APPENDIX IX

NEW BEDFORD HARBOR PILOT STUDY

PRE-OPERATIONAL MONITORING - PROGRESS REPORT:

Results of the Biological Effects Measurements on *Mytilus edulis*

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23 February 1988

Introduction

A cooperative effort has been initiated between the Environmental Protection Agency, Region I and the Environmental Research Laboratory in Narragansett, R.I. (ERLN), and the U.S. Army Corps of Engineers (COE), New England Division and Waterways Experimental Station, to conduct a Pilot Project to evaluate a series of remedial action alternatives to clean up New Bedford Harbor (NBH). The blue mussel, *Mytilus edulis*, will be used throughout this study as an integrative biological monitor to measure: 1) the effects of each stage of the operation on the release and transport of contaminants, 2) biological availability of released contaminants, and 3) chronic and acute biological effects of released contaminants. The present report describes the biological effects of the two pre-operational mussel deployments. This information will be used as baseline data against which the effects of future dike construction, dredging, filling and capping operations will be compared.

Materials and Methods

Prior to each deployment, mussels were collected from East Sandwich, Mass., returned to ERLN, and sorted according to length. A total of twenty-five mussels ranging from 5-7 cm were placed into each of 48 baskets. Custody seals were placed on all mussel baskets prior to deployment in NBH to ensure the integrity of the samples in the field. Mussels were deployed 1 m above the bottom at 3 locations in NBH (Station NBH-2, Coggeshall St. Bridge; Station NBH-3, opposite the Revere Silverware factory; Station NBH-4, the Hurricane Barrier) and at a reference station in Buzzards Bay (Fig. 1). The reference station for the first deployment was near the Cleveland Ledge lighthouse (NBH-6). The reference station was relocated to West Island for the second deployment to facilitate collections (NBH-5). Each station consisted of four replicate substations with three baskets on each.

Individual baskets were retrieved from each substation on days 3, 7, and 28 of both deployments and returned to ERLN with custody seals intact. On each retrieval date, subsamples of mussels from each basket were taken for organic and inorganic chemical analysis and frozen at -20° C.

Scope for growth (SFG) measurements were completed on mussels retrieved on days 7 and 28 for the first deployment and on days 3, 7, and 28 for the second deployment. Mussels used for SFG were placed in flowing unfiltered seawater overnight and measurements initiated the following morning. Determination of the SFG index required the measurement of three parameters: clearance rate, assimilation efficiency, and respiration rate. These procedures are described in detail by Nelson et al. (1985). Scope for growth was measured on 2 mussels from each of the 4 replicates/station at ambient Narragansett Bay temperature and salinity (within 2° C and 2°/oo of NBH).

Baskets collected on day 28 contained marked and measured individuals of the 5.0 cm size class for shell growth and survival measurements, and 7.0 cm mussels for determining survival alone. Mortality of marked mussels was recorded and growth determined on survivors by measuring increases in shell length using a Vernier calpier. At the time of collection, and at several other points in time, temperature, salinity, and dissolved oxygen were measured at each station.

Statistical differences in SFG and shell growth among stations were determined using one-way analysis of variance (ANOVA). Statistical differences in mortality among stations were completed using ANOVA after arcsine transformation of the data. In addition, Pearson correlation coefficients were calculated between SFG, shell growth, and preliminary PCB tissue residue data.

Results

The measured physical parameters of the seawater (i.e. temperature, salinity, dissolved oxygen) appear to be relatively similar among the four stations during each deployment (Tables 1, 2). While temperature may have increased or decreased during a deployment, the values were comparable among the stations on any specific collection date. Salinity was different among the four stations at only one point in time (21-SEP at NBH-2, Table 2), possibly due to heavy rains the previous week.

The SFG data from days 7 and 28 of the first deployment are listed in Table 3. The Day 7 SFG values indicate a gradient of physiological response with a significant decrease ($P<0.05$) in SFG observed moving from the mouth of NBH towards the upper end of the harbor (Station NBH-2) (Fig. 2). There was no difference between the reference station (NBH-6) and the station located at the Hurricane Barrier (NBH-4). Clearance rates were significantly lower in mussels retrieved from Station NBH-2 (2.26 l/h) than at either Stations NBH-4 or NBH-6 (3.56 and 3.77 l/h, respectively). In addition, assimilation efficiencies were significantly higher in mussels returned from Stations NBH-6 and NBH-4 (95 and 93%, respectively) than in mussels returned from Stations NBH-3 and NBH-2 (87 and 86%, respectively). There were no significant differences in mussel respiration rates among stations.

On day 28, the SFG values showed a similar pattern to those at Day 7 (i.e. higher SFG at Station NBH-4 than Station NBH-2), however, the differences were not statistically significant (P>0.05) (Fig. 2). Clearance rates were significantly higher at Station NBH-6 (4.40 l/h) than at Stations NBH-2 and NBH-3 (2.52 and 2.51 l/h, respectively), with Station NBH-4 intermediate between the others (3.29 l/h). Assimilation efficiencies were significantly higher at Stations NBH-4 and NBH-3 (82 and 79%, respectively) than at Stations NBH-6 and NBH-2 (70 and 67%, respectively). There were no significant differences among respiration rates at any of the stations.

The growth of 5.0 cm mussels was significantly different (P=0.016) among stations in NBH. The mean (± S.E.) increase in length for Stations NBH-2, NBH-3, NBH-4, and NBH-6 was 0.95 mm ± 0.15 mm, 1.37 mm ± 0.19 mm, 2.13 mm ± 0.37 mm, and 2.20 mm ± 0.20mm, respectively (Fig. 3). A multiple comparison (Fisher's LSD) indicated no difference in shell growth between Stations NBH-2 and NBH-3 (P>0.05).

Conversely, survival rates were high among stations and similar among size classes. Mean (± S.E.) percent survival for the 5.0 cm mussels was 92.7 % ± 7.3 %, 100 % ± 0.0 %, 91.8 % ± 5.3 %, and 100 % ± 0.0 % for Stations NBH-2, NBH-3, NBH-4, and NBH-6, respectively. Mortality of 7.0 cm size class mussels was also low among the four stations (Table 4).

Preliminary PCB tissue residue data are shown in Table 5. These data indicate a dramatic gradient in NBH and will be discussed in detail in a separate report. Statistical analysis indicated that the Day 28 SFG and shell growth values show a significant ($P<0.05$) inverse correlation with total PCB tissue residue concentrations ($r= -0.98$ and -0.95, respectively).

During the second preoperational deployment SFG was measured on mussels retrieved on Days 3, 7, and 28 (Table 6, Fig. 4). There were no significant differences in SFG among stations on any of the three occasions. At one point in time, Day 28, the mean clearance rate of mussels from Station NBH-5 was significantly higher than the mean clearance rate at NBH-2 (3.3 l/h and 2.0 l/h, respectively). There were no other significant differences in clearance rates, assimilation efficiencies, or respiration rates among stations during this deployment.

Shell growth in mussels during the second deployment was not significantly different ($P>0.05$) among stations. The mean (± S.E.) increase in length for Stations NBH-2, NBH-3, NBH-4, and NBH-5 was 0.72 mm ± 0.08 mm, 0.65 mm ± 0.17 mm, 0.84 mm ± 0.12 mm, and 0.67 mm ± 0.06 mm, respectively (Fig. 5).

Mortality after the second 28-day deployment was not significantly different among the four stations for either the 5 or 7 cm size classes (Table 7).

Discussion

The objective of the monitoring portion of the NBH Pilot Project is to collect baseline data on which to make comparisons of biological effects due to diking, dredging, filling, and capping activities. The preoperational mussel deployments suggested two points: 1) the physical parameters of the seawater are similar among the station locations, and 2) a gradient of biological effect can be observed at several points in time among these stations.

The physical data collected during these deployments were relatively uniform among all four stations (Table 1). Because of the eurythermal and euryhaline nature of M. edulis, the observed differences of 1-2° C and 1-2 ^{o}/oo salinity are unlikely to have been responsible for any observed differences in biological responses. In addition, dissolved oxygen levels were adequate, although it is interesting to note that they were consistently lower at Station NBH-3.

The lack of significant mortality at any of the four stations, during either deployment, indicated that there was no acute response to the ambient conditions. However, the SFG and shell growth data indicated there was a chonic response in the mussels during the first deployment. The significant reductions in SFG after 7 days and shell growth after 28 days, along with a similar pattern of SFG values among the stations at day 28, indicate a consistent negative response in mussels deployed in the upper harbor. The inverse correlations between SFG, shell growth and PCB tissue concentrations, along with the uniformity of the physical parameters, would suggest that these negative biological effects may be attributable to increased contamination in upper NBH.

The data collected during the second mussel deployment indicated a different pattern. While there was again no acute response in mortality, there was likewise no apparent chronic response in the mussels either. The SFG and shell growth data indicated neither significant differences among stations nor a pattern of negative effect similar to that observed during the first deployment. The only difference observed in any of the physiological variables was between the clearance rates of mussels at Stations NBH-5 and NBH-2. This difference was consistent with that observed in the first deployment. Chemical analyses on these mussel tissues indicated that tissue residues were comparable to those measured during the first deployment after Days 7 and 28. One possible explanation for the similarity of biological response among stations during this deployment concerns the stage of gametogenesis in the mussels. Observation of mantle tissue indicated that mussels collected during this deployment were at the peak of the reproductive cycle. It is possible that any effect of exposure in NBH was overshadowed by the natural stress of gametogenesis.

Literature Cited

Nelson, W.G., D. Black, D.K. Phelps. 1985. The Utility of the Scope for Growth Index to Assess the Physiological Impact of Black Rock Harbor Suspended Sediment on the Blue Mussel, *Mytilus edulis*: A Laboratory Evaluation. Technical Report D-85-6, prepared by the U.S. Environmental Protection Agency, Narragansett,R.I., for the U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

Table 1. Temperature (° C), salinity ($^{o}/oo$), and dissolved oxygen (mg/l) data at the four mussels stations during the first preoperational deployment.

Date	Station	Temperature	Salinity	D.O.
5-Jun-87	NBH-6	18.2	31.4	8.6
8-Jun-87	NBH-2	18.4	30.9	4.6
" "	NBH-3	17.1	32.6	3.9
" "	NBH-4	17.0	31.9	6.2
11-Jun-87	NBH-2	18.3	31.7	7.5
" "	NBH-3	17.5	32.0	7.1
" "	NBH-4	17.6	31.4	6.9
15-Jun-87	NBH-2	20.6	29.6	6.9
" "	NBH-3	18.7	30.1	6.5
" "	NBH-4	19.0	30.4	6.9
" "	NBH-6	--	--	9.0
24-Jun-87	NBH-2	20.2	31.8	5.6
" "	NBH-3	20.2	32.3	4.9
" "	NBH-4	19.6	32.8	5.9
30-Jun-87	NBH-2	22.4	31.6	8.0
" "	NBH-3	21.0	29.7	6.5
" "	NBH-4	20.5	32.7	8.1
6-Jul-87	NBH-2	22.2	30.7	6.4
" "	NBH-3	21.5	31.9	5.1
" "	NBH-4	21.8	32.9	8.6
" "	NBH-6	20.8	31.0	8.0

Table 2. Temperature (° C), salinity (^{o}/oo), and dissolved oxygen (mg/l) data at the four mussels stations during the second preoperational deployment.

Date	Station	Temperature	Salinity	D.O.
14-Sep-87	NBH-2	21.3	31.6	-
" "	NBH-3	21.1	32.9	5.9
" "	NBH-4	21.1	32.6	6.3
" "	NBH-5	20.8	33.2	7.9
17-Sep-87	NBH-2	21.3	32.3	5.4
" "	NBH-3	21.6	32.7	5.0
" "	NBH-4	21.2	32.8	6.8
" "	NBH-5	20.2	33.3	7.2
21-Sep-87	NBH-2	17.6	26.5	4.4
" "	NBH-3	18.1	30.5	6.0
" "	NBH-4	18.1	31.5	6.2
" "	NBH-5	17.5	32.7	7.3
12-Oct-87	NBH-2	13.6	33.5	7.6
" "	NBH-3	13.3	33.4	7.7
" "	NBH-4	14.2	32.5	8.2
" "	NBH-5	13.9	33.6	8.3

Table 3. Mean (standard error) scope for growth values (J/h) of mussels from four stations during the first pre-operation deployment.

Station	Scope for growth	
	Day 7	Day 28
NBH-2	-4.9(2.5)A*	-3.5(1.7)A
NBH-3	-1.1(1.6)A,B	0.0(2.4)A
NBH-4	3.7(2.0) B,C	2.7(3.6)A
NBH-6	8.2(1.5) C	2.2(1.6)A

* Means with the same letter group are not significantly different (P=0.05).

Table 4. Percent survival (standard error) of 5.0 cm and 7.0 cm mussels in New Bedford Harbor during the first preoperational deployment. There were no statistically significant differences (P=0.05) among stations.

Station	Size Class	
	5.0 cm	7.0 cm
NBH-2	93 (7)	100 (0)
NBH-3	100 (0)	100 (0)
NBH-4	92 (5)	90 (10)
NBH-6	100 (0)	100 (0)

Table 5. Mean (standard error) PCB concentrations (ng/g) in mussels deployed in New Bedford Harbor. Values were transformed (logarithm base 10) prior to statistical analysis. Means with the same letter group are not significantly different (P=0.05).

Station	Day 3	Day 7	Day 28
NBH-2	11800 (0) A	45800 (5750) A	97100 (6250) A
NBH-3	6010 (241) B	15800 (4240) B	41200 (3130) B
NBH-4	3760 (409) C	4850 (645) C	12600 (1430) C
NBH-6	--	435 (29) D	715 (77) D

Table 6. Mean (standard error) scope for growth values (J/h) of mussels from four stations during the second pre-operation deployment. There were no statistically significant differences (P=0.05) among stations on any of the collection dates.

Station	Scope for growth		
	Day 3	Day 7	Day 28
NBH-2	-12.2(2.0)	-4.8(0.7)	-1.6(1.0)
NBH-3	--	-3.8(1.2)	-1.2(0.9)
NBH-4	-6.3(0.6)	-6.1(1.0)	-1.9(0.5)
NBH-5	--	-5.2(0.2)	-1.7(0.7)

Table 7. Percent survival (standard error) of 5.0 cm and 7.0 cm mussels in New Bedford Harbor during the second preoperational deployment. There were no statistically significant differences (P=0.05) among stations.

Station	Size Class	
	5.0 cm	7.0 cm
NBH-2	80 (20)	90 (10)
NBH-3	100 (0)	75 (10)
NBH-4	100 (0)	80 (12)
NBH-5	90 (5)	87 (7)

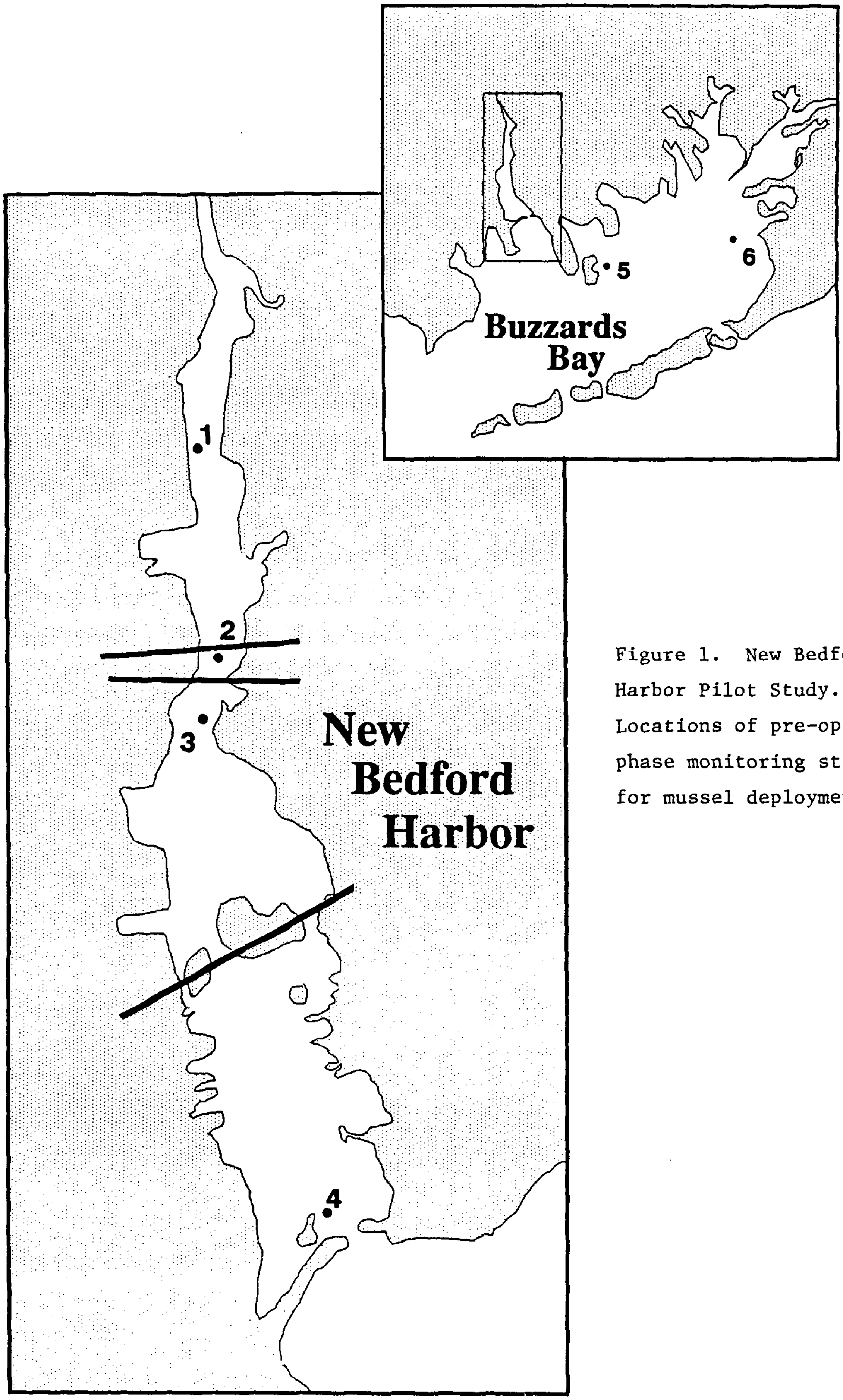

Figure 1. New Bedford Harbor Pilot Study. Locations of pre-operational phase monitoring stations for mussel deployments.

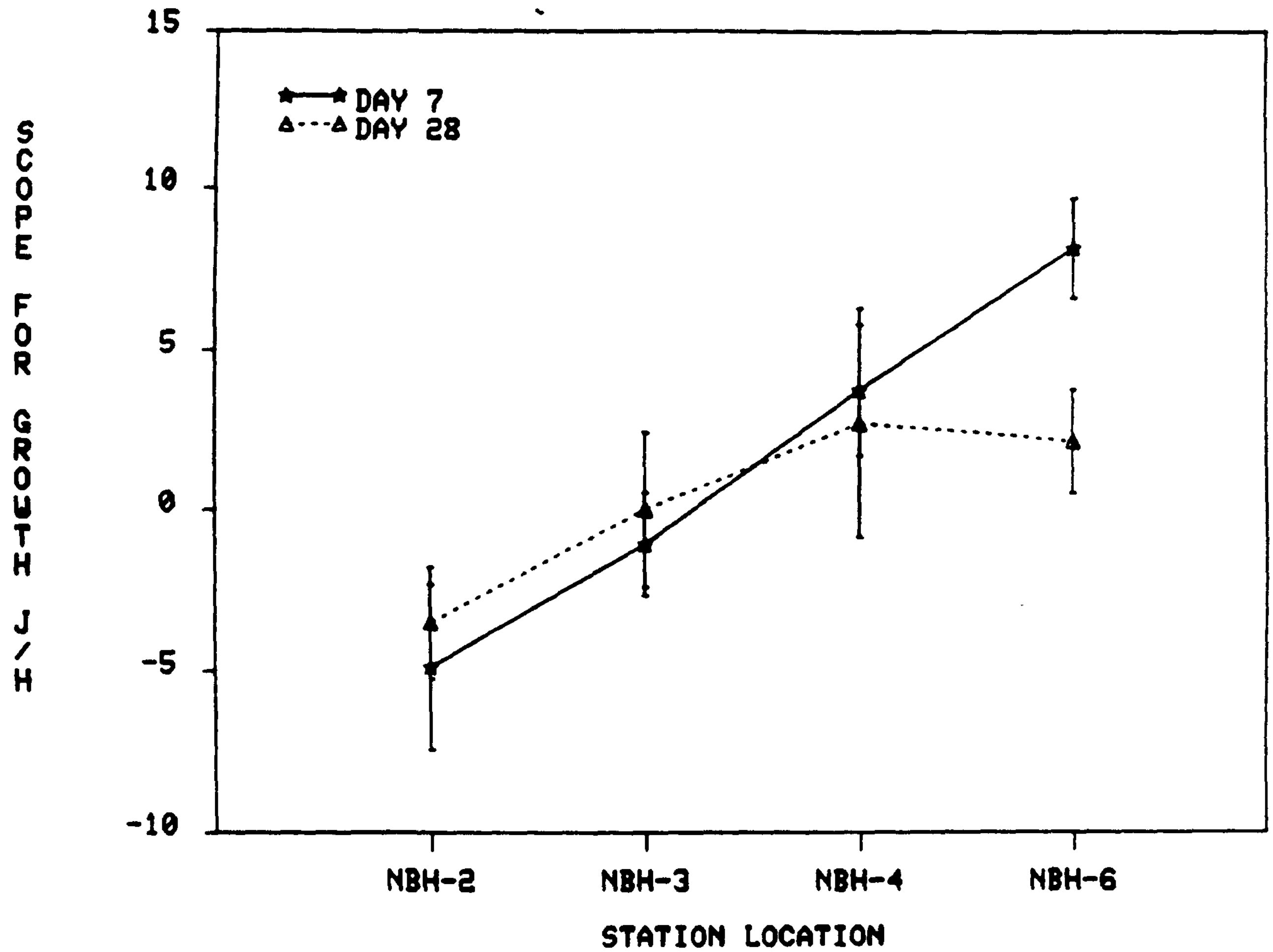

Figure 2. The mean scope for growth (± standard error) values of mussels collected from New Bedford Harbor after 7- and 28-day exposures during the first preoperational deployment.

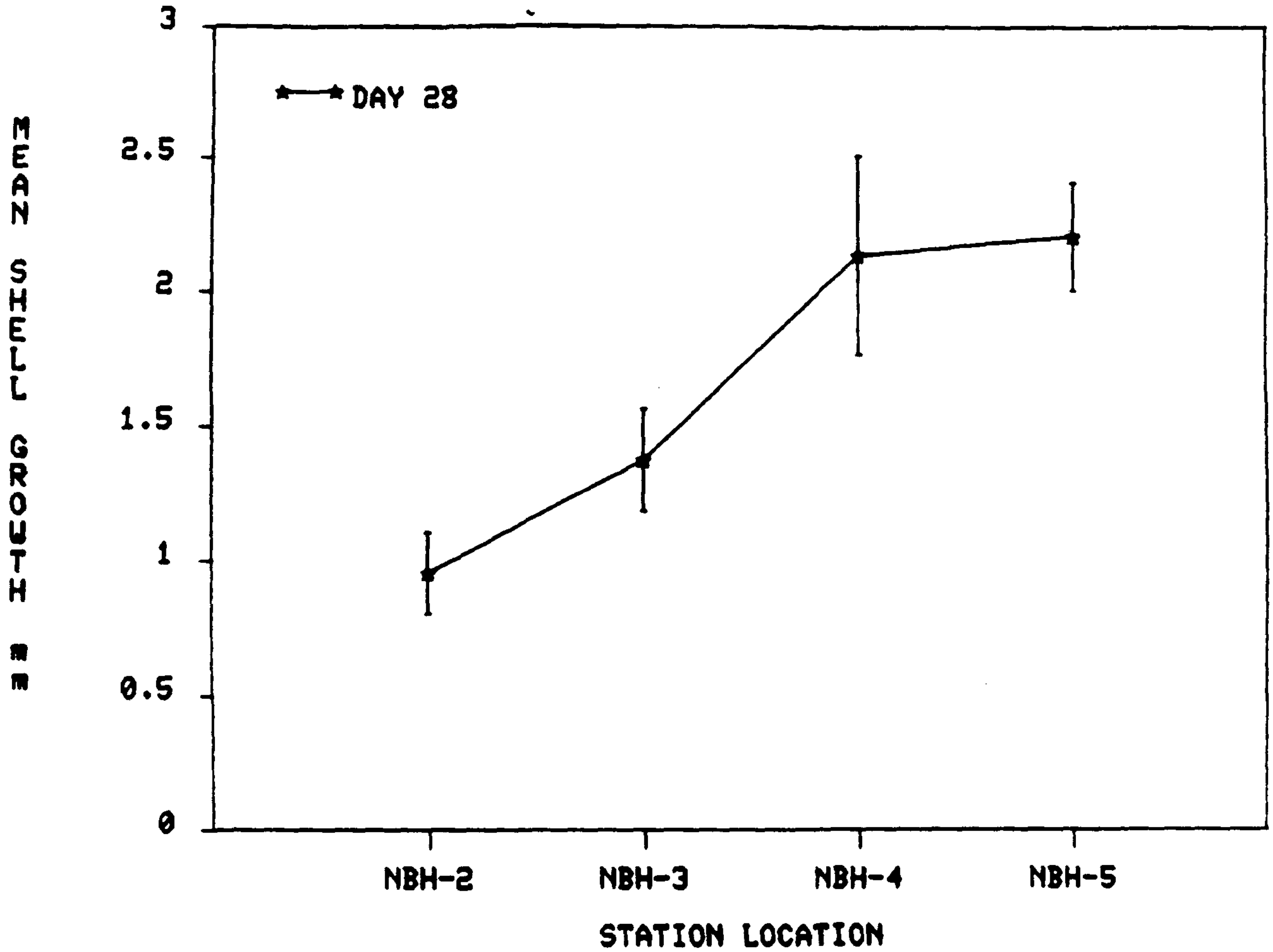

Figure 3. The mean (± standard error) increase in mussel shell length after a 28-day exposure in New Bedford Harbor during the first preoperational deployment.

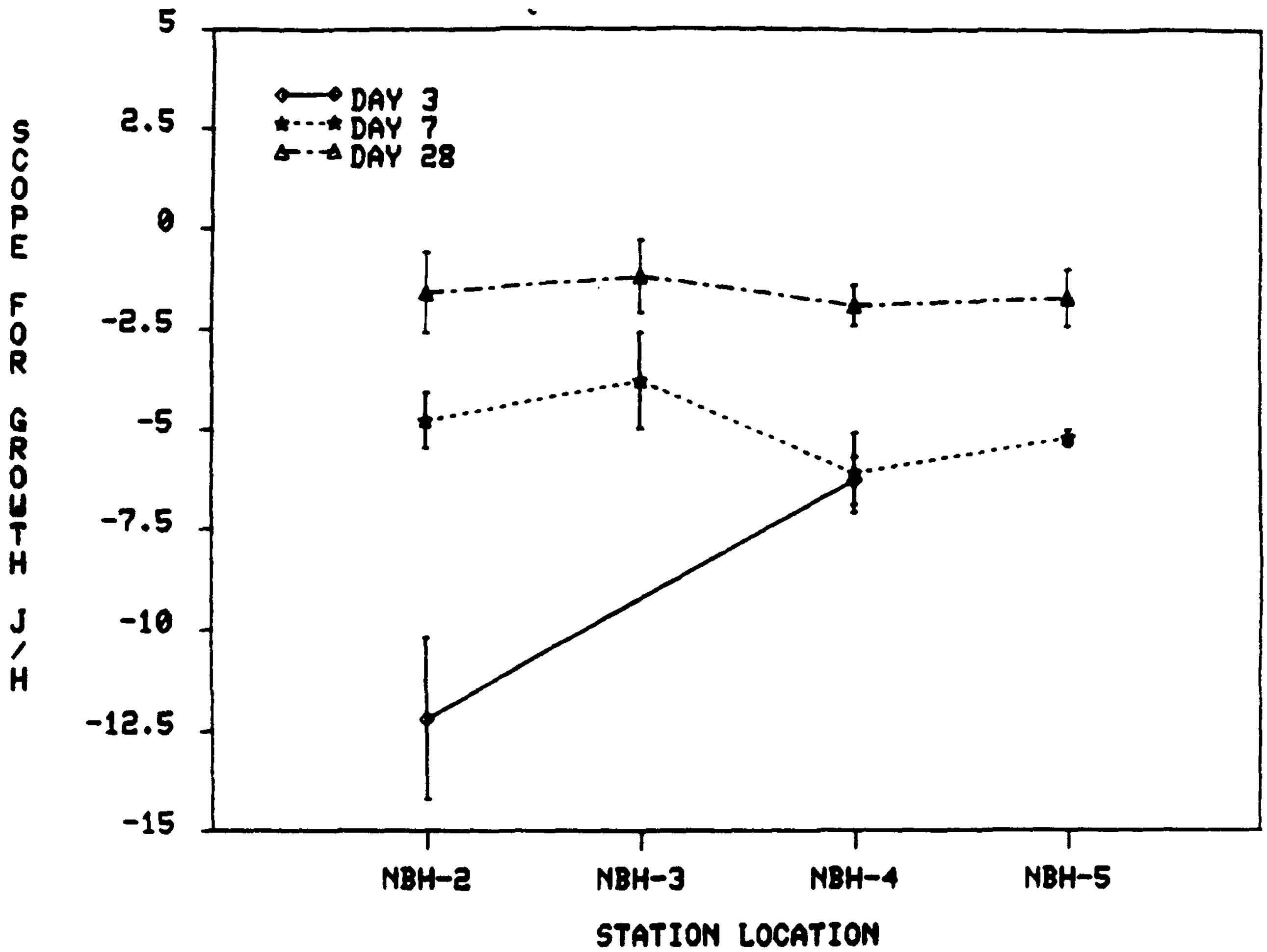

Figure 4. The mean scope for growth (± standard error) values of mussels collected from New Bedford Harbor after 3, 7, and 28-day exposures during the second preoperational deployment.

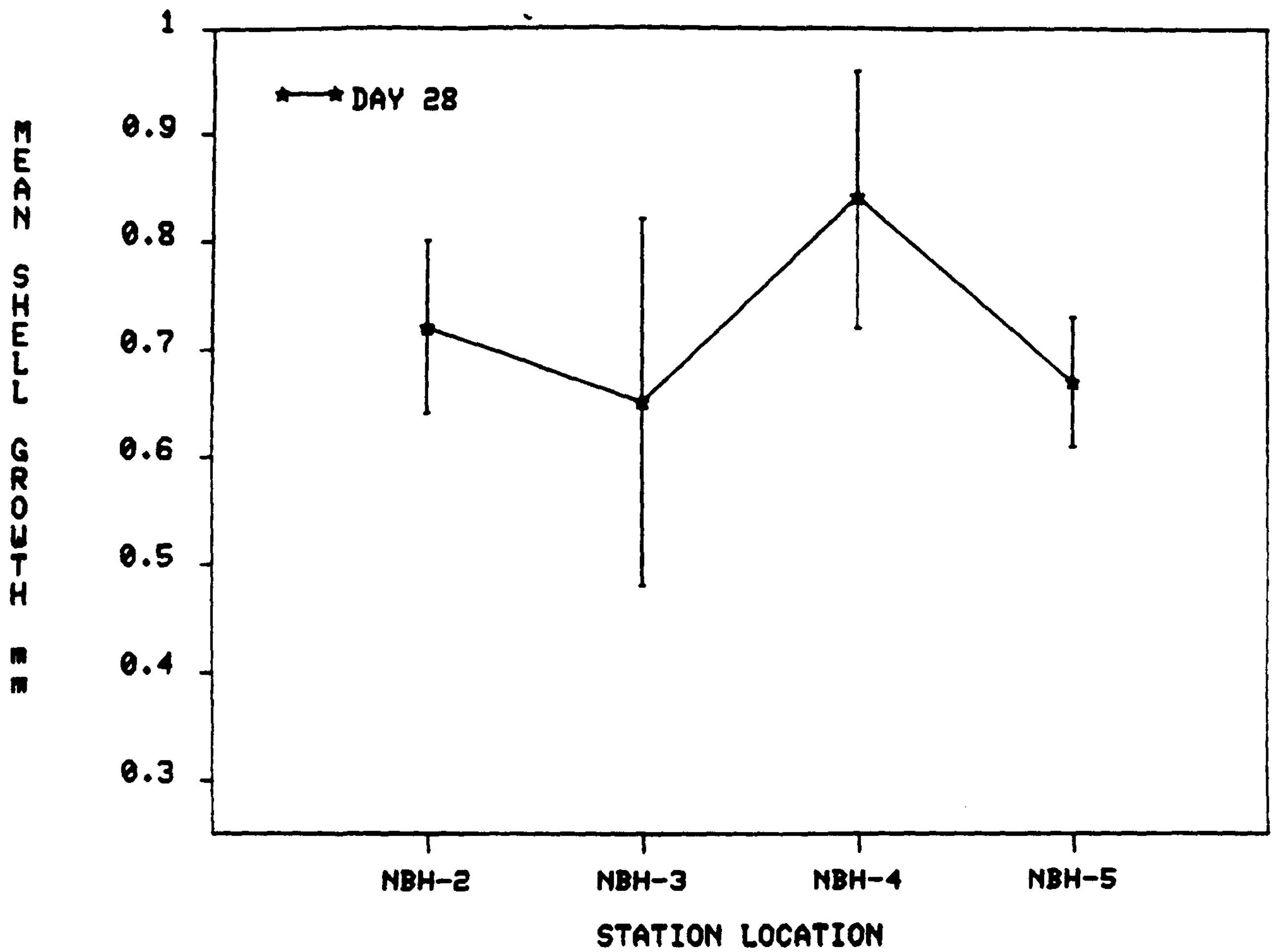

Figure 5. The mean (± standard error) increase in mussel shell length after a 28-day exposure in New Bedford Harbor during the second preoperational deployment.