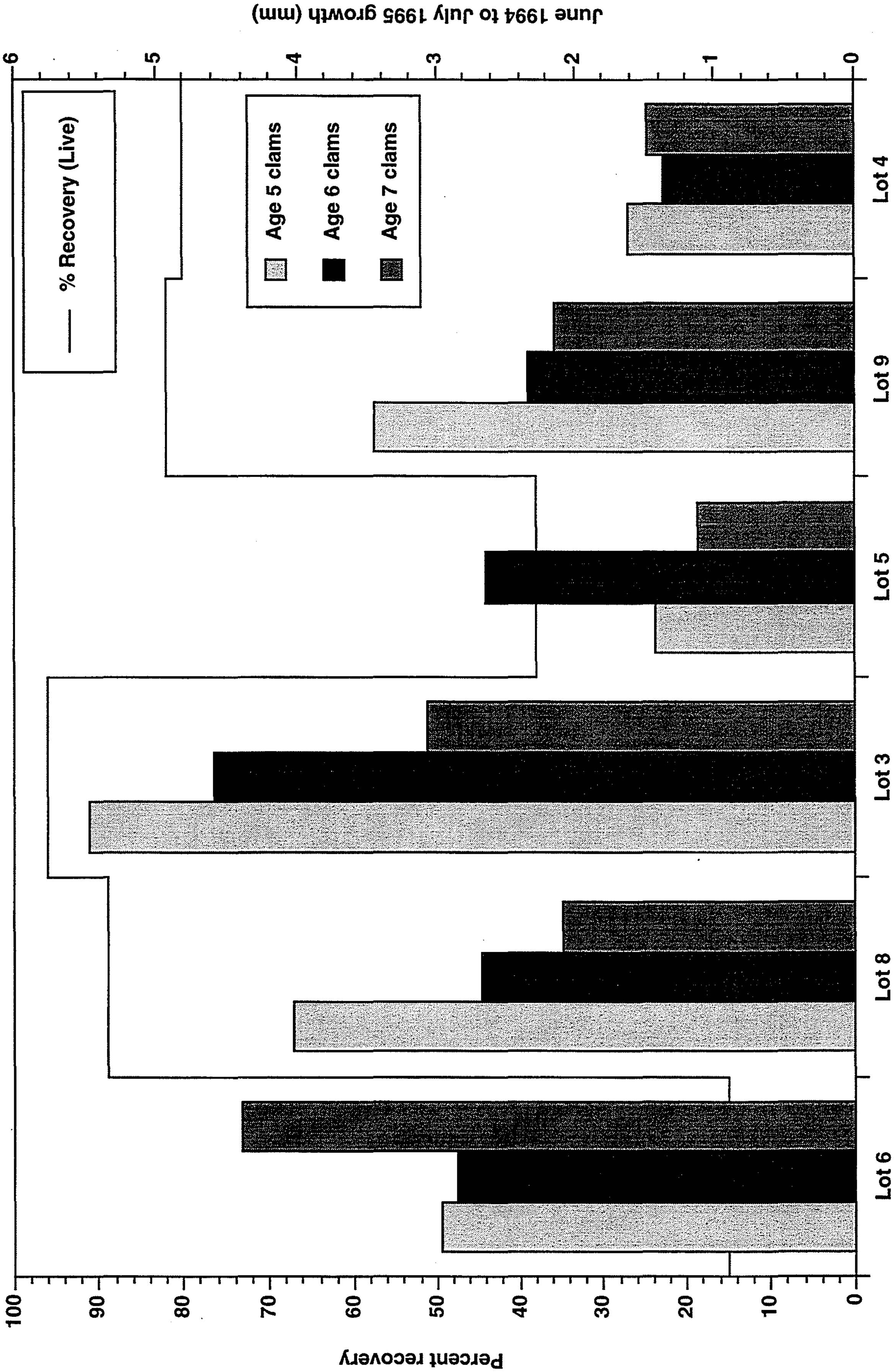


Figure 3-3. Percent recovery and mean growth of live *Protothca staminea* from transplant quadrats at Block Island.

Significant differences in average growth were found between lots of Outside Bay clams transplanted to Block Island. The highest average growth for all age 5 and 6 clams recovered at Block Island was found in Lot 3 clams planted at the left-center of the experimental transect in a portion of the site that in past years has shown a low residual sediment PAH (Figure 3-4). For age 7 clams, greatest growth was seen in Lot 6 at the far left end of the transect in the area of lowest residual PAH (Figure 3-4).

Recruitment Experiment

Sediment Quality

Samples of the defaunated test sediments from Northwest Bay (Lot 1) and the test mixture of Northwest Bay sediment and fine organic mud (Northwest Bay with added silt fraction: Lot 2) were analyzed for grain size, TOC, and TKN (Table 3-2; Figure 3-2). The Northwest Bay sediment was coarse grained with 6.25 percent fines ($\leq$ 125 μ). The test sediment also had lower TOC (0.5 percent) and TKN (49.5 parts per million [ppm]) than the other sediments used in the experiment. The test mixture of Northwest Bay sediment with added silt was finer grained (20 percent fines) than the straight Northwest Bay sediment, but still had a low TOC value (0.67 percent). The TKN value was substantially higher at 399 ppm. Block Island sediments from the lower intertidal infauna station had 16.5 percent fines, 2.1 percent TOC, and 513 ppm TKN. Outside Bay sediments from the lower intertidal infauna station had 12.3 percent fines, 1.8 percent TOC, and 224 ppm TKN.

Experimental pots filled with Northwest Bay sediments (Lot 1) and placed at Block Island and Outside Bay had accumulated increased proportions of fines (Figure 3-2) and increased TKN in June 1995, by the end of the experiment (Table 3-2). Percentage fines and TOC were essentially unchanged, and TKN increased only slightly in pots returned to Northwest Bay. This confirms that there are few sources of fines or organic matter in the sediment or water column at this site. The Northwest Bay sediments with added silt also showed an increase in fines over the experiment at Block Island and Outside Bay, but no change at Northwest Bay. TOC was considerably higher in pots from this lot when recovered in 1995 and TKN increased over the exposure period at Northwest Bay and Outside Bay, but not at Block Island. Block Island and Outside Bay sediments placed in pots at the various locations generally showed increases in percentages of fines and in TKN over the experiment and decreases in TOC (Table 3-2).

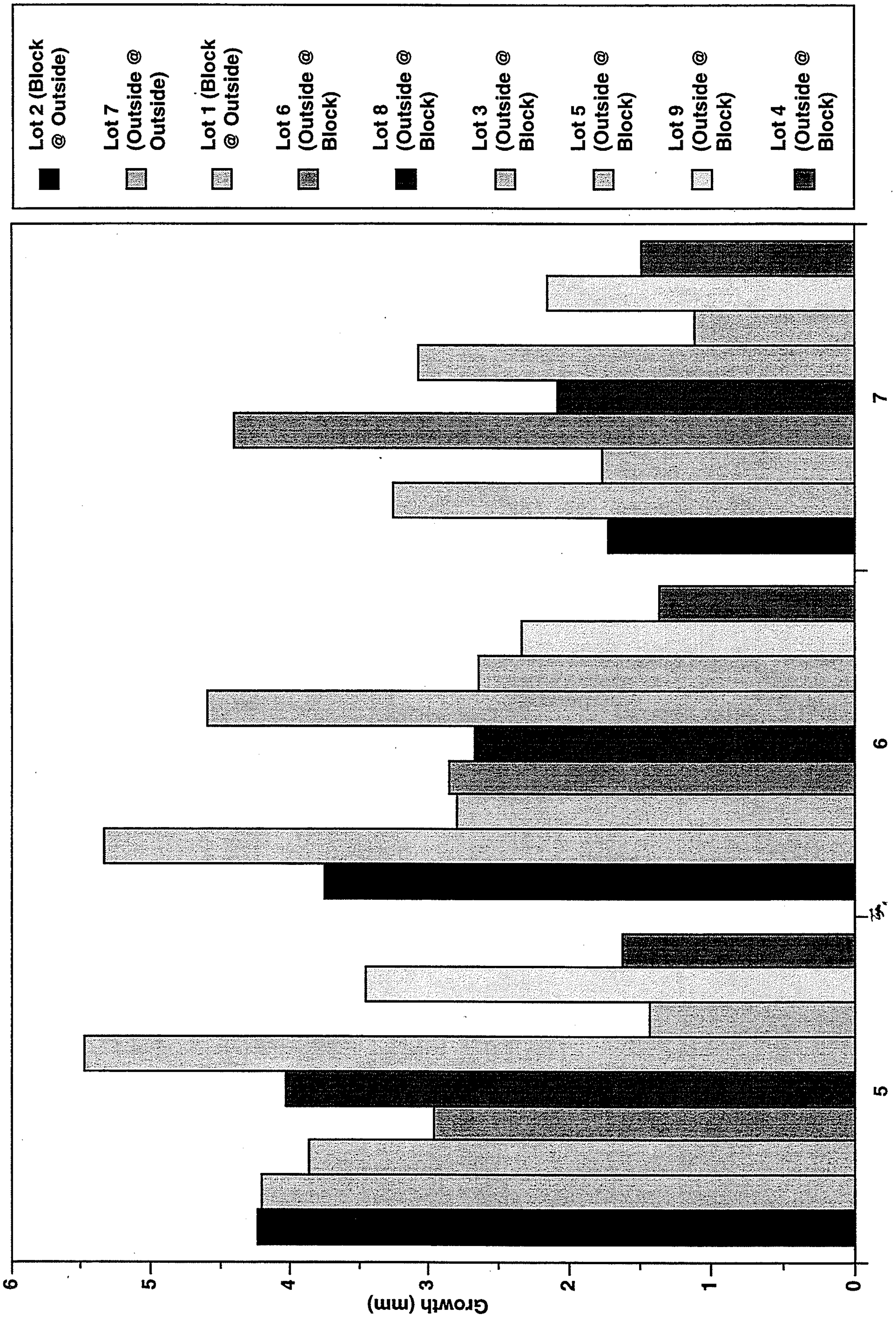


Figure 3-4. Mean growth of age 5, 6, and 7 *Protothaca staminea* from the clam transplant experiment, 1994-95.

Littleneck Clam Recruitment

Recruitment of age 0 and 1 littleneck clams in the pots between 1994 and 1995 was variable and inconsistent. No recruitment occurred in any test lot at the Northwest Bay West Arm site (Table 3-2). If the Outside Bay results are examined, the experiment would appear to have worked as expected: low recruitment (0.2 clams/pot) occurred in the raw Northwest Bay sediments; addition of silt to those sediments was associated with increased recruitment (1.4 clams/pot); and highest recruitment (2.2 clams/pot) occurred in local Outside Bay sediments (Table 3-2). Results from the Block Island experiment contradict this pattern, however. The lowest recruitment was in the Northwest Bay sediments with added silt (these pots had a mean of 47.6 percent fines), and highest recruitment was in unaltered Northwest Bay sediment (1.8 clams/pot; 14.2 percent fines). The local Block Island sediments had intermediate recruitment (1.0 clams/pot).

Recruitment of littlenecks to these experimental units (pots) did not appear to be related to the nature of sediments placed in the pots in 1994. The higher recruitment at the Block Island and Outside Bay locations and very poor recruitment at Northwest Bay West Arm is consistent with results from infaunal core sampling in previous years (Figure 3-5). Rates of recruitment per unit area in the pot sampling were lower at all stations than in infaunal cores collected at the same lower elevation stations in other years. This may be the result of the disturbance caused by the warm-water treatment used to kill indigenous organisms at the start of the experiment or to some effect of the pots and stake on the recruitment behavior of the veligers as they settled from the plankton.

Presence of several larger littleneck clams in pots of local sediments at Block Island and Outside Bay indicates that the warm-water treatment was insufficient to kill all the indigenous clams before the sediments were placed in the pots. Presence of three larger clams in Northwest Bay plus silt pots at Block Island indicates that some clams may have entered the pots from the surface. Possibly mussel bed cleaning activities immediately up slope from the experiment in the late summer of 1994 dislodged clams that were able to rebury in the pots. No larger clams were found in raw Northwest Bay sediments at Block Island (or elsewhere), however.

Table 3-2. **Recruitment of age 0 and 1 littleneck clams to experimental pots with % fines (≤ 125 µ), TKN, and TOC**

	Test sediments		
	Lot 1	**Lot 2**	**Lot 3**
Block Island	**NWB sediments**	**NWB + silt sediments**	**Local sediments**
Mean abundance of P. staminea (age 0 and 1)	1.8	0.4	1.0
% Fines	14.2%	47.6%	21.0%
TKN (ppm)	310	400	490
TOC (%)	0.7%	2.6%	1.3%
NW Bay W. Arm	**NWB sediments**	**NWB + silt sediments**	**Outside Bay sediments**
Mean abundance of *P. staminea* (age 0 and 1)	0	0	0
% Fines	5.8%	20.4%	17.9%
TKN (ppm)	110	520	320
TOC (%)	0.4%	3.5%	0.4%
Outside Bay	**NWB sediments**	**NWB + silt sediments**	**Local sediments**
Mean abundance of *P. staminea* (age 0 and 1)	0.2	1.4	2.2
% Fines	15.8%	29.7%	26.1%
TKN (ppm)	270	750	310
TOC (%)	0.7%	3.5%	0.9%
Initial sediments	**NWB sediments**	**NWB + silt sediments**	**Local sediments Block Island**
% Fines	6.3%	20.0%	12.3%
TKN (ppm)	49.5	399	513
TOC (%)	0.5%	0.7%	1.8%
			Outside Bay
% Fines			12.3%
TKN (ppm)			224
TOC (%)			1.8%

Infaunal Recruitment

Mean abundance of macroinfaunal animals in the experimental pots recovered at Block Island was lowest of the three sites with 42 per pot (all treatments combined); infauna in the Block Island pots was dominated by polychaetes, bivalves, and crustaceans (Table 3-3). Outside Bay was next lowest of the three sites at 46 per pot, infauna colonizing was dominated by gastropods, bivalves, and polychaetes. Pots at Outside Bay containing Northwest Bay sediments had more nemerteans than any other sediment treatment at Outside Bay or Block Island.

Northwest Bay West Arm had the highest overall density of infaunal organisms at a mean of 83 per pot (all treatments combined). This abundance, which was statistically greater than that at Block Island, was driven by the overwhelming dominance of nemerteans in the two lots with higher percentages of fines (Northwest Bay sediments with silt added and Outside Bay). In previous sampling at Northwest Bay, numbers of nemerteans have never been particularly high; apparently those nemerteans present invaded the pots and favored the high content of fines in two of the lots. Northwest Bay local sediments, which had a lower percentage of fines, had a more diverse infauna with gastropods, nemerteans, crustaceans, and polychaetes all abundant.

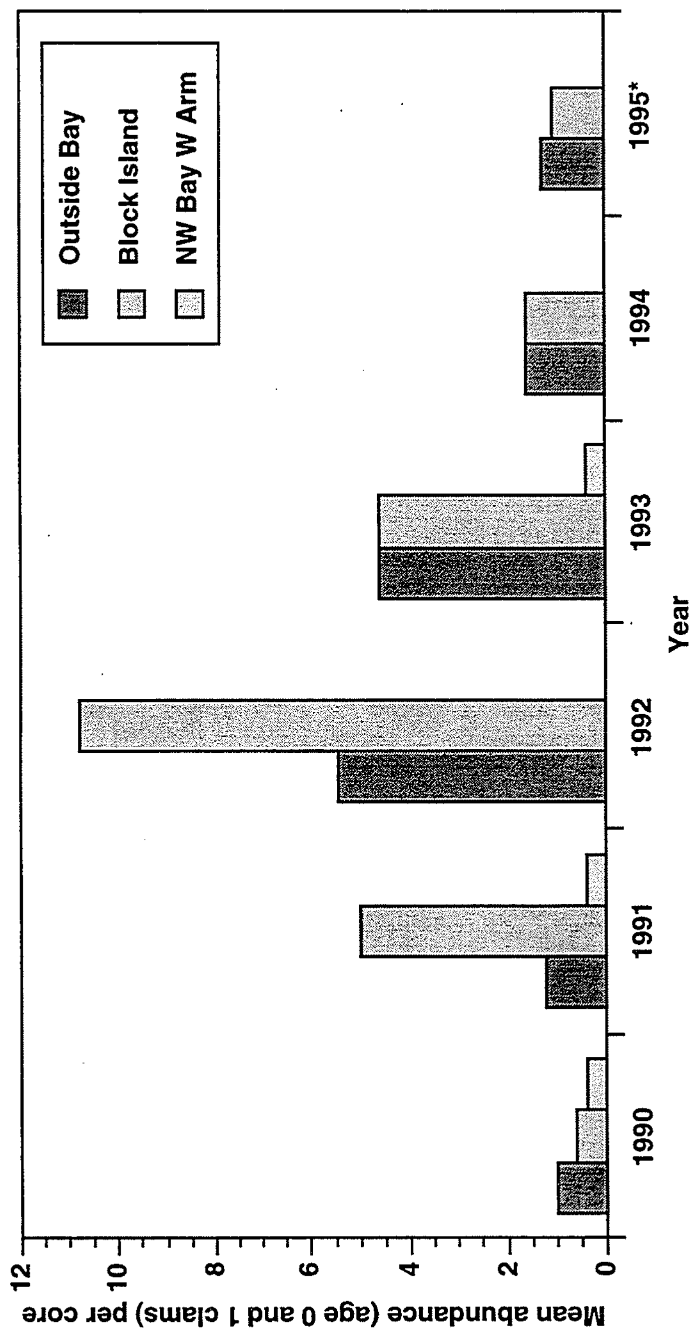


Figure 3-5. Mean abundance (No./0.009 m^2 core) of age 0 and 1 *Protothaca staminea* from summer cruises, 1990-95. * Value is mean of all sediment lots for a site.

Table 3-3. Mean abundance (no./ 0.009 m2 core) of macroinfaunal animals in experimental pots recovered in July 1995.

	NWB local (Lot 1)			NW Bay + silt (Lot 2)			Outside Bay (Lot 3)		
Taxon	**Mean**	**SD**	**Count**	**Mean**	**SD**	**Count**	**Mean**	**SD**	**Count**
NW Bay W. Arm									
Anthozoan	0.00	0.00	5	0.40	0.55	5	0.00	0.00	4
Hydrozoan	0.40	0.89	5	0.00	0.00	5	0.00	0.00	4
Nemertea	11.20	17.37	5	72.40	55.37	5	102.25	43.92	4
Bivalve (inc. Protothaca)	2.00	2.00	5	3.00	3.24	5	2.00	2.45	4
Protothaca staminea	0.00	0.00	5	0.20	0.45	5	0.00	0.00	4
Gastropoda	20.80	30.20	5	1.20	2.17	5	1.75	3.50	4
Polyplacophora	0.00	0.00	5	0.00	0.00	5	0.00	0.00	4
Crustacea	9.80	19.70	5	1.80	1.10	5	2.00	1.41	4
Polychaete	9.80	13.74	5	2.80	1.92	5	5.25	2.75	4
Echinodermata	0.00	0.00	5	0.20	0.45	5	0.00	0.00	4
Total abundance	54.00	39.70		81.80	56.71		113.25	43.97	

	NWB sediment (Lot 1)			NW Bay + silt (Lot 2)			Block Island local (Lot 3)		
Taxon	**Mean**	**SD**	**Count**	**Mean**	**SD**	**Count**	**Mean**	**SD**	**Count**
Block Island									
Anthozoan	0.00	0.00	5	0.00	0.00	5	0.00	0.00	5
Hydrozoan	0.00	0.00	5	0.00	0.00	5	0.00	0.00	5
Nemertea	1.20	2.17	5	0.60	0.89	5	4.60	4.04	5
Bivalve (inc. Protothaca)	14.00	4.12	5	10.60	9.07	5	14.60	2.61	5
Protothaca staminea	1.80	1.30	5	1.20	0.84	5	4.80	2.59	5
Gastropoda	1.80	1.64	5	2.20	2.77	5	2.00	2.35	5
Polyplacophora	0.00	0.00	5	0.00	0.00	5	0.20	0.45	5
Crustacea	11.80	12.48	5	9.80	8.47	5	5.00	4.00	5
Polychaete	9.40	4.51	5	15.40	6.43	5	14.20	4.15	5
Echinodermata	3.20	2.05	5	1.60	1.82	5	2.40	4.28	5
Total abundance	41.40	11.87		40.20	20.83		43.00	6.78	

	NWB sediment (Lot 1)			NW Bay + silt (Lot 2)			Outside Bay local (Lot 3)		
Taxon	**Mean**	**SD**	**Count**	**Mean**	**SD**	**Count**	**Mean**	**SD**	**Count**
Outside Bay									
Anthozoan	0.00	0.00	5	0.00	0.00	5	0.00	0.00	5
Hydrozoan	0.00	0.00	5	0.00	0.00	5	0.00	0.00	5
Nemertea	12.80	12.56	5	0.60	0.89	5	2.60	2.30	5
Bivalve (inc. Protothaca)	4.60	0.55	5	14.00	6.89	5	9.40	10.67	5
Protothaca staminea	0.20	0.45	5	1.40	1.52	5	2.40	1.67	5
Gastropoda	48.00	102.35	5	3.40	2.61	5	12.80	17.58	5
Polyplacophora	0.00	0.00	5	0.00	0.00	5	0.00	0.00	5
Crustacea	1.60	2.07	5	2.80	5.72	5	1.00	0.71	5
Polychaete	8.20	8.38	5	5.40	2.70	5	9.20	7.79	5
Echinodermata	1.20	2.17	5	0.00	0.00	5	0.20	0.45	5
Total abundance	76.40	112.59		26.20	10.87		35.20	20.43	

CHAPTER 4

GENERAL DISCUSSION, SUMMARY, AND CONCLUSIONS

The general discussion, summary, and conclusions in this chapter are based on analyses conducted to date on samples collected from 1989 through 1995. It is anticipated that more detailed analyses of these data will be conducted and reported as funding permits.

OVERALL IMPLICATIONS OF THE FINDINGS

Multiple null hypotheses relating to effects of hydrocarbon contamination from the tank vessel *Exxon Valdez* and to effects of subsequent shoreline treatments have been tested in the seven years of this study (1989 to 1995). Many of these null hypotheses have been rejected; these rejections indicate that significant differences existed in the condition of shorelines among our three categories of sites. For the majority of the variables tested, especially later in the study, conditions did not differ significantly among Category 1 (unoiled) and Category 2 (oiled, but not high-pressure hot-water treated) sites. At Category 3 sites (those that were high-pressure hot-water washed), some variables differed significantly from levels at other site categories, especially early in the study, and were not fully recovered in 1995. In other cases, patterns apparent in the field or in the data were not statistically significant, but the data have been included and discussed to provide information on the direction of qualitative relationships among the categories. Time-series plots including data from 1989 through 1995 are useful in evaluating these relationships. Plots presented in earlier reports have been updated with new data and have been modified somewhat to exclude data from stations not consistently sampled over the study period.

Expectations for the qualitative relationships among the treatment categories vary with the nature of the variable. Opportunistic species of epibiota, for instance, would be expected to be more abundant at Category 3 or Category 2 sites in the early years following the spill. This greater abundance was even more evident in 1991 and 1992 than in 1990; high abundances of opportunistic barnacles, littorines (*L. scutulata*), and algae (*Gloiopeltis* and several encrusting forms) were observed at Category 3 middle rocky stations. For most of these taxa, the "bloom" of opportunistic epibiotal species seen in 1990 through 1992 had disappeared or was no longer as evident after 1993. Of the infauna on mixed-soft beaches, relatively high abundances of nematodes and oligochaetes in Category 3 beaches seen through 1992 had disappeared or was no longer as evident after 1993. Of the infauna on mixed-soft beaches, relatively high abundances of nematodes and oligochaetes in Category 3 beaches through 1994 and in Category 2 beaches (especially in 1992) may also represent opportunism. These two meiofaunal taxa ranked one and four in abundance among all infaunal taxa at Category 2 stations in 1992 but have declined in relative importance since.

The long-lived epibiotal community dominants, such as mussels, drills, limpets, and rockweed, known to have suffered heavy losses due to oiling and cleanup, would be expected to be less abundant at Category 2 and 3 sites immediately following the spill. This expectation was realized to a greater degree in 1990 than in 1991; by mid-summer 1991 recovery of many of these dominants had progressed to a greater degree on Category 2 sites than on Category 3 sites. By 1992 recolonization by some of these dominants, most notably limpets (Figure 2-7) and rockweed (Figure 2-4), had more than restored abundances at Category 3 sites; other taxa, such as drills (Figure 2-10) and foliose red algae (Figure 2-13), remained depressed through 1995.

Reduced biological controls (grazing, predation, competition) or altered habitat conditions may have caused some species to become more abundant for a time in the post-event assemblage. Reduced grazer populations and perhaps reduced competition for space allowed rockweed at the oiled middle rocky stations (Categories 2 and 3; Figure 2-4) to achieve coverage greater than at the reference stations; this difference persisted into 1993 after which rockweed cover began to decline.

This increase and decline of rockweed, in turn, influenced recovery of other associated species and may be responsible for the slow recovery of red algae at middle and lower rocky stations (Figure 2-13). Total numbers of primary grazers (littorines and Lottiidae; Figures 2-6 and 2-7) are no longer depressed at oiled middle rocky stations, although densities of *L. sitkana* were lower at oiled sites than at reference sites in 1995. Category differences in density of one of the primary predators in the intertidal zone, *Nucella lamellosa*, had all but disappeared in 1992-93. This difference reappeared in 1994 as populations at Category 1 middle rocky stations increased in apparent response to increases in mussel and barnacle populations. *Nucella* numbers at all categories declined in 1995 in synchrony with a decline in mussel cover, probably due to *Nucella* predation during 1994. Our expectation is that, over time, the natural balance among predators and prey will become reestablished at Category 2 and 3 sites and that patterns and geographic scale of oscillations will continue to dampen to within the range of natural variability at unaffected sites.

The responses of organisms may be expected to vary between Category 3 and Category 2 sites where differences remain in physical or chemical habitat characteristics that resulted from treatment. For example, recolonization by infauna could be expected to proceed differently on a beach with high residual oil in the sediments from that on a beach where washing had removed some oil, along with fines and organic matter. In some cases, information was not available to develop preconceptions on the expected relationships. Thus, the information on the qualitative patterns must be interpreted separately for each taxon, site category, or variate examined. In cases where the existing data and knowledge do not permit explanation, continued monitoring may clarify the significance (if any) of these patterns.

The statistical testing performed on the 1990 data provided a strong basis to argue that conditions spanning a broad spectrum of biological properties reflected the influence of hydrocarbon contamination on one hand and shoreline treatment on the other; however, the effects of the treatment predominated (Houghton et al. 1991a). Similar testing completed on the 1991, 1992, and 1993 data provided progressively fewer instances of significant differences between the site categories. Differences between unoiled (Category 1) and oiled but untreated (Category 2) stations have been insignificant since 1991 in most cases. However, several significant differences remain between biological conditions (both infauna and epibiota) at either of those two station categories and conditions at high-pressure hot-water washed (Category 3) stations. These results—plus trends seen over time in key species abundance, directions of movement seen in principal components and multivariate analyses, and observations during field cruises—provided strong evidence that recovery was underway, even at the most severely affected sites.

The 1994 data showed as many (epibiota at middle rocky stations) or more (infauna) significant category effects in abundance or assemblage measures as did the 1993 data. At the least, this suggests that the pace of recovery had slowed considerably. In some cases (epibiota), continuing differences in 1995 clearly reflect continuing oscillations in disturbed populations and in the balance of predator-prey relationships. In other cases (infauna—through 1994 only), continuing differences may reflect real differences in the habitat conditions at stations within the respective categories. We have some concerns that the Category 3 lower mixed-soft stations have a greater wave exposure than do Category 1 and 2 stations and that this may, in part at least, explain the slow apparent rate of recovery of infauna at these sites.

EPIBIOTAL ASSEMBLAGES

Analysis of two data sets from shoreline treatment effects studies conducted in 1989 for Exxon showed that major components of the intertidal flora and fauna inhabiting Prince William Sound survived at least three to four months on heavily oiled beaches (Lees et al. 1993). Except for a few taxa, these organisms were generally present in abundances comparable to those at unoiled beaches in the sound. Based on these 1989 studies, the short-term effects of the use of high-pressure hot-water on intertidal flora and fauna of the sound were significant: all dominant taxa except one (barnacles) suffered from 60 to 100 percent mortality from treatments of less than three hours' duration.

In the first year of this study (1990; 15 to 17 months following the spill), the effects of 1989 shoreline treatments on intertidal biota remained evident and statistically significant at Category 3 rocky sites; flora and fauna on Category 2 beaches more closely resembled those on Category 1 beaches. The majority of the community dominants were present on Category 2 beaches in abundances similar to those on Category 1 beaches, but reduced numbers of some species (e.g., rockweed, *L. sitkana*, *Nucella*) at middle elevation stations indicated continued effects from oiling alone (see Figures 2-4, 2-6, and 2-7).

In 1990, statistically significant differences (lower abundances) were seen in several of the dominant taxa of epibiota on rocky and mixed-soft (gravel/sand with some cobbles) beaches. Rockweed and limpets (Figures 2-4 and 2-7), both community dominants, most commonly exhibited lower abundances on Category 3 beaches (cf. Category 1 beaches) at middle and upper intertidal elevations. Other species showing significantly lower abundances at these beaches included littorine snails (Figure 2-6), drills (Figure 2-10), and barnacles (Figure 2-9). At lower intertidal levels, effects of hot-water washing were not consistently evident in the epibiota in 1990. Filamentous green algae seem to have been more abundant at Category 2 and 3 stations than at controls; several taxa of red algae showed the opposite pattern at the single Category 3 lower station sampled (Table 2-4).

By July 1991 substantial recovery had occurred at Category 2 and 3 sites, although significant differences still remained (e.g., in limpet and rockweed abundances at middle rocky stations) between unoiled reference sites and Category 3 sites. Colonization of Category 3 sites by opportunistic species had been substantial, and community composition differed noticeably from that at Category 1 and 2 sites.

By 1992 the majority of the high-pressure hot-water washed beaches appeared, superficially at least, to have recovered. This appearance was due to the proliferation of rockweed at middle rocky stations on Category 2 and 3 beaches, where cover exceeded that on Category 1 beaches (Figure 2-4). This increased cover of rockweed was likely the result of reduced numbers of grazers at Category 2 sites in 1989 and 1990 and at Category 3 sites from 1989 through 1991. By 1992 limpet densities had recovered at oiled middle rocky stations (Figure 2-7), and more normal biological controls were expected to become reestablished in future years. Abundances of some other important species remained altered at Category 3 middle rocky stations from the expected condition as represented by Category 1 middle stations. Hermit crabs, *Littorina sitkana, Balanus glandula, Semibalanus cariosus,* and some red algae were all more abundant in 1992 at Category 1 sites; *L. scutulata, Gloiopeltis, S. balanoides,* and encrusting brown algae were all more abundant at Category 3 sites. This pattern suggested that an earlier stage of ecological succession was still extant at Category 3 middle rocky stations in 1992.

By mid-summer 1993 overall trends indicated continued progress toward recovery with no significant differences in abundant or dominant taxa among categories. Cover of rockweed continued to increase from 1992 levels at Category 2 and 3 middle rocky stations to well above the average cover at Category 1 stations (Figure 2-4). This suggested that the ecological imbalances created by loss of grazers to oiling and treatment continued to affect this assemblage. The Category 3 Block Island and Northwest Bay West Arm middle stations continued to be heavily dominated by rockweed (> 65 percent cover; Figure 2-12), whereas the Northwest Bay Islet middle station remained largely devoid of rockweed and associated biota over about half the sampling transect. Thus, it was expected that the mean rockweed cover at this station would continue to increase as recolonization progressed from its 1993 level (32 percent) towards its pretreatment cover of 79.6 percent. In fact, the limited additional growth of rockweed at the barren shoreward half of this transect in 1994 was offset by reduced cover on the seaward half so that the 1994 cover remained unchanged (30 percent).

Beginning in 1994 and continuing into 1995, there was a reduction in cover of rockweed at middle elevation stations sampled on oiled rocky habitats; in contrast, cover at unoiled reference sites increased somewhat in 1994 and declined by a like amount in 1995. The reduction at oiled sites appeared to be the result of the natural culmination of the life cycle of this species; post-spill and post-treatment colonization by germlings in late 1989 and early 1990 developed to reproductive maturity in 1992 over broad areas of the central sound. Depressed numbers of littorines and limpets (Figures 2-6 and 2-7) allowed this development to proceed with minimal grazing pressure. By 1993 this cohort of rockweed was showing signs of senescence, and numbers of grazers had increased to the point where the decline seen in 1994 was inevitable. By 1995, rockweed cover at Category 3 sites was lower than it had been since 1990 following treatment.

In 1994 littorine densities at oiled middle rocky stations (Figure 2-6) converged with those at unoiled middle stations, a sign of increasing stability. In 1995 numbers of *L. sitkana* increased at unoiled stations to a density about three times that at both categories of oiled middle stations. Limpet densities increased at oiled middle stations in 1994 (Figure 2-7), probably in response to the abundance of weakened rockweed plants. In 1995 limpet numbers continued to rise at Category 3 middle stations despite the decline in rockweed. Future trends in populations of these grazers are expected to depend on the extent and pattern of the die-back and recolonization of rockweed that occurs in the next few years.

A second predator/prey association at rocky middle intertidal stations, that of the drill (*Nucella* spp.) and its prey (barnacles and mussels), appears to be subject to more dynamic natural fluctuations in Prince William Sound than does the grazer/rockweed association discussed above. In contrast to the relative stability of rockweed cover (Figure 2-4) and littorine/limpet densities (Figures 2-6 and 2-7) at Category 1 stations over the years, abundances of mussels, barnacles, and drills have varied much more dramatically. A dense set of mussels that occurred at all middle stations, but especially at Category 1 stations in 1991, has provided prey for expansion of drill populations at these sites for the 1992 through 1994 period (Figure 2-8). A strong set of the opportunistic barnacle *S. balanoides* at Category 1 sites in 1994 supplemented this prey base and led to a sharp increase in drill abundance in 1994 (Figure 2-9). Heavy predation losses resulted in a decline in both prey species, as well as in the predator in 1995. These changes at unoiled reference sites were greater in magnitude than fluctuations in this predator prey system at oiled sites.

As defined by Ganning et al. (1984) and endorsed by this study (Houghton et al. 1993a), recovery will be considered to be complete when variability of measured population and assemblage parameters at oiled sites is consistently within the range of natural fluctuations at unoiled sites. Despite the apparent bloom (1991-93) and decline (1994-95) of rockweed at oiled stations, the trend toward normal (e.g., Category 1) abundance levels for grazers and predators at middle elevation rocky stations suggest that biological controls will become increasingly influential. Because of the wide natural fluctuations in the drill/mussel-barnacle association, it may be that these components of the intertidal assemblage can be considered to be recovered at middle rocky stations. At least through

1995, the fluctuations in the grazer/rockweed association appear to be greater at the oiled middle stations than at reference stations thus, this component of the intertidal assemblage does not appear to have recovered. Again, we expect a gradual damping of oscillations in abundances of dominant species at affected sites over the coming years.

At the single lower elevation rocky station sampled 1990 through 1995, examination of pretreatment (May 1989) data provides significant insight into the effects of treatment. Washing conducted at this station had no noticeable immediate effect on cover of rockweed (15.4 percent cover in May before treatment, 22.8 percent cover in June after treatment [Houghton et al. 1995]); this apparent lack of effect suggested that temperatures used may have been lower or that wash durations were reduced (by shorter emersion time) from those experienced at the middle elevation station where rockweed was totally removed (Figure 2-4). Impacts of washing on a group of long-lived red algae were severe, however. Cover dropped from more than 70 percent to less than 20 percent immediately following the washing (Houghton et al. 1995). During the next four years, cover of rockweed expanded to over 65 percent in 1993 before declining to about 50 percent in 1994 and increasing to 57.1 percent in 1995. Nonencrusting red algae have not exceeded 20 percent cover since 1989, and recovery to pre-treatment abundance appears unlikely for several more years. Reestablishment of red algae at middle elevations is proceeding more rapidly as evidenced at the paired Northwest Bay West Arm middle rocky stations (Figure 2-13).

Large fluctuations in abundances of limpets and littorine snails at the lower Northwest Bay Islet station have generally been brief; densities of littorines appear to be trending toward the more normal (very low) numbers of these species seen at Category 1 and 2 lower stations (Table 2-4). Density of limpets remains high, however, with a strong recruitment of small limpets in 1995 (Table 2-4).

Substantial recovery of most variables characterizing intertidal epibiotal assemblages was apparent in mid-summer 1994. Few differences remained between unoiled rocky stations and stations that were oiled but not treated with high-pressure hot-water washes. Recovery at high-pressure hot-water washed rocky stations, however, continues to lag behind that at oiled but untreated stations both in terms of reduced abundance of some taxa and increased abundance of others.

The clearance of the middle and upper intertidal biota from rocky habitats during hot-water washing was relatively thorough and consistent over scales of 10s or 100s of meters of shoreline. Thus, recolonization by rockweed occurred in synchrony over these spatial scales resulting in the monoculture of same-aged rockweed plants so evident in 1990 and 1991. The natural scale of patchiness of rockweed ages has been altered because large areas of shoreline have rockweed all the same age. In a natural middle intertidal community, different cohorts of rockweed exist in patches that exist on the scale of decimeters or, at most, meters. Typically, several cohorts from germlings to senescencing plants are represented in any given 0.25-m^2 quadrat.

In the natural community, senescence of any particular cohort does not greatly alter the overall rockweed cover nor does it greatly impact the several species dependent on the rockweed for food, shelter, or protection from desiccation. The significance of resetting of the intertidal successional clock to zero with the hot-water treatment of large areas of rocky intertidal is becoming more clear as this study progresses.

INFAUNAL EXPERIMENTS

Littleneck Clam Transplants

The 1994 to 1995 transplanting experiment was confounded by apparent disturbances at both the Block Island and Outside Bay sites. At Block Island, work crews engaged in mussel bed cleaning may have disturbed at least two of the six quadrats containing transplanted Outside Bay clams. A tidal stream meandered across the three quadrats at Outside Bay and removed two of the wooden frames. The four remaining quadrats at Block Island had survival percentages ranging from 80 to 96 percent with highest survival on portions of the beach that have historically had lower residual PAH levels. Survival and recovery of clams from these quadrats were generally higher than from four quadrats of clams from Bainbridge Bight transplanted to the same area for four months in 1991. In 1991 survival ranged from 62 percent at the most contaminated side of the beach to 88 percent at the cleanest end. This may indicate that residual hydrocarbons continue to exert a negative influence on survival of transplanted clams but that the toxicity is declining.

Similar conclusions can be drawn from measurements of growth of transplanted clams at Block Island: growth was greater for clams at quadrats in portions of the site historically shown to have lower residual PAH levels; similar results were seen in the 1991 transplant experiment.

Recruitment Experiment

The recruitment experiment provided information on what may be one of the strongest factors controlling littleneck clam recruitment, i.e., there was no recruitment of littlenecks to any of the pot treatments at Northwest Bay West Arm strongly suggests one or both of two possible conclusions:

1. There are few planktonic clams encountering the beach at the head of the West Arm at the time of metamorphosis to the benthic form, and/or

2. The size of the experimental plots was insufficient to be detected by veligers in the process of settling from the plankton.

Presumably, the higher silt content in two of the treatments would have been found more favorable for settling from the plankton had there been larvae present in the water column and had the increased silt been detected. It seems more probable that there are few larvae in the waters that reach the site; there are likely no significant areas of clam populations remaining in Northwest Bay as all possible clam beaches (e.g., adjacent to the site on the Rocky Islet) suffered the same hydraulic washing as did the West Arm study site. This, in conjunction with our conclusions from the 1991 transplant experiment (very high survival of clams transplanted to the site), suggests that transplanting of littlenecks into the West Arm would be a viable means of accelerating recovery of clam populations at this beach.

Results of the recruitment experiment were inconclusive with respect to the influence of sediment grain size, TOC, and TKN on clam recruitment. At one of the sites (Outside Bay), highest recruitment was in pots with the greatest percentage of fines; at the other site (Block Island), highest recruitment was in pots with the coarsest sediment (from Northwest Bay West Arm without silt addition). The higher recruitment at the Block Island and Outside Bay locations and very poor recruitment at Northwest Bay West Arm is consistent with results from infaunal core sampling in previous years (Figure 3-5). Rates of recruitment area in the pot sampling were lower at all stations than in infaunal cores collected at the same lower elevation stations in other years. This may be the result of the disturbance caused by the warm-water treatment used to kill indigenous organisms at the start of the experiment or to some effect of the pots and stake on the recruitment behavior of the veligers as they settled from the plankton.

Presence of several larger littleneck clams in pots of local sediments at Block Island and Outside Bay suggests that the warm-water treatment was insufficient to kill all the indigenous clams before the sediments were placed in the pots. Presence of three larger clams in Northwest Bay plus silt pots (known to lack clams at the beginning of the experiment) at Block Island indicates that some clams may have entered the pots from the surface. Possibly mussel bed cleaning activities immediately up slope from the experiment in the late summer of 1994 dislodged clams that were able to rebury in the pots. No larger clams were found in raw Northwest Bay sediments at Block Island (or elsewhere), however.

It seems that the basic design of this experiment was sound and well directed to the question at hand (Is reduced level of fines responsible for the poor recruitment of littleneck clams at Northwest Bay?). However, three factors should be altered, if the experiment is to be repeated:

1. The experimental units should be larger to increase the chance of detection by veligers and to reduce the chance that wave action will alter the surficial sediments to match those of the surrounding beach.

2. The experimental sediments should be closely examined for the presence of living organisms; heat/freshwater treatment should be increased to ensure that no live clams are planted with the experimental sediments.

3. The experimental units should be inspected during the experiment to ensure that disturbances do not occur to bias the results; ideally, the experimental units should be placed in the spring before settlement of veligers is expected and retrieved in the fall after settlement is complete to avoid the winter period of high wave action.

CHAPTER 5
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ACRONYMS

ANOVA	analysis of variance
cm	centimeter
GPS	Global Positioning System
ID	identification
km	kilometer
m	meter
mm	millimeter
MLLW	mean lower low water
NOAA	National Oceanic and Atmospheric Administration
PAH	polycyclic aromatic hydrocarbons
ppm	parts per million
ppt	parts per thousand
SD	standard deviation
SE	standard error
TKN	total Kieldahl nitrogen
TOC	total organic compound

APPENDIX A

Table A-1 Location, site, station, habitat type, and total height of all sampling 1989-95.

Location and site	Habitat	Station	Tidal ht. (ft)	Epibiota 1/4 m2	Inf. core 1 mm	Mega-inf. 1/4 m2	Sediment tPAH	Mytilus tissue	Proto. tissue	Grain size	TOC/ TKN	Water qual.
Category 1--Unoiled												
Bass Harbor (NA-27)												
Rocky	Rock	Up	8.83	4ABCDFHJ			D					DH
Boulder/cobble	Boulder/cobble	Up	7.65	ADF			DF	FH				
		Mid	5.37	ABD			ABD	ABD				
		Low	1.23	ABD			ABD					E
Outside Bay (NA-26)												
Soft 1	Gravel/cobble	Up	9.45	ABDF			ABDF					
	Gravel/cobble	Mid	4.90	ABDF	14ABDF		ABDF	BGHJ		F	F	
	Gravel/sand	Low	0.33	ABDF	13ABCDFGHJ	ADFH	ABCDFGJ		DGH	FGHJ	FGHJ	DEFGH
Soft 2	Gravel/sand	Mid					D	ABDF				
Eshamy Bay (EB-7)												
Rocky	Rock	Up	9.77	4ABDFGHJ			ABDF	D				
	Rock	Mid	5.66	1234ABDFGHJ			ABDF	ABDFHG				
	Rock	Low	2.55	123BEFGH			BF					EFGH
Hogg Bay												
Rocky	Rock	Up	9.89	4ABCDFH				FH				
	Rock	Mid	7.95	134ABCDFH			BDF	ABD				
	Rock	Low	2.62	13ABCDFH			ABDF					CDEFH
Sheep Bay												
Soft	Gravel/sand	Up	9.72	ABDF			ABDF					
		Mid	4.55	ABDF	4ABDF		ABDF	ABDFGH		F	F	
		Low	2.27	ABDF	3ABDFGH	ADFH	ABDFG		DFGH	FGH	FGH	DF
Bainbridge Bight												
Soft	Gravel/sand	Low	1.30	D	CDEFGH	DFH	CDFG	DFGH	CFGH	EFGH	FGH	CDFH
Crab Bay (EV-500)												
Rocky	Rock	Mid	6.90	134ABCDFGHJ			BDF	ABDFGHJ				
	Rock	Low	0.68	13ABDFGH			BDF					DEFGH
Soft	Gravel/cobble	Up	9.51	ABDF			BDF					
	Gravel/cobble	Mid	5.49	ABDF	ABDF		ABDF	ABDFGHJ		DF	F	
	Gravel/cobble	Low	2.63	ABF	ABFGHJ	AFH	ABFGJ		DFGH	FGHJ	FGHJ	F
Seward	Boulder/cobble	Mid						D				

1=Cruise 1, April 1989; 2=Cruise 2, May 1989; 3=Cruise 3, July 1989; 4=Cruise 4, September 1989; A=July 1990; B=September 1990; C=May 1991; D=July 1991; E=September 1991; F=July 1992; G=July 1993; H=June 1994; J= July 1995.

Table A-1 (continued)

Location and site	Habitat	Station	Tidal ht. (ft)	Epibiota 1/4 m2	Inf. core 1 mm	Mega-inf. 1/4 m2	Sediment tPAH	Mytilus tissue	Proto. tissue	Grain size	TOC/ TKN	Water qual.
Category 2--Oiled, untreated												
Northwest Bay												
West Arm Rock	Rock	Mid	7.83	4ADFGHJ								
	Rock	Low		A								
Herring Bay (KN-5000)												
Rocky	Rock	Up	9.64	4ABCDFGHJ			DGH					
	Rock	Mid	5.37	1234ABCDFGHJ			BDFH	ABDFGH				DFG
Soft	Gravel/cobble	Up	7.21	ABDF			BDFH					
	Gravel/sand	Low	0.23	ABCDF	1234ABCDFGHJ	ABDFH	BDFG	DFGH	FGH	DFGHJ	FGHJ	F
Bay of Isles (KN-07)												
Rocky	Rock	Mid	4.80	134ABD			ABDH	ABDFH				DF
Soft	Gravel/cobble	Up		ABD			ABDH					
	Gravel/cobble	Low	-0.14	BD	134BD	BD	BD		D	D		D
Snug Harbor (KN-401)												
Rocky	Rock	Up	8.41	4ABCDFGHJ			ABDFG					
	Rock	Mid	5.13	234ABCDFGHJ			ABDFGJ	ABDFGHJ				
	Rock	Low	1.52	23ABDFGH			ABDF					DEFGH
Soft	Gravel/cobble	Up	9.28	ABDF			ABDF					
	Gravel/sand	Mid	5.74	ABCDF	ABDF		ADF	ADFHJ		DF	F	
	Gravel/sand	Low	-0.15	ABCDF	234ABCDFGHJ	ADFH	ABDFGJ	G	DFGH	DFGHJ	FGHJ	F
Block Island (EL-11)												
Soft	Gravel/sand	Low	3.59	ABDF	ABCDFGHJ	ADFH	BCDFGHJ	FGJ	CDFGH	DFGHJ	FGHJ	FH
Mussel Beach South												
Soft	Gravel/sand	Mid	4.40	ABDF	BDF		ABDF	ABDFJ		DF	F	
	Gravel/sand	Low	-0.89	ACDF	234ADFGHJ	ADFH	ADFG	GH	FGH	DFGHJ	FGHJ	DFH
Crafton Island (CR-5)												
Soft	Gravel/cobble	Up	8.52	ABD			ABDF					
	Gravel/cobble	Mid	5.01	ABD	D		ABDF	ABDFHJ		D		
	Gravel/cobble	Low	2.95	ABD	ABDG	ABD	ABDFGH	G	G	DG	G	DEF
Outside Bay (NA-26)												
Rocky	Rock	Up	8.96	4ABCDFGHJ			ABF					

1=Cruise 1, April 1989; 2=Cruise 2, May 1989; 3=Cruise 3, July 1989; 4=Cruise 4, September 1989; A=July 1990; B=September 1990; C=May 1991; D=July 1991; E=September 1991; F=July 1992; G=July 1993; H=June 1994; J= July 1995.

Table A-1 (continued)

Location and site	Habitat	Station	Tidal ht. (ft)	Epibiota 1/4 m2	Inf. core 1 mm	Mega-inf. 1/4 m2	Sediment tPAH	Mytilus tissue	Proto. tissue	Grain size	TOC/ TKN	Water qual.
	Rock	Mid	5.27	134ABCDFGHJ			F					
	Rock	Low	0.70	13ABCDFGH			BDF					CDF
Ingot Island (IN-24)												
Boulder/cobble	Rock/boulder	Mid	6.80	BD			BDF	BDFH				
Soft	Gravel/cobble	Low	2.33	BDF	BDFG	BDF	BDFG	G	DG	DFG	FG	E
Category 3--Oiled, treated												
Point Helen (KN-405) Site 1												
Boulder/cobble	Boulder/cobble	Up	7.25	ADF			F					
	Boulder/cobble	Mid	4.16	ABD			ABDFH	ABDFH				
	Boulder/cobble	Low	-1.46	ABD			BDFH					DEF
Point Helen (KN-405) Site 3												
Boulder/cobble	Boulder/cobble	Up		F								
	Boulder/cobble	Mid		F								
	Boulder/cobble	Low		F								
Northwest Bay												
Rocky Islet (EL-55)	Rock	Up	9.42	4ABCDFHJ			ADFGH					
	Rock	Mid	6.97	1234ABCDFGHJ			ABDFGJ	ABDFGHJ				
	Rock	Low	2.46	234ABCDFGHJ			ABDFG					DEFGH
West Arm Rock	Rock	Mid	7.83	4ADFGHJ								FG
	Rock	Low		A								
W. Arm Soft (EL-52	Gravel/cobble	Mid	6.20	ABDFH	BDF		ABDFJ	ABDFHJ		DF	F	
	Gravel/sand	Low	0.63	ABDFH	23ABCDFGHJ	ADFH	ABCDFGJ	G	DFGH	DFGHJ	FGHJ	
Shelter Bay (EV-21)												
Soft	Gravel/sand	Up	8.57	BDF			DF					
	Gravel/sand	Mid	6.18	ABDF	4ABDF		ABDF	ABDFGHJ		DF	F	
	Gravel/sand	Low	1.02	ABDF	234ABCDFGHJ	ADFH	ABCDFGJ		DFGH	DFGHJ	FGHJ	DF
Sleepy Bay (LA-18)												
Soft	Gravel/cobble	Up	3.56	ADF	AB		ABDF					
	Gravel/sand	Mid	1.48	ABDF	ABDF		ABDF	ABDFGHJ		DF	F	
	Gravel/sand	Low	-0.85	BDF	DFGHJ	DFH	DFGJ		DF	DFGHJ	FGHJ	F

1=Cruise 1, April 1989; 2=Cruise 2, May 1989; 3=Cruise 3, July 1989; 4=Cruise 4, September 1989; A=July 1990; B=September 1990; C=May 1991; D=July 1991; E=September 1991; F=July 1992; G=July 1993; H=June 1994; J= July 1995.

Table A-1 (continued)

Location and site	Habitat	Station	Tidal ht. (ft)	Epibiota 1/4 m2	Inf. core 1 mm	Mega-inf. 1/4 m2	Sediment tPAH	Mytilus tissue	Proto. tissue	Grain size	TOC/ TKN	Water qual.
Ne Latouche Cobble (LA-15)												
Boulder/cobble	Boulder/cobble	Mid	3.19	ABDF			ABDF	ABDFH				D
	Boulder/cobble	Low	0.71	BDF			BF					F
Smith Island (SM-06)												
Boulder/cobble	Boulder/cobble	Up	8.35	BD			BDH					
N-4	Boulder/cobble	Mid	6.35	ABD			ABDH	ABDGH				
	Boulder/cobble	Low	2.14	ABD			ABDH					DEFG
Mussel Beach South (EL-13)												
Rocky	Rock	Up		4ABCDFGHJ			DF					D
Mussel Beach North (EL-13)												
Rocky	Rock	Up		FGH								
	Rock	Mid		FGH								
	Rock	Mid (ABC)		F								
	Rock	Low		FGH								F
Omni Site												
Boulder/cobble	Rock/boulder	Mid		FH			F	F				
Block Island (EL-11)												
Rocky	Rock	Up	8.27	CDFGHJ								
	Rock	Mid	3.82	ABCDFGHJ			A	ABDFGHJ		F		CDGH
Soft	Gravel/sand	Up		ABD	BF	A	ABDFH	BGH			F	
	Gravel/sand	Mid	6.49	ADF								
Elrington Island West												
Rocky	Rock	Up					F					
	Rock	Mid		4FH			F	F				
	Rock	Low		FH			F					F
Soft	Gravel/sand	Mid					F					
	Gravel/sand	Low			FGH	FH	FG	GH	FGH	FGH	FGH	
Elrington Island East												
Rocky	Rock	Up		F			F					
	Rock	Mid		4FH			F					
	Rock	Low		FH								
Soft	Gravel/sand	Mid					F	F				
	Gravel/sand	Low					F		F			
Elrington Islet--East		Up		FH								

1=Cruise 1, April 1989; 2=Cruise 2, May 1989; 3=Cruise 3, July 1989; 4=Cruise 4, September 1989; A=July 1990; B=September 1990; C=May 1991; D=July 1991; E=September 1991; F=July 1992; G=July 1993; H=June 1994; J= July 1995.

Table A-1 (continued)

Location and site	Habitat	Station	Tidal ht. (ft)	Epibiota 1/4 m2	Inf. core 1 mm	Mega-inf. 1/4 m2	Sediment tPAH	Mytilus tissue	Proto. tissue	Grain size	TOC/ TKN	Water qual.
Elrington Islet--West		Up		FH								H
Elrington Islet--North		Up		FH								
Bainbridge Bight		Low		D								
Soft												

1=Cruise 1, April 1989; 2=Cruise 2, May 1989; 3=Cruise 3, July 1989; 4=Cruise 4, September 1989; A=July 1990; B=September 1990; C=May 1991; D=July 1991; E=September 1991; F=July 1992; G=July 1993; H=June 1994; J= July 1995.

Table A-2 Water temperature (°C) and salinity (ppt) at sampling sites in Prince William Sound, July 1995.

Site	Habitat	Depth	Date	Temp.	Salinity
Block Island	Rock	0.3 m	7/12/95	11.2	28.2
Block Island	Rock	2.4 m	7/12/95	10.3	29.0
Crab Bay	Rock	0.3 m	7/15/95	11.0	27.7
Crab Bay	Rock	1.8 m	7/15/95	10.8	27.8
Eshamy Bay	Rock	0.3 m	7/14/95	13.0	22.9
Eshamy Bay	Rock	1.8 m	7/14/95	12.8	23.8
Northwest Bay Islet	Rock	0.3 m	7/13/95	10.1	29.0
Northwest Bay Islet	Rock	1.8 m	7/13/95	10.4	29.2
Outside Bay	Soft1	0.3 m	7/14/95	11.9	28.8
Outside Bay	Soft1	1.8 m	7/14/95	11.1	29.6
Snug Harbor	Rock	0.3 m	7/16/95	10.9	8.0
Snug Harbor	Rock	1.8 m	7/16/95	12.8	25.5

APPENDIX B

Table B-1 Rocky middle intertidal epibiota, July 1995

	Bass Harbor				Block Island			
Taxon	Mean	SD	SE	Count	Mean	SD	SE.	Count
Blidingia minima	0.30	0.45	0.20	5	0.00	0.00	0.00	5
Blue-green algae, spheroids	0.60	0.42	0.19	5	0.00	0.00	0.00	5
Bryophyta, unid.	0.00	0.00	0.00	5	0.00	0.00	0.00	5
Cladophora sericea	0.00	0.00	0.00	5	0.10	0.22	0.10	5
Corallina sp.	0.00	0.00	0.00	5	0.00	0.00	0.00	5
Elachista fucicola	0.20	0.27	0.12	5	0.00	0.00	0.00	5
Endocladia muricata	0.10	0.22	0.10	5	0.00	0.00	0.00	5
Endozoic green algae	0.40	0.22	0.10	5	0.10	0.22	0.10	5
Fucus gardneri	4.40	6.23	2.79	5	10.70	12.32	5.51	5
Fucus gardneri (germlings)	1.60	2.04	0.91	5	1.50	1.00	0.45	5
Gloiopeltis furcata	1.40	1.64	0.73	5	0.20	0.27	0.12	5
Halosaccion glandiforme	0.10	0.22	0.10	5	0.00	0.00	0.00	5
Hildenbrandia rubra	0.50	0.50	0.22	5	3.00	3.08	1.38	5
Leathesia difformis	0.10	0.22	0.10	5	0.00	0.00	0.00	5
Melanosiphon intestinalis	0.10	0.22	0.10	5	0.20	0.45	0.20	5
Neorhodomela oregona	0.40	0.89	0.40	5	1.20	2.68	1.20	5
Porphyra spp.	0.10	0.22	0.10	5	0.00	0.00	0.00	5
Ralfsia fungiformis	0.00	0.00	0.00	5	0.10	0.22	0.10	5
Ralfsia spp.	0.00	0.00	0.00	5	1.20	2.68	1.20	5
Verrucaria spp.	0.00	0.00	0.00	5	9.80	14.94	6.68	5
Balanus glandula (%)	6.00	10.67	4.77	5	0.80	0.76	0.34	5
Balanus/Semibalanus spp. (%)	0.00	0.00	0.00	5	1.20	2.14	0.96	5
Balanus/Semibalanus spp., set (%)	0.00	0.00	0.00	5	0.60	0.82	0.37	5
Chthamalus dalli (% set)	0.50	0.00	0.00	5	0.30	0.45	0.20	5
Chthamalus dalli (%)	3.50	2.24	1.00	5	0.30	0.27	0.12	5
Littorina spp., eggs (%)	0.00	0.00	0.00	5	0.50	0.87	0.39	5
Mytilus cf. trossulus (% spat)	0.80	1.25	0.56	5	0.10	0.22	0.10	5
Mytilus cf. trossulus (%)	0.00	0.00	0.00	5	0.40	0.89	0.40	5
Semibalanus balanoides (% set)	7.40	5.13	2.29	5	0.00	0.00	0.00	5
Semibalanus balanoides (%)	50.80	15.59	6.97	5	0.10	0.22	0.10	5
Semibalanus cariosus (%)	0.60	1.34	0.60	5	0.00	0.00	0.00	5

Table B-1 (continued)

	Bass Harbor				Block Island			
Taxon	Mean	SD	SE	Count	Mean	SD	SE.	Count
Acarina	0.00	0.00	0.00	5	0.00	0.00	0.00	5
Clinocottus acuticeps	0.00	0.00	0.00	5	0.20	0.45	0.20	5
Ligia sp.	0.00	0.00	0.00	5	0.00	0.00	0.00	5
Littorina scutulata	238.00	156.59	70.03	5	0.00	0.00	0.00	5
Littorina scutulata (juv.)	0.00	0.00	0.00	5	37.00	21.19	9.48	5
Littorina sitkana	20.00	15.83	7.08	5	0.00	0.00	0.00	5
Littorina sitkana (juv.)	0.00	0.00	0.00	5	42.80	49.03	21.93	5
Lottia digitalis	0.00	0.00	0.00	5	0.00	0.00	0.00	5
Lottia pelta	5.60	6.69	2.99	5	0.00	0.00	0.00	5
Lottiidae, unid.	24.60	21.42	9.58	5	2.40	3.91	1.75	5
Lottiidae, unid. (juv.)	0.00	0.00	0.00	5	0.40	0.89	0.40	5
Nucella lamellosa	0.20	0.45	0.20	5	0.00	0.00	0.00	5
Nucella lima	0.40	0.89	0.40	5	0.00	0.00	0.00	5
Pagurus hirsutiusculus	0.20	0.45	0.20	5	2.80	6.26	2.80	5
Protothaca staminea	0.00	0.00	0.00	5	0.00	0.00	0.00	5
Tectura persona	0.00	0.00	0.00	5	0.00	0.00	0.00	5
Tectura scutum	0.00	0.00	0.00	5	0.00	0.00	0.00	5
Balanus glandula (% dead)	0.00	0.00	0.00	5	0.10	0.22	0.10	5
Balanus/Semibalanus spp. (% dead)	0.00	0.00	0.00	5	0.10	0.22	0.10	5
Chthamalus dalli (% dead)	0.40	0.22	0.10	5	0.00	0.00	0.00	5
Mytilus cf. trossulus (dead)	0.00	0.00	0.00	5	3.40	7.06	3.16	5
Semibalanus balanoides (% dead)	3.70	2.11	0.94	5	0.10	0.22	0.10	5
Semibalanus balanoides (% set, dead)	0.00	0.00	0.00	5	0.00	0.00	0.00	5
Boulder/Cobble (%)	0.10	0.22	0.10	5	0.00	0.00	0.00	5
Gravel/Sand(%)	0.00	0.00	0.00	5	0.00	0.00	0.00	5
Oil cover (%) (primary)	0.00	0.00	0.00	5	0.00	0.00	0.00	5
Oil scale (primary)	0.00	0.00	0.00	5	0.00	0.00	0.00	5
Oil Scale (secondary)	0.00	0.00	0.00	5	0.00	0.00	0.00	5
Rock (%)	100.00	0.00	0.00	5	100.00	0.00	0.00	5
Water (%)	0.20	0.45	0.20	5	4.20	8.84	3.95	5

Table B-1 (continued)

	Eshamy Bay				Herring Bay				
Taxon	Mean	SD	SE	Count	Mean	SD	SE.	Count	Mean
Blidingia minima	0.10	0.22	0.10	5	0.00	0.00	0.00	5	0.00
Blue-green algae, spheroids	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Bryophyta, unid.	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.10
Cladophora sericea	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Corallina sp.	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Elachista fucicola	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Endocladia muricata	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Endozoic green algae	0.10	0.22	0.10	5	0.00	0.00	0.00	5	0.10
Fucus gardneri	0.80	0.76	0.34	5	0.10	0.22	0.10	5	1.40
Fucus gardneri (germlings)	0.20	0.45	0.20	5	0.60	0.42	0.19	5	0.10
Gloiopeltis furcata	0.00	0.00	0.00	5	0.10	0.22	0.10	5	0.10
Halosaccion glandiforme	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Hildenbrandia rubra	0.20	0.45	0.20	5	0.50	0.35	0.16	5	0.20
Leathesia difformis	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Melanosiphon intestinalis	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Neorhodomela oregona	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Porphyra spp.	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Ralfsia fungiformis	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Ralfsia spp.	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Verrucaria spp.	9.90	14.45	6.46	5	0.20	0.45	0.20	5	3.60
Balanus glandula (%)	0.40	0.42	0.19	5	0.70	0.27	0.12	5	0.30
Balanus/Semibalanus spp. (%)	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Balanus/Semibalanus spp., set (%)	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Chthamalus dalli (% set)	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Chthamalus dalli (%)	0.30	0.27	0.12	5	0.30	0.45	0.20	5	0.40
Littorina spp., eggs (%)	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Mytilus cf. trossulus (% spat)	0.00	0.00	0.00	5	0.10	0.22	0.10	5	0.10
Mytilus cf. trossulus (%)	0.40	0.89	0.40	5	0.10	0.22	0.10	5	0.00
Semibalanus balanoides (% set)	0.40	0.22	0.10	5	0.00	0.00	0.00	5	0.00
Semibalanus balanoides (%)	0.50	0.87	0.39	5	0.10	0.22	0.10	5	0.00
Semibalanus cariosus (%)	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00

Table B-1 (continued)

	Eshamy Bay				Herring Bay				
Taxon	Mean	SD	SE	Count	Mean	SD	SE.	Count	Mean
Acarina	0.00	0.00	0.00	5	P	-	-	4	P
Clinocottus acuticeps	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Ligia sp.	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Littorina scutulata	33.40	32.44	14.51	5	41.60	27.74	12.40	5	7.60
Littorina scutulata (juv.)	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Littorina sitkana	50.40	33.53	15.00	5	6.60	5.55	2.48	5	29.60
Littorina sitkana (juv.)	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Lottia digitalis	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Lottia pelta	0.00	0.00	0.00	5	0.00	0.00	0.00	5	6.00
Lottiidae, unid.	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Lottiidae, unid. (juv.)	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Nucella lamellosa	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Nucella lima	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Pagurus hirsutiusculus	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Protothaca staminea	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Tectura persona	7.00	10.39	4.65	5	4.20	2.17	0.97	5	0.00
Tectura scutum	0.20	0.45	0.20	5	0.00	0.00	0.00	5	0.00
Balanus glandula (% dead)	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.10
Balanus/Semibalanus spp. (% dead)	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.10
Chthamalus dalli (% dead)	0.10	0.22	0.10	5	0.00	0.00	0.00	5	0.10
Mytilus cf. trossulus (dead)	0.40	0.89	0.40	5	0.20	0.45	0.20	5	0.80
Semibalanus balanoides (% dead)	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Semibalanus balanoides (% set, dead)	0.10	0.22	0.10	5	0.00	0.00	0.00	5	0.00
Boulder/Cobble (%)	19.00	42.49	19.00	5	0.00	0.00	0.00	5	54.60
Gravel/Sand(%)	1.00	2.24	1.00	5	0.00	0.00	0.00	5	5.80
Oil cover (%) (primary)	0.00	0.00	0.00	5	0.70	0.76	0.34	5	0.00
Oil scale (primary)	0.00	0.00	0.00	5	4.80	2.68	1.20	5	0.00
Oil Scale (secondary)	0.00	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Rock (%)	80.00	44.72	20.00	5	100.00	0.00	0.00	5	39.60
Water (%)	0.30	0.45	0.20	5	0.00	0.00	0.00	5	0.00

Table B-1 (continued)

Taxon	Mussel Beach South SD	Mussel Beach South SE.	Mussel Beach South Count	NW Bay Rocky Inlet Mean	NW Bay Rocky Inlet SD	NW Bay Rocky Inlet SE.	NW Bay Rocky Inlet Count	Mean
Blidingia minima	0.00	0.00	5	0.00	0.00	0.00	5	0.30
Blue-green algae, spheroids	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Bryophyta, unid.	0.22	0.10	5	0.00	0.00	0.00	5	0.00
Cladophora sericea	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Corallina sp.	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Elachista fucicola	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Endocladia muricata	0.00	0.00	5	0.00	0.00	0.00	5	0.30
Endozoic green algae	0.22	0.10	5	0.00	0.00	0.00	5	0.20
Fucus gardneri	3.13	1.40	5	0.10	0.22	0.10	5	8.30
Fucus gardneri (germlings)	0.22	0.10	5	0.20	0.27	0.12	5	1.40
Gloiopeltis furcata	0.22	0.10	5	0.00	0.00	0.00	5	6.10
Halosaccion glandiforme	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Hildenbrandia rubra	0.27	0.12	5	0.30	0.27	0.12	5	0.20
Leathesia difformis	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Melanosiphon intestinalis	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Neorhodomela oregona	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Porphyra spp.	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Ralfsia fungiformis	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Ralfsia spp.	0.00	0.00	5	0.80	1.79	0.80	5	0.00
Verrucaria spp.	5.32	2.38	5	0.20	0.45	0.20	5	30.00
Balanus glandula (%)	0.45	0.20	5	0.20	0.45	0.20	5	0.90
Balanus/Semibalanus spp. (%)	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Balanus/Semibalanus spp., set (%)	0.00	0.00	5	0.10	0.22	0.10	5	0.00
Chthamalus dalli (% set)	0.00	0.00	5	0.10	0.22	0.10	5	0.30
Chthamalus dalli (%)	0.42	0.19	5	0.30	0.45	0.20	5	0.90
Littorina spp., eggs (%)	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Mytilus cf. trossulus (% spat)	0.22	0.10	5	0.00	0.00	0.00	5	0.00
Mytilus cf. trossulus (%)	0.00	0.00	5	0.00	0.00	0.00	5	0.10
Semibalanus balanoides (% set)	0.00	0.00	5	0.10	0.22	0.10	5	0.50
Semibalanus balanoides (%)	0.00	0.00	5	0.20	0.27	0.12	5	2.50
Semibalanus cariosus (%)	0.00	0.00	5	0.00	0.00	0.00	5	0.00

Table B-1 (continued)

	Mussel Beach South			NW Bay Rocky Inlet				
Taxon	SD	SE.	Count	Mean	SD	SE.	Count	Mean
Acarina	-	-	2	0.00	0.00	0.00	5	P
Clinocottus acuticeps	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Ligia sp.	0.00	0.00	5	0.00	0.00	0.00	5	1.00
Littorina scutulata	13.79	6.17	5	103.40	46.94	20.99	5	141.60
Littorina scutulata (juv.)	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Littorina sitkana	25.47	11.39	5	19.20	10.80	4.83	5	16.00
Littorina sitkana (juv.)	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Lottia digitalis	0.00	0.00	5	0.00	0.00	0.00	5	0.20
Lottia pelta	9.41	4.21	5	0.60	0.89	0.40	5	0.00
Lottiidae, unid.	0.00	0.00	5	0.00	0.00	0.00	5	1.40
Lottiidae, unid. (juv.)	0.00	0.00	5	0.80	1.79	0.80	5	0.00
Nucella lamellosa	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Nucella lima	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Pagurus hirsutiusculus	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Protothaca staminea	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Tectura persona	0.00	0.00	5	0.20	0.45	0.20	5	0.00
Tectura scutum	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Balanus glandula (% dead)	0.22	0.10	5	0.00	0.00	0.00	5	0.00
Balanus/Semibalanus spp. (% dead)	0.22	0.10	5	0.10	0.22	0.10	5	0.00
Chthamalus dalli (% dead)	0.22	0.10	5	0.10	0.22	0.10	5	0.00
Mytilus cf. trossulus (dead)	1.79	0.80	5	0.00	0.00	0.00	5	0.00
Semibalanus balanoides (% dead)	0.00	0.00	5	0.00	0.00	0.00	5	0.20
Semibalanus balanoides (% set, dead)	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Boulder/Cobble (%)	49.39	22.09	5	0.00	0.00	0.00	5	0.00
Gravel/Sand(%)	4.92	2.20	5	0.00	0.00	0.00	5	0.00
Oil cover (%) (primary)	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Oil scale (primary)	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Oil Scale (secondary)	0.00	0.00	5	0.00	0.00	0.00	5	0.00
Rock (%)	54.23	24.25	5	100.00	0.00	0.00	5	100.00
Water (%)	0.00	0.00	5	0.00	0.00	0.00	5	0.60

Table B-1 (continued)

Taxon	Outside Bay SD	Outside Bay SE.	Outside Bay Count	Snug Harbor Mean	Snug Harbor SD	Snug Harbor SE.	Snug Harbor Count
Blidingia minima	0.27	0.12	5	0.00	0.00	0.00	5
Blue-green algae, spheroids	0.00	0.00	5	0.00	0.00	0.00	5
Bryophyta, unid.	0.00	0.00	5	0.00	0.00	0.00	5
Cladophora sericea	0.00	0.00	5	0.00	0.00	0.00	5
Corallina sp.	0.00	0.00	5	0.00	0.00	0.00	5
Elachista fucicola	0.00	0.00	5	0.00	0.00	0.00	5
Endocladia muricata	0.27	0.12	5	0.00	0.00	0.00	5
Endozoic green algae	0.27	0.12	5	0.60	0.82	0.37	5
Fucus gardneri	14.96	6.69	5	41.00	47.06	21.05	5
Fucus gardneri (germlings)	2.04	0.91	5	0.50	0.35	0.16	5
Gloiopeltis furcata	13.36	5.98	5	0.40	0.42	0.19	5
Halosaccion glandiforme	0.00	0.00	5	0.00	0.00	0.00	5
Hildenbrandia rubra	0.45	0.20	5	6.30	7.09	3.17	5
Leathesia difformis	0.00	0.00	5	0.00	0.00	0.00	5
Melanosiphon intestinalis	0.00	0.00	5	0.00	0.00	0.00	5
Neorhodomela oregona	0.00	0.00	5	0.00	0.00	0.00	5
Porphyra spp.	0.00	0.00	5	0.00	0.00	0.00	5
Ralfsia fungiformis	0.00	0.00	5	0.00	0.00	0.00	5
Ralfsia spp.	0.00	0.00	5	0.00	0.00	0.00	5
Verrucaria spp.	25.98	11.62	5	4.40	6.07	2.71	5
Balanus glandula (%)	1.24	0.56	5	1.50	1.00	0.45	5
Balanus/Semibalanus spp. (%)	0.00	0.00	5	0.00	0.00	0.00	5
Balanus/Semibalanus spp., set (%)	0.00	0.00	5	0.40	0.42	0.19	5
Chthamalus dalli (% set)	0.27	0.12	5	0.00	0.00	0.00	5
Chthamalus dalli (%)	1.24	0.56	5	0.20	0.27	0.12	5
Littorina spp., eggs (%)	0.00	0.00	5	0.00	0.00	0.00	5
Mytilus cf. trossulus (% spat)	0.00	0.00	5	0.30	0.27	0.12	5
Mytilus cf. trossulus (%)	0.22	0.10	5	0.90	0.65	0.29	5
Semibalanus balanoides (% set)	0.87	0.39	5	0.40	0.22	0.10	5
Semibalanus balanoides (%)	3.28	1.47	5	0.40	0.42	0.19	5
Semibalanus cariosus (%)	0.00	0.00	5	0.00	0.00	0.00	5

Table B-1 (continued)

Taxon	Outside Bay			Snug Harbor			
	SD	SE.	Count	Mean	SD	SE.	Count
Acarina	-	-	3	0.00	0.00	0.00	5
Clinocottus acuticeps	0.00	0.00	5	0.00	0.00	0.00	5
Ligia sp.	1.22	0.55	5	0.00	0.00	0.00	5
Littorina scutulata	159.10	71.15	5	7.80	3.19	1.43	5
Littorina scutulata (juv.)	0.00	0.00	5	0.00	0.00	0.00	5
Littorina sitkana	18.36	8.21	5	98.80	89.89	40.20	5
Littorina sitkana (juv.)	0.00	0.00	5	0.00	0.00	0.00	5
Lottia digitalis	0.45	0.20	5	0.00	0.00	0.00	5
Lottia pelta	0.00	0.00	5	0.20	0.45	0.20	5
Lottiidae, unid.	1.14	0.51	5	7.80	5.07	2.27	5
Lottiidae, unid. (juv.)	0.00	0.00	5	0.00	0.00	0.00	5
Nucella lamellosa	0.00	0.00	5	0.00	0.00	0.00	5
Nucella lima	0.00	0.00	5	0.00	0.00	0.00	5
Pagurus hirsutiusculus	0.00	0.00	5	4.00	7.31	3.27	5
Protothaca staminea	0.00	0.00	5	0.20	0.45	0.20	5
Tectura persona	0.00	0.00	5	2.60	3.71	1.66	5
Tectura scutum	0.00	0.00	5	0.00	0.00	0.00	5
Balanus glandula (% dead)	0.00	0.00	5	0.10	0.22	0.10	5
Balanus/Semibalanus spp. (% dead)	0.00	0.00	5	0.00	0.00	0.00	5
Chthamalus dalli (% dead)	0.00	0.00	5	0.00	0.00	0.00	5
Mytilus cf. trossulus (dead)	0.00	0.00	5	0.20	0.45	0.20	5
Semibalanus balanoides (% dead)	0.27	0.12	5	0.10	0.22	0.10	5
Semibalanus balanoides (% set, dead)	0.00	0.00	5	0.00	0.00	0.00	5
Boulder/Cobble (%)	0.00	0.00	5	92.40	6.02	2.69	5
Gravel/Sand(%)	0.00	0.00	5	7.60	6.02	2.69	5
Oil cover (%) (primary)	0.00	0.00	5	0.20	0.45	0.20	5
Oil scale (primary)	0.00	0.00	5	0.00	0.00	0.00	5
Oil Scale (secondary)	0.00	0.00	5	1.20	2.68	1.20	5
Rock (%)	0.00	0.00	5	0.00	0.00	0.00	5
Water (%)	1.34	0.60	5	0.20	0.45	0.20	5

Table B-2. Rocky middle intertidal epibiota, July 1995.

	Block Island				Crab Bay			
Taxon	Mean	S.D.	S.E.	Count	Mean	S.D.	S.E.	Count
Acrosiphonia sp.	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Black crust (maybe H. rubra w/ endophytic green)	0.15	0.24	0.08	10	0.00	0.00	0.00	10
Blidingia minima	0.05	0.16	0.05	10	0.00	0.00	0.00	10
Blue-green algae, spheroids	0.30	0.26	0.08	10	0.00	0.00	0.00	10
Chaetomorpha tortuosa	0.00	0.00	0.00	10	0.40	0.66	0.21	10
Cladophora sericea	0.65	1.06	0.33	10	0.00	0.00	0.00	10
Cryptosiphonia woodii	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Dictyosiphon foeniculaceus	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Elachista fucicola	0.80	0.75	0.24	10	0.00	0.00	0.00	10
Encrusting coralline algae	0.10	0.32	0.10	10	0.00	0.00	0.00	10
Encrusting green algae	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Endocladia muricata	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Endozoic green algae	0.50	0.33	0.11	10	0.70	0.86	0.27	10
Enteromorpha intestinalis	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Enteromorpha linza	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Fucus gardneri	28.00	28.11	8.89	10	44.50	35.10	11.10	10
Fucus gardneri (germlings)	2.80	2.03	0.64	10	2.00	3.95	1.25	10
Gloiopeltis furcata	0.50	0.24	0.07	10	1.35	1.45	0.46	10
Halosaccion glandiforme	0.10	0.21	0.07	10	0.00	0.00	0.00	10
Hildenbrandia rubra	0.80	0.48	0.15	10	0.00	0.00	0.00	10
Leathesia difformis	0.10	0.21	0.07	10	0.05	0.16	0.05	10
Mastocarpus papillatus	0.05	0.16	0.05	10	0.10	0.32	0.10	10
Mazzaella spp. (Iridaea sp.)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Melanosiphon intestinalis	0.50	0.94	0.30	10	0.00	0.00	0.00	10
Monostroma grevillei	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Nemalion helminthoides	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Neorhodomela oregona	3.45	5.95	1.88	10	0.95	2.15	0.68	10
Neorhodomela larix	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Palmaria callophylloides	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Petrocelis spp.	0.30	0.95	0.30	10	0.00	0.00	0.00	10
Pilayella littoralis	0.70	1.34	0.42	10	0.30	0.95	0.30	10
Pterosiphonia bipinnata	0.10	0.32	0.10	10	0.00	0.00	0.00	10
Ralfsia spp.	0.50	0.82	0.26	10	0.00	0.00	0.00	10
Rhodochorton purpureum	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Scytosiphon lomentaria	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Soranthera ulvoidea	0.95	2.50	0.79	10	0.05	0.16	0.05	10
Sphacelaria rigidula	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Ulva/Ulvaria spp.	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Verrucaria spp.	0.15	0.24	0.08	10	0.05	0.16	0.05	10

Table B-2. (continued).

Taxon	Block Island				Crab Bay			
	Mean	S.D.	S.E.	Count	Mean	S.D.	S.E.	Count
Balanus glandula (% set)	0.35	0.63	0.20	10	0.10	0.32	0.10	10
Balanus glandula (%)	3.60	4.50	1.42	10	2.45	4.49	1.42	10
Balanus rostratus (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Balanus/Semibalanus spp., set (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Chthamalus dalli (% set)	0.15	0.24	0.08	10	0.10	0.21	0.07	10
Chthamalus dalli (%)	0.50	0.24	0.07	10	0.95	1.82	0.57	10
Encrusting bryozoan (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Littorina spp., eggs (%)	0.25	0.26	0.08	10	0.00	0.00	0.00	10
Mytilus cf. trossulus (% spat)	0.90	0.66	0.21	10	0.55	0.28	0.09	10
Mytilus cf. trossulus (%)	8.65	8.92	2.82	10	6.55	7.41	2.34	10
Nucella spp. (% eggs)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Semibalanus balanoides (% set)	3.15	1.94	0.61	10	0.40	0.32	0.10	10
Semibalanus balanoides (%)	4.85	4.89	1.55	10	0.95	1.04	0.33	10
Semibalanus cariosus (% set)	0.00	0.00	0.00	10	0.05	0.16	0.05	10
Semibalanus cariosus (%)	0.00	0.00	0.00	10	0.05	0.16	0.05	10
Siphonaria thersites, eggs (%)	0.00	0.00	0.00	10	0.25	0.26	0.08	10
Spirorbidae, unid. (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	10

Table B-2. (continued).

Taxon	Block Island				Crab Bay			
	Mean	S.D.	S.E.	Count	Mean	S.D.	S.E.	Count
Acarina	P	-	-	6	P	-	-	6
Anthopleura artemisia	0.10	0.32	0.10	10	0.00	0.00	0.00	10
Clinocottus acuticeps	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Emplectonema gracile	0.10	0.32	0.10	10	0.10	0.32	0.10	10
Gammaridea, unid.	P	-	-	9	0.00	0.00	0.00	10
Gnorimosphaeroma oregonensis	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Heptacarpus sp.	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Lacuna spp.	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Lacuna variegata	0.00	0.00	0.00	10	0.50	1.58	0.50	10
Leptasterias hexactis	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Littorina scutulata	21.40	23.56	7.45	10	7.60	12.04	3.81	10
Littorina scutulata (juv.)	4.80	14.13	4.47	10	0.00	0.00	0.00	10
Littorina sitkana	17.20	14.47	4.58	10	128.30	145.76	46.09	10
Littorina sitkana (juv.)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Lottia pelta	2.40	4.17	1.32	10	1.90	3.31	1.05	10
Lottiidae, unid.	48.30	20.48	6.48	10	29.70	29.04	9.18	10
Lottiidae, unid. (juv.)	1.30	1.77	0.56	10	0.00	0.00	0.00	10
Musculus spp.	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Nucella lamellosa	0.00	0.00	0.00	10	1.40	2.55	0.81	10
Nucella lima	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Onchidella borealis	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Pagurus granosimanus	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Pagurus hirsutiusculus	19.60	21.49	6.80	10	5.80	6.97	2.21	10
Pentidotea wosnesenskii	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Pododesmus macroschismata	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Polychaeta, unid.	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Searlesia dira	0.30	0.67	0.21	10	0.00	0.00	0.00	10
Siphonaria thersites	0.70	1.89	0.60	10	2.90	3.45	1.09	10
Tectura persona	0.00	0.00	0.00	10	2.10	6.30	1.99	10
Tectura scutum	0.60	1.26	0.40	10	0.80	2.53	0.80	10
Encrusting coralline algae (dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Fucus gardneri (dead)	0.45	0.28	0.09	10	0.15	0.24	0.08	10

Table B-2. (continued).

Taxon	Block Island Mean	Block Island S.D.	Block Island S.E.	Block Island Count	Crab Bay Mean	Crab Bay S.D.	Crab Bay S.E.	Crab Bay Count
Balanus crenatus (% dead)	0.05	0.16	0.05	10	0.00	0.00	0.00	10
Balanus glandula (% dead)	0.25	0.26	0.08	10	0.30	0.35	0.11	10
Balanus/Semibalanus spp. (% dead)	0.05	0.16	0.05	10	0.00	0.00	0.00	10
Balanus/Semibalanus spp. (% set, dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Chthamalus dalli (% dead)	0.15	0.24	0.08	10	0.00	0.00	0.00	10
Encrusting bryozoan (% dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Mytilus cf. trossulus (dead)	4.20	3.61	1.14	10	2.70	3.74	1.18	10
Semibalanus balanoides (% dead)	0.25	0.26	0.08	10	0.75	1.18	0.37	10
Semibalanus balanoides (% set, dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Semibalanus cariosus (% set, dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Boulder/Cobble (%)	0.10	0.32	0.10	10	30.80	36.68	11.60	10
Gravel/Sand(%)	0.20	0.42	0.13	10	14.70	26.89	8.50	10
Mud (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Rock (%)	99.70	0.48	0.15	10	54.50	47.93	15.16	10
Water (%)	3.95	6.73	2.13	10	0.10	0.21	0.07	10

Table B-2. (continued).

Taxon	Eshamy Bay				Herring Bay			
	Mean	S.D.	S.E.	Count	Mean	S.D.	S.E.	Count
Acrosiphonia sp.	0.05	0.16	0.05	10	0.00	0.00	0.00	10
Black crust (maybe H. rubra w/ endophytic green)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Blidingia minima	0.15	0.24	0.08	10	0.05	0.16	0.05	10
Blue-green algae, spheroids	0.05	0.16	0.05	10	0.70	0.54	0.17	10
Chaetomorpha tortuosa	0.50	1.58	0.50	10	0.00	0.00	0.00	10
Cladophora sericea	5.00	10.00	3.16	10	2.85	6.14	1.94	10
Cryptosiphonia woodii	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Dictyosiphon foeniculaceus	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Elachista fucicola	1.55	2.77	0.88	10	0.85	1.73	0.55	10
Encrusting coralline algae	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Encrusting green algae	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Endocladia muricata	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Endozoic green algae	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Enteromorpha intestinalis	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Enteromorpha linza	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Fucus gardneri	22.00	19.20	6.07	10	42.80	22.85	7.23	10
Fucus gardneri (germlings)	1.30	1.44	0.45	10	10.90	10.05	3.18	10
Gloiopeltis furcata	0.55	0.44	0.14	10	0.05	0.16	0.05	10
Halosaccion glandiforme	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Hildenbrandia rubra	0.05	0.16	0.05	10	0.00	0.00	0.00	10
Leathesia difformis	0.25	0.63	0.20	10	0.00	0.00	0.00	10
Mastocarpus papillatus	0.05	0.16	0.05	10	0.05	0.16	0.05	10
Mazzaella spp. (Iridaea sp.)	0.00	0.00	0.00	10	0.10	0.32	0.10	10
Melanosiphon intestinalis	0.05	0.16	0.05	10	0.55	0.96	0.30	10
Monostroma grevillei	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Nemalion helminthoides	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Neorhodomela oregona	2.80	6.58	2.08	10	1.90	3.25	1.03	10
Neorhodomela larix	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Palmaria callophylloides	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Petrocelis spp.	0.00	0.00	0.00	10	0.10	0.32	0.10	10
Pilayella littoralis	0.50	0.97	0.31	10	1.10	1.66	0.53	10
Pterosiphonia bipinnata	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Ralfsia spp.	0.00	0.00	0.00	10	0.10	0.21	0.07	10
Rhodochorton purpureum	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Scytosiphon lomentaria	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Soranthera ulvoidea	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Sphacelaria rigidula	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Ulva/Ulvaria spp.	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Verrucaria spp.	0.00	0.00	0.00	10	0.00	0.00	0.00	10

Table B-2. (continued).

Taxon	Eshamy Bay				Herring Bay			
	Mean	S.D.	S.E.	Count	Mean	S.D.	S.E.	Count
Balanus glandula (% set)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Balanus glandula (%)	0.75	1.62	0.51	10	0.15	0.24	0.08	10
Balanus rostratus (%)	0.05	0.16	0.05	10	0.00	0.00	0.00	10
Balanus/Semibalanus spp., set (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Chthamalus dalli (% set)	0.15	0.24	0.08	10	0.00	0.00	0.00	10
Chthamalus dalli (%)	0.95	1.14	0.36	10	0.35	0.34	0.11	10
Encrusting bryozoan (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Littorina spp., eggs (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Mytilus cf. trossulus (% spat)	0.20	0.35	0.11	10	0.80	0.54	0.17	10
Mytilus cf. trossulus (%)	1.00	1.94	0.61	10	0.95	1.23	0.39	10
Nucella spp. (% eggs)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Semibalanus balanoides (% set)	5.25	6.53	2.06	10	16.80	5.29	1.67	10
Semibalanus balanoides (%)	4.15	12.60	3.98	10	37.80	20.26	6.41	10
Semibalanus cariosus (% set)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Semibalanus cariosus (%)	0.10	0.21	0.07	10	0.00	0.00	0.00	10
Siphonaria thersites, eggs (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Spirorbidae, unid. (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	10

Table B-2. (continued).

Taxon	Eshamy Bay				Herring Bay			
	Mean	S.D.	S.E.	Count	Mean	S.D.	S.E.	Count
Acarina	P	-	-	7	P	-	-	7
Anthopleura artemisia	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Clinocottus acuticeps	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Emplectonema gracile	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Gammaridea, unid.	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Gnorimosphaeroma oregonensis	0.00	0.00	0.00	10	0.40	0.70	0.22	10
Heptacarpus sp.	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Lacuna spp.	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Lacuna variegata	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Leptasterias hexactis	0.20	0.63	0.20	10	0.00	0.00	0.00	10
Littorina scutulata	109.00	195.73	61.89	10	38.50	23.91	7.56	10
Littorina scutulata (juv.)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Littorina sitkana	31.50	56.69	17.93	10	57.70	95.86	30.31	10
Littorina sitkana (juv.)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Lottia pelta	0.80	1.75	0.55	10	4.80	3.88	1.23	10
Lottiidae, unid.	18.70	17.60	5.57	10	41.00	30.76	9.73	10
Lottiidae, unid. (juv.)	0.00	0.00	0.00	10	11.20	23.69	7.49	10
Musculus spp.	0.00	0.00	0.00	10	0.10	0.32	0.10	10
Nucella lamellosa	1.60	2.27	0.72	10	0.20	0.63	0.20	10
Nucella lima	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Onchidella borealis	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Pagurus granosimanus	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Pagurus hirsutiusculus	8.80	10.33	3.27	10	2.40	1.35	0.43	10
Pentidotea wosnesenskii	0.00	0.00	0.00	10	0.20	0.42	0.13	10
Pododesmus macroschismata	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Polychaeta, unid.	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Searlesia dira	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Siphonaria thersites	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Tectura persona	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Tectura scutum	2.20	2.35	0.74	10	0.70	1.34	0.42	10
Encrusting coralline algae (dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Fucus gardneri (dead)	0.25	0.35	0.11	10	0.30	0.35	0.11	10

Table B-2. (continued).

Taxon	Eshamy Bay				Herring Bay			
	Mean	S.D.	S.E.	Count	Mean	S.D.	S.E.	Count
Balanus crenatus (% dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Balanus glandula (% dead)	0.20	0.42	0.13	10	0.00	0.00	0.00	10
Balanus/Semibalanus spp. (% dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Balanus/Semibalanus spp. (% set, dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Chthamalus dalli (% dead)	0.10	0.21	0.07	10	0.00	0.00	0.00	10
Encrusting bryozoan (% dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Mytilus cf. trossulus (dead)	6.10	10.29	3.25	10	2.20	2.49	0.79	10
Semibalanus balanoides (% dead)	0.10	0.21	0.07	10	0.05	0.16	0.05	10
Semibalanus balanoides (% set, dead)	0.05	0.16	0.05	10	0.00	0.00	0.00	10
Semibalanus cariosus (% set, dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Boulder/Cobble (%)	64.10	41.50	13.12	10	8.80	15.85	5.01	10
Gravel/Sand(%)	2.40	2.76	0.87	10	1.80	3.82	1.21	10
Mud (%)	0.00	0.00	0.00	10	0.50	1.08	0.34	10
Rock (%)	27.50	44.80	14.17	10	88.90	18.40	5.82	10
Water (%)	1.50	4.74	1.50	10	0.00	0.00	0.00	10

Table B-2. (continued).

Taxon	NW Bay Rocky Inlet				Outside Bay			
	Mean	S.D.	S.E.	Count	Mean	S.D.	S.E.	Count
Acrosiphonia sp.	0.00	0.00	0.00	10	0.20	0.26	0.08	10
Black crust (maybe H. rubra w/ endophytic green)	0.00	0.00	0.00	10	0.15	0.34	0.11	10
Blidingia minima	0.05	0.16	0.05	10	1.10	1.26	0.40	10
Blue-green algae, spheroids	0.35	0.41	0.13	10	0.00	0.00	0.00	10
Chaetomorpha tortuosa	0.00	0.00	0.00	10	0.15	0.34	0.11	10
Cladophora sericea	1.30	3.77	1.19	10	2.10	4.65	1.47	10
Cryptosiphonia woodii	0.00	0.00	0.00	10	0.45	0.83	0.26	10
Dictyosiphon foeniculaceus	0.50	1.58	0.50	10	0.00	0.00	0.00	10
Elachista fucicola	0.45	0.96	0.30	10	5.60	5.44	1.72	10
Encrusting coralline algae	0.00	0.00	0.00	10	0.35	0.67	0.21	10
Encrusting green algae	0.00	0.00	0.00	10	0.10	0.32	0.10	10
Endocladia muricata	0.00	0.00	0.00	10	0.50	0.85	0.27	10
Endozoic green algae	0.20	0.26	0.08	10	0.05	0.16	0.05	10
Enteromorpha intestinalis	0.05	0.16	0.05	10	0.00	0.00	0.00	10
Enteromorpha linza	0.00	0.00	0.00	10	0.10	0.21	0.07	10
Fucus gardneri	16.40	15.49	4.90	10	61.60	24.63	7.79	10
Fucus gardneri (germlings)	1.05	1.66	0.52	10	1.70	2.96	0.93	10
Gloiopeltis furcata	0.50	0.62	0.20	10	1.35	1.80	0.57	10
Halosaccion glandiforme	0.05	0.16	0.05	10	1.65	1.65	0.52	10
Hildenbrandia rubra	0.15	0.24	0.08	10	0.25	0.63	0.20	10
Leathesia difformis	0.10	0.21	0.07	10	0.05	0.16	0.05	10
Mastocarpus papillatus	0.00	0.00	0.00	10	3.25	4.52	1.43	10
Mazzaella spp. (Iridaea sp.)	0.00	0.00	0.00	10	0.45	0.83	0.26	10
Melanosiphon intestinalis	0.20	0.35	0.11	10	0.40	0.66	0.21	10
Monostroma grevillei	0.00	0.00	0.00	10	0.05	0.16	0.05	10
Nemalion helminthoides	0.00	0.00	0.00	10	0.15	0.24	0.08	10
Neorhodomela oregona	0.60	1.35	0.43	10	0.20	0.26	0.08	10
Neorhodomela larix	0.00	0.00	0.00	10	0.20	0.63	0.20	10
Palmaria callophylloides	0.00	0.00	0.00	10	0.10	0.32	0.10	10
Petrocelis spp.	0.00	0.00	0.00	10	4.90	7.84	2.48	10
Pilayella littoralis	0.05	0.16	0.05	10	2.35	3.43	1.09	10
Pterosiphonia bipinnata	0.00	0.00	0.00	10	0.35	0.94	0.30	10
Ralfsia spp.	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Rhodochorton purpureum	0.00	0.00	0.00	10	0.05	0.16	0.05	10
Scytosiphon lomentaria	0.05	0.16	0.05	10	0.00	0.00	0.00	10
Soranthera ulvoidea	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Sphacelaria rigidula	0.00	0.00	0.00	10	0.85	2.52	0.80	10
Ulva/Ulvaria spp.	0.00	0.00	0.00	10	0.45	0.96	0.30	10
Verrucaria spp.	0.00	0.00	0.00	10	0.00	0.00	0.00	10

Table B-2. (continued).

Taxon	NW Bay Rocky Inlet				Outside Bay			
	Mean	S.D.	S.E.	Count	Mean	S.D.	S.E.	Count
Balanus glandula (% set)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Balanus glandula (%)	1.15	0.78	0.25	10	0.45	0.93	0.29	10
Balanus rostratus (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Balanus/Semibalanus spp., set (%)	0.00	0.00	0.00	10	1.75	3.81	1.20	10
Chthamalus dalli (% set)	0.20	0.26	0.08	10	0.15	0.34	0.11	10
Chthamalus dalli (%)	0.75	0.26	0.08	10	11.55	6.61	2.09	10
Encrusting bryozoan (%)	0.00	0.00	0.00	10	0.15	0.34	0.11	10
Littorina spp., eggs (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Mytilus cf. trossulus (% spat)	0.50	0.62	0.20	10	2.65	7.86	2.48	10
Mytilus cf. trossulus (%)	3.30	3.97	1.25	10	0.00	0.00	0.00	10
Nucella spp. (% eggs)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Semibalanus balanoides (% set)	0.30	0.35	0.11	10	0.95	2.22	0.70	10
Semibalanus balanoides (%)	7.40	9.30	2.94	10	0.65	1.55	0.49	10
Semibalanus cariosus (% set)	0.00	0.00	0.00	10	0.25	0.63	0.20	10
Semibalanus cariosus (%)	0.00	0.00	0.00	10	2.20	2.72	0.86	10
Siphonaria thersites, eggs (%)	0.00	0.00	0.00	10	0.55	0.55	0.17	10
Spirorbidae, unid. (%)	0.00	0.00	0.00	10	0.10	0.21	0.07	10

Table B-2. (continued).

Taxon	NW Bay Rocky Inlet				Outside Bay			
	Mean	S.D.	S.E.	Count	Mean	S.D.	S.E.	Count
Acarina	0.00	0.00	0.00	10	P	-	-	7
Anthopleura artemisia	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Clinocottus acuticeps	0.00	0.00	0.00	10	0.10	0.32	0.10	10
Emplectonema gracile	0.00	0.00	0.00	10	0.50	0.71	0.22	10
Gammaridea, unid.	0.05	0.16	0.05	10	P	-	-	7
Gnorimosphaeroma oregonensis	0.60	1.58	0.50	10	0.00	0.00	0.00	10
Heptacarpus sp.	0.20	0.42	0.13	10	0.00	0.00	0.00	10
Lacuna spp.	0.00	0.00	0.00	10	0.30	0.95	0.30	10
Lacuna variegata	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Leptasterias hexactis	0.00	0.00	0.00	10	0.30	0.95	0.30	10
Littorina scutulata	244.00	117.05	37.01	10	5.80	9.43	2.98	10
Littorina scutulata (juv.)	0.00	0.00	0.00	10	17.50	32.18	10.18	10
Littorina sitkana	43.80	43.74	13.83	10	0.90	1.20	0.38	10
Littorina sitkana (juv.)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Lottia pelta	2.10	3.41	1.08	10	1.70	3.53	1.12	10
Lottiidae, unid.	57.40	60.35	19.09	10	22.00	29.83	9.43	10
Lottiidae, unid. (juv.)	11.10	35.10	11.10	10	4.30	11.94	3.78	10
Musculus spp.	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Nucella lamellosa	0.00	0.00	0.00	10	6.60	9.94	3.14	10
Nucella lima	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Onchidella borealis	0.00	0.00	0.00	10	1.90	4.31	1.36	10
Pagurus granosimanus	0.00	0.00	0.00	10	0.20	0.42	0.13	10
Pagurus hirsutiusculus	4.30	5.03	1.59	10	1.80	3.12	0.99	10
Pentidotea wosnesenskii	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Pododesmus macroschismata	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Polychaeta, unid.	0.00	0.00	0.00	10	0.30	0.48	0.15	10
Searlesia dira	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Siphonaria thersites	0.00	0.00	0.00	10	16.90	23.13	7.31	10
Tectura persona	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Tectura scutum	1.30	3.20	1.01	10	4.90	6.59	2.08	10
Encrusting coralline algae (dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Fucus gardneri (dead)	0.35	0.67	0.21	10	0.20	0.26	0.08	10

Table B-2. (continued).

Taxon	NW Bay Rocky Inlet Mean	S.D.	S.E.	Count	Outside Bay Mean	S.D.	S.E.	Count
Balanus crenatus (% dead)	0.10	0.32	0.10	10	0.00	0.00	0.00	10
Balanus glandula (% dead)	0.30	0.26	0.08	10	0.10	0.21	0.07	10
Balanus/Semibalanus spp. (% dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Balanus/Semibalanus spp. (% set, dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Chthamalus dalli (% dead)	0.05	0.16	0.05	10	1.10	1.41	0.45	10
Encrusting bryozoan (% dead)	0.00	0.00	0.00	10	0.20	0.63	0.20	10
Mytilus cf. trossulus (dead)	3.70	5.85	1.85	10	2.90	7.87	2.49	10
Semibalanus balanoides (% dead)	0.35	0.41	0.13	10	1.75	4.67	1.48	10
Semibalanus balanoides (% set, dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Semibalanus cariosus (% set, dead)	0.00	0.00	0.00	10	0.25	0.35	0.11	10
Boulder/Cobble (%)	2.50	7.91	2.50	10	99.80	0.63	0.20	10
Gravel/Sand(%)	2.00	6.32	2.00	10	0.20	0.63	0.20	10
Mud (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	10
Rock (%)	95.50	9.56	3.02	10	0.00	0.00	0.00	10
Water (%)	2.30	6.29	1.99	10	0.00	0.00	0.00	10

Table B-2. (continued).

Taxon	Snug Harbor				NW Bay W Arm Treated			
	Mean	S.D.	S.E.	Count	Mean	S.D.	S.E.	Count
Acrosiphonia sp.	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Black crust (maybe H. rubra w/ endophytic green)	0.05	0.16	0.05	10	0.20	0.45	0.20	5
Blidingia minima	0.10	0.21	0.07	10	0.11	0.22	0.10	5
Blue-green algae, spheroids	0.05	0.16	0.05	10	0.00	0.00	0.00	5
Chaetomorpha tortuosa	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Cladophora sericea	0.35	0.67	0.21	10	2.11	2.00	0.89	5
Cryptosiphonia woodii	0.00	0.00	0.00	10	1.00	2.24	1.00	5
Dictyosiphon foeniculaceus	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Elachista fucicola	0.00	0.00	0.00	10	1.40	3.13	1.40	5
Encrusting coralline algae	0.00	0.00	0.00	10	0.80	1.79	0.80	5
Encrusting green algae	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Endocladia muricata	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Endozoic green algae	0.55	0.90	0.28	10	0.00	0.00	0.00	5
Enteromorpha intestinalis	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Enteromorpha linza	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Fucus gardneri	13.30	12.98	4.10	10	13.00	20.84	9.32	5
Fucus gardneri (germlings)	0.70	0.26	0.08	10	1.70	1.72	0.77	5
Gloiopeltis furcata	0.75	0.54	0.17	10	0.90	0.74	0.33	5
Halosaccion glandiforme	0.05	0.16	0.05	10	0.10	0.22	0.10	5
Hildenbrandia rubra	0.15	0.34	0.11	10	6.50	8.53	3.81	5
Leathesia difformis	0.00	0.00	0.00	10	0.81	1.25	0.56	5
Mastocarpus papillatus	0.05	0.16	0.05	10	0.00	0.00	0.00	5
Mazzaella spp. (Iridaea sp.)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Melanosiphon intestinalis	0.00	0.00	0.00	10	0.50	0.87	0.39	5
Monostroma grevillei	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Nemalion helminthoides	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Neorhodomela oregona	0.15	0.34	0.11	10	2.90	3.17	1.42	5
Neorhodomela larix	0.00	0.00	0.00	10	0.60	1.34	0.60	5
Palmaria callophylloides	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Petrocelis spp.	0.45	1.26	0.40	10	0.00	0.00	0.00	5
Pilayella littoralis	0.55	0.69	0.22	10	1.00	2.24	1.00	5
Pterosiphonia bipinnata	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Ralfsia spp.	0.00	0.00	0.00	10	0.90	1.24	0.56	5
Rhodochorton purpureum	0.60	1.35	0.43	10	0.00	0.00	0.00	5
Scytosiphon lomentaria	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Soranthera ulvoidea	0.00	0.00	0.00	10	0.50	0.87	0.39	5
Sphacelaria rigidula	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Ulva/Ulvaria spp.	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Verrucaria spp.	0.05	0.16	0.05	10	0.00	0.00	0.00	5

Table B-2. (continued).

Taxon	Snug Harbor				NW Bay W Arm Treated			
	Mean	S.D.	S.E.	Count	Mean	S.D.	S.E.	Count
Balanus glandula (% set)	0.00	0.00	0.00	10	0.10	0.22	0.10	5
Balanus glandula (%)	1.15	0.82	0.26	10	1.80	1.25	0.56	5
Balanus rostratus (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Balanus/Semibalanus spp., set (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Chthamalus dalli (% set)	0.40	0.21	0.07	10	0.10	0.22	0.10	5
Chthamalus dalli (%)	0.45	0.28	0.09	10	9.80	1.10	0.49	5
Encrusting bryozoan (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Littorina spp., eggs (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Mytilus cf. trossulus (% spat)	0.30	0.26	0.08	10	0.50	0.00	0.00	5
Mytilus cf. trossulus (%)	2.60	2.75	0.87	10	0.00	0.00	0.00	5
Nucella spp. (% eggs)	0.05	0.16	0.05	10	0.00	0.00	0.00	5
Semibalanus balanoides (% set)	9.05	9.04	2.86	10	11.40	9.71	4.34	5
Semibalanus balanoides (%)	0.75	1.01	0.32	10	1.70	1.57	0.70	5
Semibalanus cariosus (% set)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Semibalanus cariosus (%)	0.00	0.00	0.00	10	0.20	0.27	0.12	5
Siphonaria thersites, eggs (%)	0.00	0.00	0.00	10	0.10	0.22	0.10	5
Spirorbidae, unid. (%)	0.00	0.00	0.00	10	0.10	0.22	0.10	5

Table B-2. (continued).

Taxon	Snug Harbor				NW Bay W Arm Treated			
	Mean	S.D.	S.E.	Count	Mean	S.D.	S.E.	Count
Acarina	0.00	0.00	0.00	10	P	-	-	4
Anthopleura artemisia	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Clinocottus acuticeps	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Emplectonema gracile	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Gammaridea, unid.	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Gnorimosphaeroma oregonensis	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Heptacarpus sp.	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Lacuna spp.	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Lacuna variegata	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Leptasterias hexactis	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Littorina scutulata	8.20	6.16	1.95	10	51.80	39.33	17.59	5
Littorina scutulata (juv.)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Littorina sitkana	12.60	17.66	5.59	10	12.40	11.97	5.35	5
Littorina sitkana (juv.)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Lottia pelta	0.30	0.48	0.15	10	1.60	1.34	0.60	5
Lottiidae, unid.	14.80	10.85	3.43	10	36.80	5.07	2.27	5
Lottiidae, unid. (juv.)	0.40	1.26	0.40	10	0.00	0.00	0.00	5
Musculus spp.	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Nucella lamellosa	0.00	0.00	0.00	10	1.00	1.22	0.55	5
Nucella lima	1.20	1.69	0.53	10	0.00	0.00	0.00	5
Onchidella borealis	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Pagurus granosimanus	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Pagurus hirsutiusculus	5.70	6.40	2.02	10	4.40	5.86	2.62	5
Pentidotea wosnesenskii	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Pododesmus macroschismata	0.00	0.00	0.00	10	0.20	0.45	0.20	5
Polychaeta, unid.	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Searlesia dira	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Siphonaria thersites	0.00	0.00	0.00	10	2.20	1.79	0.80	5
Tectura persona	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Tectura scutum	0.90	1.29	0.41	10	0.20	0.45	0.20	5
Encrusting coralline algae (dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Fucus gardneri (dead)	0.10	0.21	0.07	10	6.20	13.31	5.95	5

Table B-2. (continued).

Taxon	Snug Harbor				NW Bay W Arm Treated			
	Mean	S.D.	S.E.	Count	Mean	S.D.	S.E.	Count
Balanus crenatus (% dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Balanus glandula (% dead)	0.55	0.90	0.28	10	0.20	0.27	0.12	5
Balanus/Semibalanus spp. (% dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Balanus/Semibalanus spp. (% set, dead)	0.25	0.35	0.11	10	0.00	0.00	0.00	5
Chthamalus dalli (% dead)	0.10	0.21	0.07	10	0.70	0.27	0.12	5
Encrusting bryozoan (% dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Mytilus cf. trossulus (dead)	4.10	4.56	1.44	10	0.00	0.00	0.00	5
Semibalanus balanoides (% dead)	0.45	0.93	0.29	10	0.50	0.00	0.00	5
Semibalanus balanoides (% set, dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Semibalanus cariosus (% set, dead)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Boulder/Cobble (%)	90.05	7.84	2.48	10	0.00	0.00	0.00	5
Gravel/Sand(%)	9.95	7.84	2.48	10	0.00	0.00	0.00	5
Mud (%)	0.00	0.00	0.00	10	0.00	0.00	0.00	5
Rock (%)	0.00	0.00	0.00	10	100.00	0.00	0.00	5
Water (%)	0.90	2.02	0.64	10	5.30	8.36	3.74	5

Table B-2. (continued).

Taxon	NW Bay W Arm Untreated			
	Mean	S.D.	S.E.	Count
Acrosiphonia sp.	0.00	0.00	0.00	5
Black crust (maybe H. rubra w/ endophytic green)	0.00	0.00	0.00	5
Blidingia minima	0.00	0.00	0.00	5
Blue-green algae, spheroids	0.40	0.22	0.10	5
Chaetomorpha tortuosa	0.00	0.00	0.00	5
Cladophora sericea	3.10	1.95	0.87	5
Cryptosiphonia woodii	0.10	0.22	0.10	5
Dictyosiphon foeniculaceus	0.00	0.00	0.00	5
Elachista fucicola	0.20	0.45	0.20	5
Encrusting coralline algae	2.20	0.84	0.37	5
Encrusting green algae	0.00	0.00	0.00	5
Endocladia muricata	0.00	0.00	0.00	5
Endozoic green algae	0.20	0.27	0.12	5
Enteromorpha intestinalis	0.00	0.00	0.00	5
Enteromorpha linza	0.00	0.00	0.00	5
Fucus gardneri	45.80	32.81	14.67	5
Fucus gardneri (germlings)	3.20	1.48	0.66	5
Gloiopeltis furcata	4.00	3.08	1.38	5
Halosaccion glandiforme	3.50	3.24	1.45	5
Hildenbrandia rubra	7.60	9.24	4.13	5
Leathesia difformis	0.70	0.84	0.37	5
Mastocarpus papillatus	0.90	1.02	0.46	5
Mazzaella spp. (Iridaea sp.)	0.00	0.00	0.00	5
Melanosiphon intestinalis	0.80	0.76	0.34	5
Monostroma grevillei	0.00	0.00	0.00	5
Nemalion helminthoides	0.00	0.00	0.00	5
Neorhodomela oregona	1.00	1.00	0.45	5
Neorhodomela larix	3.20	4.60	2.06	5
Palmaria callophylloides	0.00	0.00	0.00	5
Petrocelis spp.	0.00	0.00	0.00	5
Pilayella littoralis	6.60	2.41	1.08	5
Pterosiphonia bipinnata	1.20	0.76	0.34	5
Ralfsia spp.	0.00	0.00	0.00	5
Rhodochorton purpureum	0.00	0.00	0.00	5
Scytosiphon lomentaria	0.00	0.00	0.00	5
Soranthera ulvoidea	0.30	0.27	0.12	5
Sphacelaria rigidula	0.00	0.00	0.00	5
Ulva/Ulvaria spp.	0.00	0.00	0.00	5
Verrucaria spp.	0.00	0.00	0.00	5

Table B-2. (continued).

Taxon	NW Bay W Arm Untreated			
	Mean	S.D.	S.E.	Count
Balanus glandula (% set)	0.30	0.45	0.20	5
Balanus glandula (%)	2.30	2.28	1.02	5
Balanus rostratus (%)	0.00	0.00	0.00	5
Balanus/Semibalanus spp., set (%)	0.00	0.00	0.00	5
Chthamalus dalli (% set)	0.80	0.76	0.34	5
Chthamalus dalli (%)	8.80	4.71	2.11	5
Encrusting bryozoan (%)	0.00	0.00	0.00	5
Littorina spp., eggs (%)	0.00	0.00	0.00	5
Mytilus cf. trossulus (% spat)	2.10	1.75	0.78	5
Mytilus cf. trossulus (%)	0.00	0.00	0.00	5
Nucella spp. (% eggs)	0.00	0.00	0.00	5
Semibalanus balanoides (% set)	4.60	6.49	2.90	5
Semibalanus balanoides (%)	0.50	0.35	0.16	5
Semibalanus cariosus (% set)	0.80	0.76	0.34	5
Semibalanus cariosus (%)	1.40	2.04	0.91	5
Siphonaria thersites, eggs (%)	0.00	0.00	0.00	5
Spirorbidae, unid. (%)	0.00	0.00	0.00	5

Table B-2. (continued).

Taxon	NW Bay W Arm Untreated			
	Mean	S.D.	S.E.	Count
Acarina	P	-	-	3
Anthopleura artemisia	0.20	0.45	0.20	5
Clinocottus acuticeps	0.20	0.45	0.20	5
Emplectonema gracile	0.00	0.00	0.00	5
Gammaridea, unid.	P	-	-	4
Gnorimosphaeroma oregonensis	0.00	0.00	0.00	5
Heptacarpus sp.	0.00	0.00	0.00	5
Lacuna spp.	0.00	0.00	0.00	5
Lacuna variegata	0.00	0.00	0.00	5
Leptasterias hexactis	0.00	0.00	0.00	5
Littorina scutulata	14.40	17.40	7.78	5
Littorina scutulata (juv.)	16.40	36.67	16.40	5
Littorina sitkana	21.80	25.38	11.35	5
Littorina sitkana (juv.)	1.20	2.68	1.20	5
Lottia pelta	0.60	0.89	0.40	5
Lottiidae, unid.	62.20	14.13	6.32	5
Lottiidae, unid. (juv.)	0.00	0.00	0.00	5
Musculus spp.	0.00	0.00	0.00	5
Nucella lamellosa	7.20	6.34	2.84	5
Nucella lima	0.00	0.00	0.00	5
Onchidella borealis	0.00	0.00	0.00	5
Pagurus granosimanus	0.00	0.00	0.00	5
Pagurus hirsutiusculus	4.40	7.64	3.41	5
Pentidotea wosnesenskii	0.00	0.00	0.00	5
Pododesmus macroschismata	0.00	0.00	0.00	5
Polychaeta, unid.	0.00	0.00	0.00	5
Searlesia dira	0.00	0.00	0.00	5
Siphonaria thersites	18.60	12.78	5.71	5
Tectura persona	0.00	0.00	0.00	5
Tectura scutum	0.00	0.00	0.00	5
Encrusting coralline algae (dead)	0.80	1.30	0.58	5
Fucus gardneri (dead)	0.40	0.42	0.19	5

Table B-2. (continued).

Taxon	NW Bay W Arm Untreated			
	Mean	S.D.	S.E.	Count
Balanus crenatus (% dead)	0.00	0.00	0.00	5
Balanus glandula (% dead)	0.40	0.42	0.19	5
Balanus/Semibalanus spp. (% dead)	0.00	0.00	0.00	5
Balanus/Semibalanus spp. (% set, dead)	0.00	0.00	0.00	5
Chthamalus dalli (% dead)	0.60	0.82	0.37	5
Encrusting bryozoan (% dead)	0.00	0.00	0.00	5
Mytilus cf. trossulus (dead)	23.40	21.51	9.62	5
Semibalanus balanoides (% dead)	0.20	0.27	0.12	5
Semibalanus balanoides (% set, dead)	0.50	0.87	0.39	5
Semibalanus cariosus (% set, dead)	0.30	0.45	0.20	5
Boulder/Cobble (%)	0.00	0.00	0.00	5
Gravel/Sand(%)	0.20	0.45	0.20	5
Mud (%)	0.00	0.00	0.00	5
Rock (%)	99.80	0.45	0.20	5
Water (%)	2.20	4.38	1.96	5

Table B-3 Rocky lower intertidal epibiota, July 1995.

	NW Bay Rocky Inlet			
Taxon	**Mean**	**SD**	**SE**	**Count**
Acrosiphonia sp.	0.40	1.26	0.40	10
Blidingia minima	0.10	0.21	0.07	10
Blue-green algae, spheroids	0.15	0.24	0.08	10
Cladophora sericea	4.65	4.14	1.31	10
Corallina frondescens	0.05	0.16	0.05	10
Cryptosiphonia woodii	2.20	3.22	1.02	10
Elachista fucicola	1.50	1.35	0.43	10
Encrusting coralline algae	1.40	2.63	0.83	10
Endozoic green algae	0.05	0.16	0.05	10
Enteromorpha linza	0.05	0.16	0.05	10
Fucus gardneri	57.10	33.84	10.70	10
Fucus gardneri (germlings)	1.30	1.01	0.32	10
Gloiopeltis furcata	0.30	0.42	0.13	10
Halosaccion glandiforme	1.20	1.92	0.61	10
Hildenbrandia rubra	4.30	6.48	2.05	10
Leathesia difformis	0.15	0.24	0.08	10
Mastocarpus papillatus	2.25	3.14	0.99	10
Mazzaella spp. (Iridaea sp.)	0.30	0.67	0.21	10
Melanosiphon intestinalis	0.55	0.64	0.20	10
Monostroma grevillei	0.95	1.17	0.37	10
Neorhodomela oregona	7.65	7.87	2.49	10
Palmaria mollis	0.20	0.35	0.11	10
Petrocelis spp.	3.60	9.47	2.99	10
Pilayella littoralis	1.10	2.51	0.80	10
Polysiphonia spp.	0.05	0.16	0.05	10
Pterosiphonia bipinnata	0.65	1.20	0.38	10
Ptilota filicina	0.10	0.32	0.10	10
Ralfsia spp.	5.70	6.98	2.21	10
Scytosiphon lomentaria	0.05	0.16	0.05	10
Sphacelaria rigidula	1.45	1.79	0.56	10
Tokidadendron kurilensis	0.05	0.16	0.05	10
Ulva/Ulvaria spp.	0.80	0.95	0.30	10
Balanus glandula (%)	0.30	0.35	0.11	10
Balanus rostratus (%)	0.30	0.26	0.08	10
Bryozoan, gray epiphytic	0.30	0.63	0.20	10
Chthamalus dalli (% set)	0.15	0.24	0.08	10
Chthamalus dalli (%)	0.75	1.23	0.39	10
Littorina spp., eggs (%)	0.10	0.21	0.07	10
Mytilus cf. trossulus (% spat)	0.40	0.21	0.07	10
Semibalanus balanoides (% set)	0.70	1.87	0.59	10
Semibalanus balanoides (%)	0.10	0.21	0.07	10
Semibalanus cariosus (% set)	0.05	0.16	0.05	10
Semibalanus cariosus (%)	0.05	0.16	0.05	10
Spirorbidae, unid. (%)	0.30	0.26	0.08	10

Table B-3 (Continued)

	NW Bay Rocky Inlet			
Taxon	**Mean**	**SD**	**SE**	**Count**
Acarina	P	-	-	5
Amphiporus spp. (Nemertea, white)	0.10	0.32	0.10	10
Anthopleura elegantissima	0.10	0.32	0.10	10
Clinocottus acuticeps	0.10	0.32	0.10	10
Gammaridea, unid.	P	-	-	8
Katharina tunicata	0.10	0.32	0.10	10
Lacuna spp.	0.50	0.53	0.17	10
Littorina scutulata	3.10	5.07	1.60	10
Littorina scutulata (juv.)	0.70	1.57	0.50	10
Littorina sitkana	0.40	0.70	0.22	10
Lottiidae, unid. (juv.)	105.20	109.09	34.50	10
Margarites marginatus	0.40	0.70	0.22	10
Musculus spp.	0.05	0.16	0.05	10
Nemertea, pink	0.20	0.42	0.13	10
Nemertea, unid.	0.10	0.32	0.10	10
Nucella lamellosa	0.10	0.32	0.10	10
Pagurus hirsutiusculus	14.50	12.04	3.81	10
Pisaster ochraceus	0.20	0.42	0.13	10
Pycnopodia helianthoides (juvenile)	0.20	0.42	0.13	10
Searlesia dira	0.10	0.32	0.10	10
Fucus gardneri (dead)	0.15	0.24	0.08	10
Balanus glandula (% dead)	0.05	0.16	0.05	10
Balanus rostratus (% set, dead)	0.30	0.63	0.20	10
Balanus/Semibalanus spp. (% set, dead)	0.05	0.16	0.05	10
Chthamalus dalli (% dead)	0.15	0.24	0.08	10
Hiatella arctica (dead)	0.40	1.26	0.40	10
Mytilus cf. trossulus (dead)	1.80	2.78	0.88	10
Semibalanus balanoides (% dead)	0.10	0.21	0.07	10
Semibalanus balanoides (% set, dead)	0.20	0.26	0.08	10
Boulder/Cobble (%)	0.60	1.26	0.40	10
Gravel/Sand(%)	1.70	3.47	1.10	10
Mud (%)	0.20	0.63	0.20	10
Rock (%)	97.50	4.62	1.46	10
Water (%)	0.10	0.21	0.07	10

APPENDIX C

Table C-1 Sediment grain size distribution, total percent fines (≤ 125 μ), TOC, and TKN from the initial test sediments used in the clam recruitment experiment, 1994-95.

Test sediment	12.5 mm	6.3 mm	2 mm	1 mm	500 μ	250 μ	125 μ	63 μ	Silt/clay	Fines	TKN (ppm)	TOC
Outside Bay	22.3%	21.3%	11.7%	17.0%	1.6%	13.8%	3.9%	2.9%	5.5%	12.3%	224	1.8%
Block Island	28.1%	13.6%	26.3%	18.9%	3.9%	5.7%	1.2%	0.5%	1.8%	3.5%	513	2.1%
NW Bay (Lot 1)	17.7%	15.5%	35.3%	11.1%	9.8%	4.3%	2.7%	2.4%	1.1%	6.3%	50	0.5%
NW Bay + added silt (Lot 2)	19.6%	11.6%	20.4%	10.1%	6.6%	11.4%	8.7%	6.6%	5.0%	20.4%	399	0.7%

Table C-2 Sediment grain size distribution, total percent fines (≤ μ), TOC, and TKN from the sediments used in the clam recruitment experiment when recovered in 1995.

Block Island Lot No.	Rep.	12.5 mm	6.3 mm	2 mm	1 mm	500 μ	250 μ	125 μ	63 μ	Silt/clay	% Fines	TKN (ppm)	TOC
1	1	36.9%	23.5%	13.4%	5.4%	2.7%	5.4%	2.7%	2.7%	7.4%	12.8%		
1	2	33.6%	15.7%	17.7%	5.2%	2.5%	4.5%	4.1%	3.2%	13.4%	20.7%		
1	3	37.0%	17.0%	20.8%	5.9%	2.9%	2.3%	4.4%	2.3%	7.3%	14.1%		
1	4	23.0%	22.5%	22.0%	8.9%	8.9%	4.7%	2.6%	2.6%	4.7%	9.9%		
1	5	18.3%	15.5%	26.9%	11.9%	8.2%	5.5%	5.5%	4.6%	3.7%	13.7%		
Average		**29.8%**	**18.8%**	**20.2%**	**7.4%**	**5.0%**	**4.5%**	**3.9%**	**3.1%**	**7.3%**	**14.2%**	**310**	**0.74%**
SD		**13.3%**	**8.4%**	**9.0%**	**3.3%**	**2.3%**	**2.0%**	**1.7%**	**1.4%**	**3.3%**			
2	1	18.7%	23.2%	25.4%	3.8%	5.4%	3.2%	3.2%	2.2%	14.9%	57.4%		
2	2	20.3%	18.6%	19.8%	5.2%	4.3%	3.2%	2.3%	6.6%	19.8%	60.9%		
2	3	15.3%	15.8%	24.8%	8.1%	5.4%	5.2%	5.2%	5.4%	14.9%	31.2%		
2	4	19.4%	16.2%	22.2%	6.3%	6.0%	3.5%	4.8%	4.1%	17.5%	35.5%		
2	5	10.7%	17.3%	26.0%	7.0%	4.3%	5.0%	3.0%	4.0%	22.7%	52.9%		
Average		**16.9%**	**18.2%**	**23.6%**	**6.1%**	**5.1%**	**4.0%**	**3.7%**	**4.5%**	**17.9%**	**47.6%**	**400**	**2.60%**
SD		**7.6%**	**8.1%**	**10.6%**	**2.7%**	**2.3%**	**1.8%**	**1.6%**	**2.0%**	**8.0%**			
3	1	14.9%	11.7%	19.5%	9.6%	9.9%	9.2%	6.7%	3.5%	14.9%	25.2%		
3	2	17.2%	13.1%	18.2%	9.9%	10.2%	12.4%	4.8%	3.2%	11.1%	19.1%		
3	3	10.8%	14.9%	18.7%	13.3%	10.8%	11.2%	7.9%	3.3%	9.1%	20.3%		
3	4	17.7%	15.1%	18.5%	8.6%	9.9%	10.3%	6.5%	3.0%	10.3%	19.8%		
3	5	18.0%	12.3%	17.1%	8.5%	11.1%	12.3%	7.6%	3.5%	9.5%	20.6%		
Average		**15.7%**	**13.4%**	**18.4%**	**10.0%**	**10.4%**	**11.1%**	**6.7%**	**3.3%**	**11.0%**	**21.0%**	**490**	**1.30%**
SD		**7.0%**	**6.0%**	**8.2%**	**4.5%**	**4.6%**	**5.0%**	**3.0%**	**1.5%**	**4.9%**			

Table C-2 (continued)

Northwest Bay West Arm Lot No.	Rep.	12.5 mm	6.3 mm	2 mm	1 mm	500 µ	250 µ	125 µ	63 µ	silt/clay	% Fines	TKN (ppm)	TOC
1	1	26.9%	15.6%	25.6%	10.6%	9.3%	5.0%	3.3%	1.3%	2.3%	7.0%		
1	2	22.2%	16.4%	26.8%	12.6%	10.7%	6.5%	1.9%	1.5%	1.3%	4.8%		
1	3	40.4%	13.2%	15.1%	8.7%	11.3%	5.7%	1.9%	2.3%	1.5%	5.7%		
1	4	13.3%	17.7%	30.5%	14.3%	12.8%	6.9%	2.0%	1.5%	1.2%	4.7%		
1	5	23.7%	17.2%	23.7%	10.1%	9.1%	9.1%	3.0%	2.0%	2.0%	7.1%		
Average		**25.3%**	**16.0%**	**24.3%**	**11.3%**	**10.6%**	**6.6%**	**2.4%**	**1.7%**	**1.7%**	**5.8%**	**110**	**0.40%**
SD		**11.3%**	**7.2%**	**10.9%**	**5.0%**	**4.8%**	**3.0%**	**1.1%**	**0.8%**	**0.8%**			
2	1	27.6%	11.5%	10.5%	9.9%	7.6%	10.2%	3.0%	4.6%	15.1%	22.7%		
2	2	24.4%	16.4%	14.8%	9.0%	9.0%	7.1%	2.9%	3.5%	12.9%	19.3%		
2	3	15.9%	20.6%	18.7%	11.1%	8.7%	8.3%	3.6%	3.2%	9.9%	16.7%		
2	4	28.1%	15.4%	15.8%	10.5%	7.5%	5.7%	3.9%	3.5%	9.6%	17.1%		
2	5	19.6%	11.4%	15.3%	6.7%	10.2%	11.0%	6.7%	5.5%	13.7%	25.9%		
Average		**23.1%**	**15.1%**	**15.0%**	**9.4%**	**8.6%**	**8.5%**	**4.0%**	**4.1%**	**12.3%**	**20.4%**	**520**	**3.50%**
SD		**10.3%**	**6.7%**	**6.7%**	**4.2%**	**3.8%**	**3.8%**	**1.8%**	**1.8%**	**5.5%**			
3	1	17.9%	19.5%	20.7%	8.0%	6.0%	4.0%	12.0%	2.0%	10.0%	23.9%		
3	2	10.1%	22.4%	24.1%	7.6%	5.5%	4.6%	7.6%	4.2%	13.9%	25.7%		
3	3	32.9%	13.4%	16.0%	9.1%	10.0%	9.1%	2.2%	3.0%	4.3%	9.5%		
3	4	25.4%	18.0%	19.0%	9.2%	8.5%	7.5%	4.1%	2.7%	5.8%	12.5%		
Average		**21.6%**	**18.3%**	**19.9%**	**8.5%**	**7.5%**	**6.3%**	**6.4%**	**3.0%**	**8.5%**	**17.9%**	**320**	**0.43%**
SD		**9.7%**	**8.2%**	**8.9%**	**3.8%**	**3.3%**	**2.8%**	**2.9%**	**1.3%**	**3.8%**			

Table C-2 (continued)

Outside Bay Lot No.	Rep.	12.5 mm	6.3 mm	2 mm	1 mm	500 µ	250 µ	125 µ	63 µ	silt/clay	% Fines	TKN (ppm)	TOC
1	1	26.4%	16.5%	23.6%	9.4%	8.0%	5.2%	2.8%	2.8%	5.2%	10.8%		
1	2	14.3%	17.7%	26.1%	9.4%	7.4%	4.4%	7.9%	3.4%	9.4%	20.7%		
1	3	34.0%	13.7%	22.0%	5.8%	5.0%	4.1%	5.4%	4.1%	5.8%	15.4%		
1	4	14.0%	10.1%	27.0%	14.0%	6.2%	6.7%	8.4%	5.1%	8.4%	21.9%		
1	5	15.2%	18.3%	23.2%	16.5%	11.0%	5.5%	3.7%	2.4%	4.3%	10.4%		
Average		**20.8%**	**15.3%**	**24.4%**	**11.0%**	**7.5%**	**5.2%**	**5.6%**	**3.6%**	**6.6%**	**15.8%**	**270**	**0.69%**
SD		**9.3%**	**6.8%**	**10.9%**	**4.9%**	**3.4%**	**2.3%**	**2.5%**	**1.6%**	**3.0%**			
2	1	15.1%	15.4%	19.1%	8.1%	7.0%	6.6%	8.1%	5.9%	14.7%	28.7%		
2	2	8.9%	17.4%	18.3%	7.6%	6.7%	8.9%	9.4%	7.1%	15.6%	32.1%		
2	3	28.2%	12.9%	20.3%	7.1%	3.3%	4.6%	4.6%	5.0%	14.1%	23.7%		
2	4	7.9%	19.6%	20.1%	9.8%	5.6%	8.9%	8.9%	4.7%	14.5%	28.0%		
2	5	10.3%	13.0%	19.3%	6.1%	6.4%	9.0%	6.1%	5.9%	24.0%	35.9%		
Average		**14.1%**	**15.7%**	**19.4%**	**7.7%**	**5.8%**	**7.6%**	**7.4%**	**5.7%**	**16.6%**	**29.7%**	**750**	**3.50%**
SD		**6.3%**	**7.0%**	**8.7%**	**3.5%**	**2.6%**	**3.4%**	**3.3%**	**2.6%**	**7.4%**			
3	1	28.6%	18.3%	24.1%	8.3%	3.3%	2.9%	5.0%	2.9%	6.6%	14.5%		
3	2	17.6%	14.4%	24.3%	10.8%	6.3%	5.0%	6.8%	3.6%	11.3%	21.6%		
3	3	22.8%	10.2%	13.4%	9.1%	4.3%	4.7%	5.5%	5.5%	24.4%	35.4%		
3	4	24.0%	12.2%	16.9%	6.3%	5.5%	7.1%	8.7%	4.7%	14.6%	28.0%		
3	5	19.7%	12.9%	15.5%	6.9%	6.9%	7.3%	9.0%	5.2%	16.7%	30.9%		
Average		**22.6%**	**13.6%**	**18.8%**	**8.3%**	**5.3%**	**5.4%**	**7.0%**	**4.4%**	**14.7%**	**26.1%**	**310**	**0.90%**
SD		**10.1%**	**6.1%**	**8.4%**	**3.7%**	**2.4%**	**2.4%**	**3.1%**	**2.0%**	**6.6%**			

Table C-3. Age and growth data from 1994-95 littleneck clam transplant experiment.

				Last Annulus (1994-95)			Age 1 (1993-94)			Age 2 (1992-93)			Age 3 (1991-92)			Experimental	
Age	No.	Total Length	SD	Length	SD	95 Growth	Length	SD	94 Growth	Length	SD	93 Growth	Length	SD	92 Growth	Growth (95-96)	SD
Outside Bay Lot No. 1																	
4	1	23.70		21.50		2.20	16.60		4.90	10.10		6.50	4.10		6.00	1.60	
5	11	26.89	2.49	25.25	3.18	1.64	21.56	3.18	3.69	16.78	2.59	4.78	10.16	3.48	6.62	3.85	2.12
6	21	28.92	2.90	26.76	2.90	2.16	23.71	2.90	3.05	20.07	2.99	3.64	14.90	2.50	5.17	2.80	2.27
7	9	30.44	3.33	28.54	3.03	1.90	26.07	3.03	2.48	22.43	2.90	3.63	17.11	2.42	5.32	1.77	1.73
8	12	31.33	3.13	30.35	3.35	0.98	28.02	3.35	2.33	24.90	3.60	3.12	20.50	3.13	4.40	0.84	1.15
9	4	33.05	2.04	32.55	2.15	0.50	30.65	2.15	1.90	27.40	2.96	3.25	24.30	2.70	3.10		
10	3	34.73	1.27	33.63	2.18	1.10	32.30	2.18	1.33	29.43	2.60	2.87	25.70	2.61	3.73	0.87	0.85
11	4	32.25	0.87	31.55	1.13	0.70	30.08	1.13	1.48	28.88	1.67	1.20	27.28	1.54	1.60	0.30	0.54
12	1	32.80		32.40		0.40	30.20		2.20	28.50		1.70	27.50		1.00		
	66																
Dead	3																
		86% recovery															

				Last Annulus (1994-95)			Age 1 (1993-94)			Age 2 (1992-93)			Age 3 (1991-92)			Experimental	
Age	No.	Total Length	SD	Length	SD	95 Growth	Length	SD	94 Growth	Length	SD	93 Growth	Length	SD	92 Growth	Growth (95-96)	SD
Outside Bay Lot No. 2																	
4	3	26.15	3.04	23.00	1.84	3.15	18.20	1.84	4.80	11.80	3.39	6.40	5.70	1.56	6.10	4.90	2.83
5	11	25.06	3.59	23.08	2.42	1.98	19.51	2.42	3.57	15.81	1.87	3.70	8.59	1.85	7.22	4.23	2.11
6	15	27.06	2.78	25.16	3.04	1.90	22.85	3.04	2.31	19.67	2.13	3.18	15.57	1.80	4.09	3.75	1.93
7	7	29.93	1.93	28.61	2.33	1.31	27.46	2.33	1.16	24.24	2.81	3.21	20.47	3.63	3.77	1.73	1.37
8	7	29.53	2.32	27.68	1.81	1.85	25.50	1.81	2.18	22.68	1.16	2.82	18.90	1.09	3.78	3.28	1.83
9	2	28.25	5.44	27.60	5.02	0.65	26.05	5.02	1.55	24.45	5.16	1.60	21.85	5.59	2.60	1.25	1.77
10	2	30.30	1.84	30.10	2.05	0.20	28.45	2.05	1.65	27.10	0.99	1.35	23.90	1.27	3.20	0.75	1.06
	47																
Dead	2																
		57% recovery															

Table C-3. (continued)

Age	No.	Total Length	SD	Last Annulus (1994-95) Length	SD	95 Growth	Age 1 (1993-94) Length	SD	94 Growth	Age 2 (1992-93) Length	SD	93 Growth	Age 3 (1991-92) Length	SD	92 Growth	Experimental Growth (95-96)	SD
Block Lot No. 3																	
5	6	24.37	2.70	21.75	2.63	2.62	19.23	2.63	2.52	15.32	1.73	3.92	10.43	2.08	4.88	5.47	2.16
6	16	27.25	3.60	24.69	3.44	2.56	21.85	3.44	2.84	18.37	3.34	3.48	14.28	3.13	4.09	4.59	2.19
7	18	30.01	3.49	27.84	3.66	2.16	25.30	3.66	2.54	22.18	3.24	3.12	18.41	3.02	3.78	3.07	1.89
8	22	30.22	3.81	28.53	3.84	1.69	26.78	3.84	1.75	24.54	3.16	2.25	21.14	3.19	3.40	2.65	1.65
9	5	33.92	2.58	33.36	3.54	0.56	31.18	3.54	2.18	28.60	5.95	2.58	25.30	6.42	3.30	0.82	0.88
10	7	35.00	4.03	33.90	3.44	1.10	32.20	3.44	1.70	30.27	3.63	1.93	28.03	3.40	2.24	1.39	1.07
11	3	34.70	0.66	33.13	1.10	1.57	32.03	1.10	1.10	30.30	2.17	1.73	28.27	1.54	2.03	2.13	1.31
12	1	37.80		36.80		1.00	36.40		0.40	35.50		0.90	32.30		3.20	0.90	
	78																
N/C	1	1 7yr w/ initial length>end length															
		96% recovery															

Age	No.	Total Length	SD	Last Annulus (1994-95) Length	SD	95 Growth	Age 1 (1993-94) Length	SD	94 Growth	Age 2 (1992-93) Length	SD	93 Growth	Age 3 (1991-92) Length	SD	92 Growth	Experimental Growth (95-96)	SD
Block Lot No. 4																	
3	1	15.60		10.80		4.80	6.60		4.20	4.00		2.60			4.00		
4	1	21.90		19.80		2.10	14.70		5.10	7.90		6.80	2.50		5.40	2.10	
5	12	22.80	2.20	20.73	1.62	2.07	18.01	1.62	2.73	13.87	1.75	4.14	8.41	1.42	5.46	1.62	1.30
6	14	26.88	4.05	25.48	3.96	1.40	23.07	3.96	2.41	18.83	3.05	4.24	14.61	2.79	4.21	1.36	1.38
7	17	28.22	3.52	26.92	3.07	1.29	25.09	3.07	1.84	22.30	3.46	2.79	18.24	3.62	4.06	1.49	1.48
8	13	29.98	3.89	28.79	3.88	1.18	27.04	3.88	1.75	24.60	3.81	2.44	21.08	3.93	3.52	1.28	1.19
9	6	31.18	2.60	30.43	1.67	0.75	28.47	1.67	1.97	26.48	1.74	1.98	23.65	2.56	2.83	0.43	0.48
10	1	32.70		32.40		0.30	31.30		1.10	27.50		3.80	26.00		1.50	0.20	
	65																
Dead	0																
		80% recovery															

Table C-3. (continued)

				Last Annulus (1994-95)			Age 1 (1993-94)			Age 2 (1992-93)			Age 3 (1991-92)			Experimental	
Age	No.	Total Length	SD	Length	SD	95 Growth	Length	SD	94 Growth	Length	SD	93 Growth	Length	SD	92 Growth	Growth (95-96)	SD
Block Lot No. 5																	
5	6	24.58	2.21	22.68	3.14	1.90	19.88	3.14	2.80	14.85	2.28	5.03	10.17	0.98	4.68	1.43	1.70
6	8	26.45	2.06	24.41	2.91	2.04	21.54	2.91	2.88	18.40	3.49	3.14	14.09	3.36	4.31	2.65	1.92
7	9	29.58	3.85	27.91	4.84	1.67	25.09	4.84	2.82	22.02	4.14	3.07	18.09	3.58	3.93	1.11	1.37
8	4	32.95	4.71	31.80	4.19	1.15	29.63	4.19	2.18	26.88	4.88	2.75	23.63	3.76	3.25	2.60	2.75
9	3	33.40	2.82	32.97	2.25	0.43	31.33	2.25	1.63	28.77	2.10	2.57	26.47	2.20	2.30	1.77	2.47
10	2	38.05	5.73	37.20	5.23	0.85	35.20	5.23	2.00	31.70	3.54	3.50	29.85	4.17	1.85	0.65	0.92
	32																
Dead	3																
		41% recovery															

				Last Annulus (1994-95)			Age 1 (1993-94)			Age 2 (1992-93)			Age 3 (1991-92)			Experimental	
Age	No.	Total Length	SD	Length	SD	95 Growth	Length	SD	94 Growth	Length	SD	93 Growth	Length	SD	92 Growth	Growth (95-96)	SD
Block Lot No. 6																	
5	3	23.07	2.35	21.87	2.40	1.20	19.87	2.40	2.00	16.13	0.21	3.73	10.17	0.55	5.97	2.97	2.57
6	2	21.10	4.95	19.25	6.58	1.85	17.45	6.58	1.80	15.90	7.21	1.55	12.45	7.14	3.45	2.85	0.35
7	4	28.33	1.48	25.95	2.69	2.38	23.75	2.69	2.20	20.88	1.84	2.88	18.05	0.85	2.83	4.40	2.05
9	2	24.95	6.43	23.80	6.51	1.15	23.00	6.51	0.80	21.60	7.21	1.40	18.25	4.31	3.35	1.55	1.06
10	1	40.10		39.50		0.60	38.50		1.00	37.10		1.40	34.30		2.80	0.40	
11	1	34.60		34.30		0.30	33.50		0.80	33.00		0.50	28.70		4.30	0.10	
	13																
Dead	0																
		15% recovery															

Table C-3. (continued)

Age	No.	Total Length	SD	Last Annulus (1994-95) Length	SD	95 Growth	Age 1 (1993-94) Length	SD	94 Growth	Age 2 (1992-93) Length	SD	93 Growth	Age 3 (1991-92) Length	SD	92 Growth	Experimental Growth (95-96)	SD
Outside Bay Lot No. 7																	
5	4	26.85	3.34	25.50	4.32	1.35	21.20	4.32	4.30	15.90	3.75	5.30	10.70	1.78	5.20	4.20	2.79
6	11	28.18	3.88	24.95	3.29	3.24	22.43	3.29	2.52	19.08	3.86	3.35	14.22	2.78	4.86	5.34	0.98
7	10	30.81	3.30	29.26	3.02	1.55	26.68	3.02	2.58	24.08	2.59	2.60	19.74	3.11	4.34	3.25	1.71
8	13	31.92	3.31	30.12	3.47	1.80	27.54	3.47	2.58	24.76	3.47	2.78	20.90	2.45	3.86	3.31	1.77
9	11	32.56	4.14	30.76	4.32	1.80	29.17	4.32	1.59	26.93	4.65	2.25	23.56	5.19	3.36	2.63	1.31
10	8	35.06	2.17	33.95	2.23	1.11	32.25	2.23	1.70	30.41	1.68	1.84	27.69	1.85	2.73	2.10	0.96
11	1	31.20		30.90		0.30	29.60		1.30	26.90		2.70	25.50		1.40	0.40	
	58																
Dead	1																
		71% recovery															

Age	No.	Total Length	SD	Last Annulus (1994-95) Length	SD	95 Growth	Age 1 (1993-94) Length	SD	94 Growth	Age 2 (1992-93) Length	SD	93 Growth	Age 3 (1991-92) Length	SD	92 Growth	Experimental Growth (95-96)	SD
Block Lot No. 8																	
3	1	17.30		16.00		1.30	11.80		4.20	7.20		4.60			7.20	1.00	
4	7	21.01	3.53	18.51	1.96	2.50	15.93	1.96	2.59	10.60	2.32	5.33	5.50	1.74	5.10	3.56	1.90
5	9	23.84	3.61	21.33	2.81	2.51	18.23	2.81	3.10	14.87	2.81	3.37	9.57	1.82	5.30	4.02	1.08
6	16	25.48	3.36	23.85	3.02	1.63	21.74	3.02	2.11	18.66	2.75	3.09	14.25	2.28	4.41	2.67	1.53
7	20	28.47	3.34	26.82	3.38	1.65	25.13	3.38	1.70	22.51	3.37	2.62	18.23	3.17	4.28	2.09	1.13
8	12	31.08	3.58	29.79	3.85	1.29	28.46	3.85	1.33	25.84	3.80	2.62	22.08	3.61	3.77	1.49	1.03
9	11	33.35	4.27	32.15	4.10	1.19	30.65	4.10	1.51	28.65	3.98	2.00	25.56	3.15	3.08	1.53	1.08
10	6	32.35	3.73	30.97	3.95	1.38	29.55	3.95	1.42	27.70	3.77	1.85	25.52	3.33	2.18	1.28	0.86
	82																
Dead	2																
N/C	1	1 -6 yr old w/ initial length>end length															
		91% recovery															

Table C-3. (continued)

				Last Annulus (1994-95)			Age 1 (1993-94)			Age 2 (1992-93)			Age 3 (1991-92)			Experimental	
Age	No.	Total Length	SD	Length	SD	95 Growth	Length	SD	94 Growth	Length	SD	93 Growth	Length	SD	92 Growth	Growth (95-96)	SD
Block Lot No. 9																	
4	7	21.21	3.53	19.46	3.72	1.76	16.00	3.72	3.46	10.41	2.79	5.59	4.71	1.29	5.70	2.80	2.10
5	18	24.96	2.56	22.53	2.51	2.43	19.67	2.51	2.86	15.84	2.34	3.83	10.29	1.99	5.55	3.45	1.45
6	20	25.73	2.63	23.87	2.98	1.86	22.16	2.98	1.72	19.06	2.68	3.10	14.20	2.15	4.87	2.33	1.51
7	21	28.80	2.93	27.09	3.60	1.70	25.00	3.60	2.09	22.22	3.70	2.78	17.82	2.89	4.40	2.15	1.31
8	4	29.63	3.40	27.58	4.31	2.05	24.90	4.31	2.68	22.15	3.13	2.75	19.18	2.10	2.98	2.03	1.47
9	3	29.30	2.18	28.77	2.48	0.53	26.73	2.48	2.03	24.10	1.39	2.63	19.07	1.79	5.03	0.13	0.12
10	3	38.83	0.40	37.70	0.21	1.13	35.87	0.21	1.83	33.17	0.55	2.70	30.47	1.52	2.70		
11	1	33.30		31.90		1.40	31.00		0.90	29.20		1.80	26.20		3.00	3.20	
12	1	42.40		40.50		1.90	38.40		2.10	35.90		2.50	34.50		1.40	1.30	
	78																
Dead	5																
		84% recovery															