Appendix IIIB1.A. Total HubLine Benthic Infaunal Species List

CNIDARIA
Hydrozoa
Edwardsia elegans Verrill, 1869
Ceriantheopsis americana (Verrill, 1866)

NEMERTEA
*Cerebratulus lacteus (*Leidy, 1851*)*
Micrura spp.
Tetrastemma spp.

ANNELIDA
Polychaeta
Ampharetidae
A*sabellides oculata* (Webster, 1979)
Capitellidae
Capitella capitata (Fabricius, 1780)
Capitella jonesi Hartman, 1959
Mediomastus californiensis Hartman, 1944
Cirratulidae
Chaetozone hystricosus Doner and Blake, 2006
Cirriformia grandis Verrill, 1873
Monticellina baptisteae (Blake, 1991)
*Monticellina dorsobranchialis (*Kirkegaard,1959)
Tharyx acutus Webster & Benedict, 1887
Dorvilleidae
Parougia caeca (Webster & Benedict, 1884)
Flabelligeridae
Pherusa affinis Oken, 1807
Lumbrineridae
Lumbrineris tenuis (Verrill, 1873)
Ninoë nigripes Verrill, 1873
Maldanidae
Clymenella torquata (Leidy, 1855)
Nephtyidae
Nephtys bucera Ehlers, 1868
Nephtys cornuta Berkeley & Berkeley, 1945
Nephtys spp. (juv)
Nereididae
Nereis grayi Pettibone, 1956
Opheliidae
Ophelina acuminate Oersted, 1843
Orbiniidae
Leitoscoloplos robustus Verrill, 1873
Paraonidae
Levinsenia gracilis (Tauber, 1879)
Aricidea catherinae Laubier, 1967
Paranois sp.1
Pholoidae
Pholoe minuta (Fabricius, 1780)
Phyllodocidae
Eteone longa (Fabricius, 1780)
Eulalia viridis (Linnaeus, 1767)
Phyllodoce mucosa Oersted, 1843
Polygordiidae
Polygordius jouinae Ramey, Fiege, and Leander 2006
Polynoidae
Harmothoe extenuata (Grube, 1840)
Harmothoe imbricate (Linnaeus, 1767)
Sigalionidae
Sthenelais limicola (Ehlers, 1864)
Spionidae
Dipolydora quadrilobata Jacobi, 1883
Dipolydora socialis (Schmarda, 1861)
Polydora cornuta Bosc, 1802
Prionospio steenstrupi Malmgren, 1867
Pygospio elegans Calparède, 1863
Spio limicola Verrill, 1880
Spiophanes bombyx Calparède, 1870
Sternaspidae
Sternaspis scutata (Otto, 1821)
Syllidae spp.
Exogone hebes (Webster & Benedict, 1884)

Terebellidae
Polycirrus eximus (Leidy, 1855)
Pista cristata (O.F. Müller, 1776)
Trichobranchidae
Terebellides atlantis Williams, 1984
Oligochaeta
Oligochaeta spp.

ARTHROPODA
CRUSTACEA
Amphipoda
Amphipoda spp.
Ampeliscidae
Ampelisca abdita Mills, 1964
Ampelisca vadorum Mills, 1963
Aoridae
Leptochirus pinguis Stimpson, 1853
Microdeutopus gryllotalpa Costa, 1853
Pseudunciola obliquua (Shoemaker, 1949)
Unciola irrorata Say, 1818
Caprellidae
Aeginella spinosa Boeck, 1861
Corophiidae
Crassicorophium bonelli H.M. Edwards, 1830
Isaeidae
Photis pollex Walker, 1895
Protomedia fasciata Krøyer, 1846
Ischyroceridae
Ischyrocerus anguipes (Krøyer, 1842)
Lysianassidae
Orchomenella minuta (Krøyer, 1842)
Phoxocephalidae
Harpinia propinqua Sars, 1895
Phoxocephalus holbolli (Krøyer, 1842)
Podoceridae
Dulichia facata Boeck, 1870
Dyopedos monacanthus (Metzger, 1875)
Pontogeniidae
Pontogeneia inermis (Krøyer, 1842)
Stenothoidae
Proboloides holmesi Bousfield, 1973
Cumacea
Diastylidae
Diastylis polita (S.I. Smith, 1879)
Diastylis sculpta Sars, 1871
Decapoda
Anomura
Axiidae
Axius serratus Stimpson, 1852
Caridea
Crangonidae
Crangon septemspinosa Say, 1818
Paguridae
Pagurus longicarpus Say, 1817
Cirrepedia
Balanidae
Balanus crenatus Bruguiere, 1789
Isopoda
Idoteidae
Edotia montosa (Stimson, 1853)

MOLLUSCA
Bivalvia
Arcticidae
Arctica islandica (Linnaeus 1767)

Appendix IIIB1.A. (*Continued*). Total HubLine Benthic Infaunal Species List

Astartidae
Astarte undata (Say, 1822)
Cardiidae
Cerastoderma pinnulatum (Conrad, 1831)
Carditidae
Cyclocardia borealis (Conrad, 1831)
Hiatellidae
Hiatella arctica (Linnaeus, 1767)
Lyonsiidae
Lyonsia arenosa Möller, 1842
Lyonsia hyaline Conrad, 1831
Lyonsia spp.
Mactridae
Spisula solidissima (Dillwyn, 1817)
Mytilidae
Crenella decussata (Montague, 1808)
Mytilus edulis Linnaeus, 1758
Nuculidae
Nucula delphinodonata Mighels & Adams, 1842
Petricolidae
Petricola pholadiformis (Lamarck, 1818)
Solenidae
Ensis directus Conrad, 1843
Tellinidae
Tellina agilis Stimpson, 1857
Gastropoda
Neotaenioglossa
Calyptraeidae
Crepidula fornicata (Linnaeus, 1758)
Crepidula spp.
PHORONIDA
Phoronis architecta Andrews, 1890

ECHINODERMATA
Echinoidea
Echinarachnius parma (Lamarck, 1816)

Appendix IIIB1.B. HubLine Benthic Infaunal Species List by Station

Top 9 Dominant Species from Station 1 HUB		
Only 9 dominant species identified		
SPECIES		**%total**
No. of species	32	-
No. of individuals	60.5	-
Lumbrineris tenuis	9.5	0.157024793
Leptocheirus pinguis	8.5	0.140495868
Prionospio steenstrupi	7	0.115702479
Ninoë nigripes	4.5	0.074380165
Aricidea catherinae	4.5	0.074380165
Oligochaeta sp.	3	0.049586777
Polygordius jouinae	2.5	0.041322314
Monticellina dorsobranchialis	2.5	0.041322314
Mediomastus californiensis	2.5	0.041322314
Nephtys cornuta	2	0.033057851
Ampelisca vadorum	2	0.033057851
Tharyx acutus	1	0.016528926
Leitoscoloplos robustus	1	0.016528926
Capitella capitata	1	0.016528926
Tetrastemma spp	0.5	0.008264463
Spiophanes bombyx	0.5	0.008264463
Polydora cornuta	0.5	0.008264463
Phyllodoce mucosa	0.5	0.008264463
Photis pollex	0.5	0.008264463
Ophelina acuminata	0.5	0.008264463
Nucula delphinodonta	0.5	0.008264463
Nephtys bucera	0.5	0.008264463
Mytilus edulis	0.5	0.008264463
Microdeutopus gryllotalpa	0.5	0.008264463
Lyonsia arenosa	0.5	0.008264463
Hiatella arctica	0.5	0.008264463
Harpinia propinqua	0.5	0.008264463
Eulalia viridis	0.5	0.008264463
Dipolydora quadrilobata	0.5	0.008264463
Diastylis sculpta	0.5	0.008264463
Crenella decussata	0.5	0.008264463
Cerebratulus lacteus	0.5	0.008264463

Appendix IIIB1.B. (*Continued*). HubLine Benthic Infaunal Species List by Station

Top 9 Dominant Species from Station 1 OFF		
Only 9 dominant species identified		
SPECIES		**% total**
No. of species	18	
No. of individuals	58	
Nephtys cornuta	13.5	0.2328
Aricidea catherinae	10.5	0.181
Lumbrineris tenuis	9	0.1552
Prionospio steenstrupi	8	0.1379
Ninoë nigripes	6	0.1034
Monticellina dorsobranchialis	2	0.0345
Leptocheirus pinguis	1.5	0.0259
Levinsenia gracilis	1	0.0172
Mediomastus californiensis	1	0.0172
Diastylis sculpta	1	0.0172
Oligochaeta sp.	1	0.0172
Polydora cornuta	0.5	0.0086
Pholoe minuta	0.5	0.0086
Eteone longa	0.5	0.0086
Lyonsia arenosa	0.5	0.0086
Edwardsia elegans	0.5	0.0086
Tetrastemma spp	0.5	0.0086
Micrura spp	0.5	0.0086

Top 10 Dominant Species at 2 HUB		
SPECIES		
No. of species	41	-
No. of individuals	160.5	-
Prionospio steenstrupi	21	0.1308411
Ampelisca vadorum	19	0.1183801
Polydora cornuta	17.5	0.1090343
Aricidea catherinae	14.5	0.0903427
Phyllodoce mucosa	12.5	0.0778816
Lumbrineris tenuis	11.5	0.0716511
Leptocheirus pinguis	7	0.0436137
Ninoë nigripes	5.5	0.0342679
Mediomastus californiensis	5	0.0311526
Monticellina baptisteae	4	0.0249221

Appendix IIIB1.B. (*Continued*). HubLine Benthic Infaunal Species List by Station

Top 10 Dominant Species at 2 OFF		
SPECIES		
No. of species	45	-
No. of individuals	180	-
Leptocheirus pinguis	63	0.35
Monticellina dorsobranchialis	16	0.088889
Ampelisca vadorum	15	0.083333
Aricidea catherinae	12.5	0.069444
Lumbrineris tenuis	11	0.061111
Unciola irrorata	7.5	0.041667
Spiophanes bombyx	7	0.038889
Polydora cornuta	5.5	0.030556
Nucula delphinodonta	5.5	0.030556
Crepidula spp.	4.5	0.025
Phyllodoce mucosa	3.5	0.019444

Top 10 Dominant Species at 3 HUB		
SPECIES		
No. of species	27	-
No. of individuals	128	-
Leptocheirus pinguis	22.5	0.1758
Aricidea catherinae	20.5	0.1602
Spiophanes bombyx	20.5	0.1602
Dipolydora quadrilobata	17	0.1328
Ampelisca abdita	6.5	0.0508
Pygospio elegans	5	0.0391
Paranois	3.5	0.0273
Exogone hebes	3.5	0.0273
Phoronis architecta	3.5	0.0273
Nephtys bucera	3.5	0.0273
Leitoscoloplos robustus	3	0.0234
Clymenella torquata	2.5	0.0195
Crepidula spp.	2.5	0.0195
Phyllodoce mucosa	2	0.0156
Phoxocephalus holbolli	2	0.0156
Tellina agilis	1.5	0.0117

Appendix IIIB1.B. (*Continued*). HubLine Benthic Infaunal Species List by Station

Top 9 Dominant Species at 3 OFF		
Only 9 dominant species identified		
SPECIES		
sandy mud	30	
No. of species	29	
No. of individuals	131	
Pygospio elegans	28.5	0.2176
Dipolydora quadrilobata	25	0.1908
Aricidea catherinae	11.5	0.0878
Spiophanes bombyx	10.5	0.0802
Exogone hebes	3.5	0.0267
Clymenella torquata	2.5	0.0191
Phyllodoce mucosa	2.5	0.0191
Eteone longa	2	0.0153
Eulalia viridis	1.5	0.0115
Polygordius jouinae	1.5	0.0115
Nephtys bucera	1	0.0076
Tellina agilis	1	0.0076
Lyonsia spp.	1	0.0076
Crepidula spp.	1	0.0076
Mediomastus californiensis	1	0.0076
Nereis grayi	1	0.0076
Pista cristata	1	0.0076
Nucula delphinodonta	0.5	0.0038
Tharyx acutus	0.5	0.0038
Polydora cornuta	0.5	0.0038
Cirriformia grandis	0.5	0.0038
Parougia caeca	0.5	0.0038
Leitoscoloplos robustus	0.5	0.0038
Monticellina dorsobranchialis	0.5	0.0038
Ninoë nigripes	0.5	0.0038
Terebellides atlantis	0.5	0.0038
Lyonsia arenosa	0.5	0.0038
Oligochaeta	0.5	0.0038
Crepidula fornicata	0.5	0.0038

Appendix IIIB1.B. (*Continued*). HubLine Benthic Infaunal Species List by Station

Top 7 Dominant Species at 4 HUB Only 7 dominant species were identified		
SPECIES		
No. of species	12	-
No. of individuals	27.5	-
Aricidea catherinae	7	0.2545
Echinarachnius parma	6	0.2182
Chaetozone hystricosus	3.5	0.1273
Astarte undata	2.5	0.0909
Nephtys bucera	2	0.0727
Exogone hebes	1.5	0.0545
Polygordius jouinae	1.5	0.0545
Leitoscoloplos robustus	1.5	0.0545
Phyllodoce mucosa	0.5	0.0182
Crepidula spp.	0.5	0.0182
Monticellina dorsobranchialis	0.5	0.0182
Spisula solidissima	0.5	0.0182

Top 5 Dominant Species at 4 OFF Only 5 dominant species were identified		
SPECIES		
No. of species	16	-
No. of individuals	18.5	-
Aricidea catherinae	4.5	0.2432
Exogone hebes	4	0.2162
Echinarachnius parma	2	0.1081
Polygordius jouinae	1	0.0541
Leitoscoloplos robustus	1	0.0541
Nephtys bucera	1	0.0541
Capitella jonesi	0.5	0.027
Eteone longa	0.5	0.027
Crassicorophium bonelli	0.5	0.027
Monticellina dorsobranchialis	0.5	0.027
Ninoë nigripes	0.5	0.027
Oligochaeta	0.5	0.027
Astarte undata	0.5	0.027
Spisula solidissima	0.5	0.027
Pseudunciola obliquua	0.5	0.027
Cyclocardia boreallis	0.5	0.027

Appendix IIIB1.B. (*Continued*). HubLine Benthic Infaunal Species List by Station

Top 8 Dominant Species at 5 HUB Only 8 dominant species identified		
SPECIES		
No. of species	21	-
No. of individuals	62	-
Aricidea catherinae	19.5	0.3145
Nephtys cornuta	18	0.2903
Leitoscoloplos robustus	3.5	0.0565
Dyopedos monacanthus	3.5	0.0565
Phyllodoce mucosa	3	0.0484
Tharyx acutus	2	0.0323
Ophelina acuminata	2	0.0323
Mediomastus californiensis	1.5	0.0242
Diastylis polita	1.5	0.0242
Prionospio steenstrupi	1	0.0161
Polydora cornuta	1	0.0161
Ninoë nigripes	1	0.0161
Pygospio elegans	0.5	0.0081
Ampelisca abdita	0.5	0.0081
Leptocheirus pinguis	0.5	0.0081
Lumbrineris tenuis	0.5	0.0081
Nephtys bucera	0.5	0.0081
Asabellides ocilata	0.5	0.0081
Photis pollex	0.5	0.0081
Cerebratulus lacteus	0.5	0.0081
Diastylis sculpta	0.5	0.0081

Appendix IIIB1.B. (*Continued*). HubLine Benthic Infaunal Species List by Station

Top 7 Dominant Species at 5 OFF Only 7 dominant species identified		
SPECIES	**5 OFF**	
muddy		
No. of species	20	-
No. of individuals	174.5	-
Nephtys cornuta	141	0.808023
Leptocheirus pinguis	7.5	0.04298
Dulichia facata	3.5	0.020057
Leitoscoloplos robustus	3	0.017192
Diastylis sculpta	3	0.017192
Prionospio steenstrupi	2	0.011461
Eulalia viridis	2	0.011461
Photis pollex	1.5	0.008596
Dyopedos monacanthus	1.5	0.008596
Aricidea catherinae	1	0.005731
Tharyx acutus	1	0.005731
Phyllodoce mucosa	1	0.005731
Crangon septemspinosa	1	0.005731
Ninoë nigripes	1	0.005731
Mediomastus californiensis	1	0.005731
Lumbrineris tenuis	1	0.005731
Harmothoe extenuata	1	0.005731
Polydora cornuta	0.5	0.002865
Capitella capitata	0.5	0.002865
Ensis directus	0.5	0.002865

Appendix IVA.A. Benthic and demersal fish and invertebrate species found at eelgrass sites in Boston Harbor and Nahant.

Fish	Invertebrates
Cyclopterus lumpus	*Amphipod* spp.
Myoxocephalus aenaeus	*Cancer borealis*
Pholis gunnellus	*Cancer irroratus*
Pseudopleuronectes americanus	*Caprella* spp.
Sygnathus fuscus	*Carcinus maenus*
Tautogolabrus adspersus	*Crangon septemspinosa*
	Crepidula fornicate
	Echinaracnius parma
	Homarus americanus
	Libinia emarginata
	Littorina spp
	*Laticidae (*Moon Shell*)* spp.
	Mysis spp.
	Mytilus edulis
	Pagurus spp.

Appendix IVA.B. Infaunal species observed in eelgrass sediment core analysis.
*** = 2006 only; ^ = 2007 only; no mark = both years.**

ANNELIDA
- Oligochaeta
  - Enchytraeidae
    - *Grania longiducta* Erseus & Lasserre, 1976*
    - Oligochaete sp. 1
    - Oligochaete sp. 2
- Polychaeta
  - Capitellidae
    - *Capitella capitata* Fabricius, 1780
    - *Capitella jonesi* Hartman, 1959
    - *Heteromastus filiformis* Claparède, 1864*
    - *Mediomastus ambiseta* Hartman, 1947
    - *Mediomastus californiensis*, Hartman 1944^
  - Cirratulidae
    - *Cirriformia grandis* Verrill, 1873
    - *Chaetozone hystricosus**
    - *Tharyx acutus* Webster & Benedict, 1887
  - Dorvilleidae
    - *Parougia caeca* Webster & Benedict, 1884*
  - Flabelligeridae
    - *Brada villosa* Rathke, 1843*
  - Hesionidae
    - *Microphthalmus pettiboneae* Riser, 2000
  - Lumbrineridae
    - *Lumbrineris tenuis*, Verrill, 1873^
  - Maldanidae
    - *Clymenella torquata* Leidy, 1855
    - Maldanidae sp. 1
  - Nephtyidae
    - *Nephtys buccera*^
    - *Nephtys caeca* Fabricius, 1780
    - *Nephtys discors* Ehlers, 1868*
    - *Nephtys incisa* Malmgren, 1865
    - *Nephtys picta* Ehlers, 1868
    - Nephtys sp. 1
  - Nereididae
    - *Nereis diversicolor* O.F. Müller, 1776
    - *Nereis succinea* Frey & Leuchart, 1847*
    - Nereidindae spp.
  - Orbiniidae
    - *Leitoscoloplos acutus* Verrill, 1873*
    - *Leitoscoloplos robustus* Verrill, 1873
    - *Scoloplos armiger* O.F. Müller, 1776*
  - Paraonidae
    - *Aricidea catherinae* Laubier, 1967
    - *Levinsenia gracilis* Tauber, 1879
  - Pectinariidae
    - *Pectinaria gouldi* Verrill, 1873*
  - Phyllocidae
    - *Eteone longa* Fabricius, 1780
    - *Eulalia viridis* Linnaeus, 1767*
    - *Pholoe minuta* Fabricius, 1780
    - *Phyllodoce mucosa* Oersted, 1843
    - Phyllodoce sp. 1
  - Polygordiidae
    - *Polygordius jouinae* Ramey, 2006
  - Polynoidae
    - *Harmothoe imbricata* Linnaeus, 1767
  - Spionidae
    - *Dipolydora quadrilobata,* Jacobi, 1883^
    - *Polycirrus eximius* Leidy, 1855
    - *Polydora cornuta* Bosc, 1802
    - *Prionospio steenstrupi* Malmgren, 1867*
    - *Pygospio elegans* Calparède, 1863
    - *Spiophanes bombyx* Calparède, 1870
    - *Spio limicola* Fabricius, 1785^
    - *Spio setosa* Verrill, 1873
    - *Streblospio benedicti* Webster, 1879
  - Syllidae
    - *Exogone hebes* Webster & Benedict, 1884
    - *Proceraea cornuta* Agassiz, 1862^
    - Syllid sp. 1*

ARTHROPODA
- Malacostraca
  - Ampeliscidae
    - *Ampelisca abdita* Mills, 1964
    - *Ampelisca vadorum* Mills 1963^
  - Aoridae
    - *Leptocheirus pinguis* Stimpson, 1853
    - *Microdeutopus anomalous*^
    - *Microdeutopus gryllotalpa* Costa, 1853*
    - *Unciola irrorata* Say, 1818
    - Unciola sp.
  - Cancridae
    - *Cancer borealis* Stimson, 1859^
    - *Cancer irroratus* Say, 1817*
  - Caprellidae
    - *Aeginina longicornis* Krøyer, 1842^
    - *Caprella unica* Mayer, 1903*
  - Corophiidae
    - Corophiidae sp.
    - *Crassicorophium bonelli* H.M. Edwards, 1830
    - *Crassicorophium crassicorne* Bruzelius, 1859
    - *Monocorophium sextonae* Crawford, 1937
  - Crangonidae
    - *Crangon septemspinosa* Fabricius, 1798
  - Dexaminidae
    - *Dexamine thea* Boeck, 1861^
  - Diastylidae
    - *Diastylis sculpta* Sars, 1871^
    - *Oxyurostylis smithi* Calman, 1912*
  - Idoteidae
    - *Idotea balthica* Pallus, 1772
    - *Idotea phospohorea* Harher 1873^
  - Isaeidae
    - *Photis pollex* Shoemaker, 1945^
  - Ischyroceridae
    - *Jassa marmorata* Holmes, 1903
  - Liljeborgiidae
    - *Listriella barnardi* Wigley, 1963*
    - *Listriella clymenellae* Mills, 1962^
  - Mysidae
    - *Mysis stenolepsis* Tyler, 1973^
    - *Neomysis americana* S.I. Smith, 1873*
  - Phoxocephalidae
    - *Eobrolgus spinosus* Holmes, 1903*
    - *Phoxocephalus holbolli* Kroyer, 1842

CHORDATA
- Ascidiacea
  - Stolidobranchia
    - *Molgula arenata* Stimpson, 1852*

MOLLUSCA
- Bivalvia
  - Lyonsiidae
    - *Lyonsia arenosa* Moller, 1842^
    - *Lyonsia hyalina* Conrad, 1831^
    - Lyonsia sp. 1
  - Myidae
    - *Mya arenaria* Linnaeus, 1758

Appendix IVA.B (*Continued*). Infaunal species observed in eelgrass sediment core analysis. * = 2006 only; ^ = 2007 only; no mark = both years.

Mytilidae
Mytilus edulis Linnaeus, 1758
Pharidae
Ensis directus Conrad, 1843*
Tellinidae
Tellina agilis Stimpson, 1857
Thraciidae
Thracia conradi Couthouy, 1839*
Gastropoda
Calptraeidae
Crepidula fornicata Linne, 1758^
Crepidula sp. 1*
Littorinidae
Lacuna vincta Montagu, 1803
Nassariidae
Ilyanassa trivittata Say, 1822
Phoronida
Phoronidae
Phoronis psammophila Cori, 1889 aka *Phoronis architecta* Andrews, 1890^

SIPUNCULA
Sipunculida
Sipunculidae
Phascolopsis gouldi Pourtales, 1851

Appendix IVB.A. Artificial Reef Design

Reef Design Characteristics

Six rectangular 400-m^2 plots (10 m x 40 m) arranged in three parallel arrays and three rectangular 400-m^2 (10 m x 40 m) control plots without reefs were planned within the reef footprint (Figure A1). The actual reef substrate encompassed a total area of 2400 m^2, while 1200 m^2 remained undisturbed as designated control areas. Reef and control plots were separated by 10 m on all dimensions to minimize the total footprint necessary for reef installation and to facilitate ease of sampling. The entire footprint (including spacing, reef and control areas) was 7000 m^2 in size. The size of the cobble/boulder area (2400 m^2) is twice that of successful cobble reefs deployed in Boston Harbor (Sculpin Ledge) and in Narragansett Bay, Rhode Island. The reef arrays were situated perpendicular to the prevailing current to promote larval transportation and food delivery to other reef dwellers.

Four rock sizes were used to construct the reef: 6 - 11 cm cobble, 12 - 25 cm cobble, 30 - 45 cm boulders and 50 - 75 cm boulders (lengths refer to diameter of individual rocks). Rock sizes were assigned to target different phases of lobster and fish (Cobb 1971; Dixon 1987; Wahle 1992; Wahle and Steneck 1992; Dorf and Powell 1997; Tupper and Boutilier 1995 and 1997; Bigelow and Schroeder 2002; Pappal et. al. 2004). Rocks were separated by size, and arranged in a graduated fashion within each plot (Figure A1). Each rock size was represented equally within the total placement area.

Locations of individual reef unit and control area within the total reef footprint were determined by random number assignment. The design of the reef allows for hypothesis testing among reef units and between reef and control units. In addition, the separation of rock sizes within each reef unit permits hypothesis testing based on rock size. This experimental design will provide researchers with the ability to compare species densities and diversity among reef units and reference sites and among rock sizes.

Reef Construction

Upon completion of the site selection process, *MarineFisheries* solicited bids from independent contractors for reef construction. After meeting with RDA Construction to discuss methods and costs, we selected RDA Construction Corp. as our general contractor.

In the contract, RDA was responsible for obtaining clean reef materials from local quarries. The quarry rocks were blasted cobble and boulder. All rocks were cleaned of silt and sediment outside of coastal resource areas prior to transportation and installation. *MarineFisheries* expected at least 95% of the cobble and boulder material to be within one of six specified size categories. *MarineFisheries* independently inspected reef materials to ensure adherence to rock size specifications prior to deployment on the site. In addition to deploying the reef units accurately and according to the contracted dimensions, RDA Construction Corp. was also responsible for transporting all materials to the site and coordinating a post-construction side-scan sonar survey. According to the contract, *MarineFisheries* was responsible for obtaining all necessary permits and conducting independent surveys to verify correct reef placement.

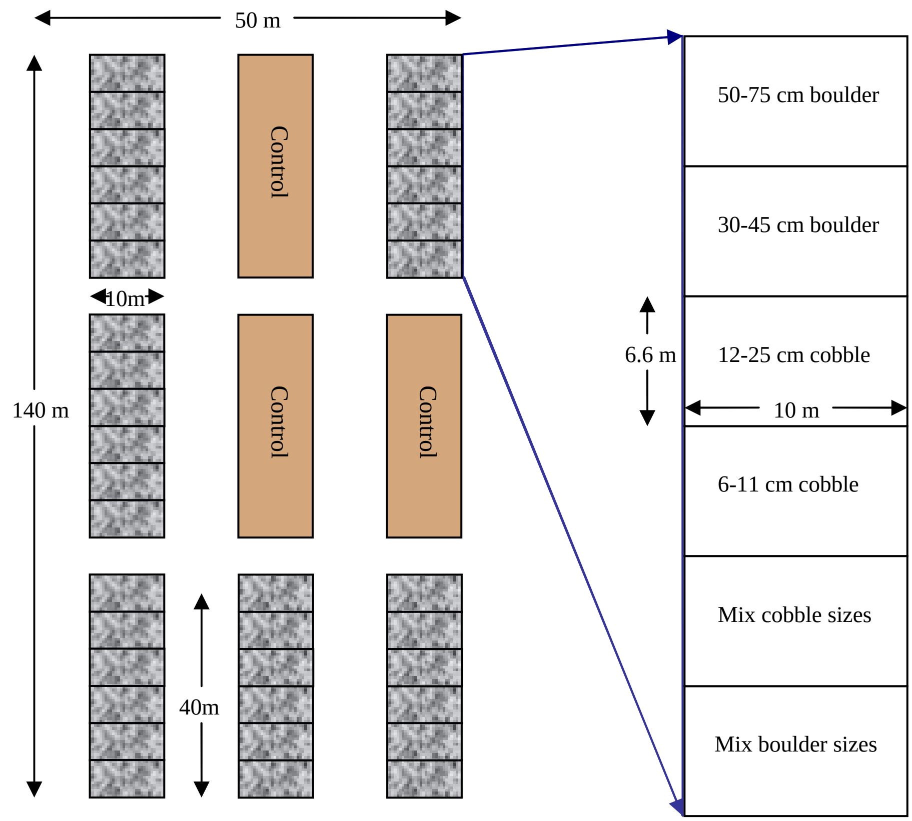


Figure A1. Artificial reef design.

MarineFisheries required that construction start by March 1, 2006 and be complete by April 15, 2006 in order to comply with time-of-year (TOY) construction limits that are normally assigned to marine construction projects in Massachusetts Bay. These TOY limits were not assigned to *MarineFisheries* in the permitting process; however, because we are a state environmental agency, we self-imposed these TOY work windows in order to avoid impacting aquatic resources and habitat. Winter construction also minimized user conflicts because lobstermen generally fish less intensively in the winter. Construction in March and April allowed for the reef to develop significant invertebrate and algal growth during the spring of 2006, which could encourage larval lobster and finfish settlement on the reef during its first year of deployment. Another advantage of winter construction was that it minimized impacts to spawning migrations of finfish and periods of shellfish and lobster spawning activity.

Construction required the precise placement of rocks by size within each reef footprint. The rocks were separated by size, and arranged in a graduated fashion within each plot so that each rock size contributed equally to the total placement area. RDA construction used a dump scow to build the reef according to the desired dimensions (40 m x 10 m for each reef unit). The dump scow had six pockets and due to loading safety requirements, each of the six pockets was filled with stone so that the rock weight would be evenly distributed throughout the barge. The following rock sizes (estimated diameter lengths) were assigned to each of the six sections: (1) 50 - 75 cm boulder, (2) 30 - 45 cm boulder, (3) 12 - 25 cm cobble, (4) 6 - 11 cm cobble, (5) mix of 6 - 11 cm and 12 - 25 cm cobble, and (6) mix of 30 - 45 cm and 50 - 75 cm boulder (Figure 17). Thus, each reef unit was composed of six smaller sections of individual rock sizes (Figure 17). The six 6.6 m x 10 m pockets of rock were dropped at the same time alongside one another to create each 40 m x 10 m reef unit. The total volume of rock used to construct the reef was 1153 m^3 (192 m^3 per reef unit).

Construction began in early March 2006. *MarineFisheries* employees monitored all construction activities to ensure compliance with permit requirements. We conducted site visits to RDA Construction's staging area to measure the rocks and check the cleanliness of rocks. RDA met the contracted rock dimension requirements for all rock sizes but the largest boulders. Diameters of the largest boulders exceeded the planned maximum size. To prevent additional delays to a project already behind schedule due to various problems that RDA encountered, the larger rocks were approved. *MarineFisheries* concluded that the larger boulders would not compromise the value or function of the reef. The larger rocks will create more relief and potentially attract more fish to the reef area than the rock sizes originally planned and were not a navigation hazard. All rocks met the required cleanliness prior to construction.

The first reef unit was constructed on March 23, 2006, and the five remaining reef units were built in the following weeks. The last reef unit was dropped on April 11, 2006. Construction was considered to be complete at this point. Throughout the construction period, *MarineFisheries* divers inspected each reef after it was dropped on site. All dimensions were within 25% of the original specifications and the reef units were positioned according to the contracted coordinates for each.

Appendix IVB.B. Site Selection and Monitoring Protocols

Introduction

The purpose of this appendix is to provide a detailed supplement to the methods described in Chapters 1 and 2. These protocols are intended to provide the reader with sufficient detail as to directly replicate our site selection and field monitoring methods.

SITE SELECTION PROTOCOLS

Identifying Potential Site Locations Using GIS

Initial GIS Analysis

Prior to beginning field work, a simple model was developed to select potential sites for habitat enhancement using ESRI's ArcGIS 9.0 mapping software. Three parameters were selected for use in our model: substrate, bathymetry, and proximity to the pipeline. These data layers were coded to represent prime, potential, and unsuitable areas for habitat enhancement and multiplied together to create a single layer map. The commands used to reach the final product of the map are included below:

Sequence of Commands Used to Reach the Final Analysis:

1. Buffered the HubLine by 22.7 m and 304 m to create a "nearby" buffer zone and a "maximum width" buffer zone.
2. Dissolved the HubLine to create one solid polygon for both buffered layers.
3. Created a new field in the substrate data layer called "ReefSubstrateSelection."
4. Used "symbol" in substrate to create new attributes: PoorSediment (combined the Erosion Nondeposition 4 with Deposition), PrimeSediment (Erosion Nondeposition 3), OKSediment (Sediment Reworking), Islands, Water/Other (Figure B1).
5. Dissolved on these new attributes.
6. Clipped bathymetry polygon with both new HubLine polygons.
7. Clipped sediment polygon with both new HubLine polygons.
8. Converted new clipped polygons to raster dataset with 10-m^2 cells – the bathymetry data was converted on "depthrange" and the substrate data was converted on "reef substrateselection."
9. Used the "reclassify" command in spatial analyst to reclassify the grid substrate types into the following numbers:
   PoorSediment = 0
   Islands = 0
   Water/Other = 0
   OK Sediment = 1
   PrimeSediment = 2
10. Used "reclassify" command in spatial analyst to reclassify the grid bathymetry types into the following numbers:
    5 through -10 m = 2
    10 through -15 m = 1
    all other depths = 0
11. Used raster calculator to multiply the two grids and their new classifications together to obtain a final output of areas for potential habitat enhancement sites.
    Final output:
    0 = unsuitable
    1= potential
    2 = suitable
    4 = prime

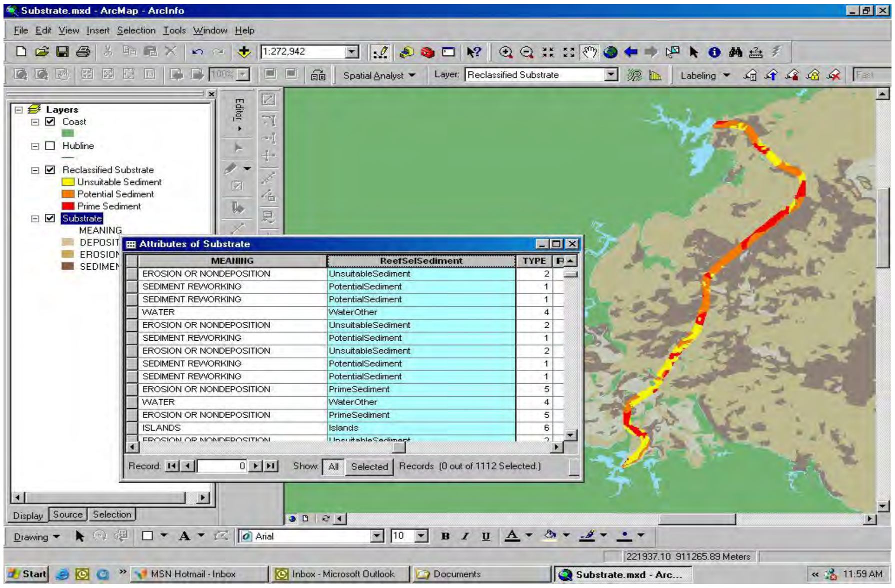


Figure B1. Image of the sediment reclassification process in ArcGIS 9.0.

The results of this model allowed us to identify four prime locations for potential reef sites (29.6 acres total prime area) off of Boston, Hull, Marblehead, and Beverly, Massachusetts. Within these areas we selected a total of 24 sites (and five alternate sites) that occurred within 304 m of the HubLine pathway. The 24 potential site polygons and five alternate site polygons were drawn in GIS, and waypoints corresponding to these polygons were gathered. Through the use of GIS, we were able to eliminate 80% of potential reef area prior to field assessments.

Field Assessments of Potential Site Locations

Depth and Slope Data

After completing the initial selection process using ArcGIS, *MarineFisheries* collected bathymetry data in the field at each of the 24 potential sites. These data were used to verify the GIS model and calculate slope. Four buoys, each with 21 m of line and a weight, were used to mark the corners of each 50 x 140-m reef footprint. The following steps describe the methods used to collect depth data:

1. Boat started at one corner of a footprint, marked with a buoy (Figure B2).
2. While keeping a constant rpm, boat operator headed towards the next corner marked with a buoy.
3. Using a stopwatch, depth (as read on the sounder) was recorded every 10 seconds until the next corner was reached.
4. This process was repeated for each corner and once down the center length of the footprint. The boat was always driven lengthwise in the same direction when data were being collected.

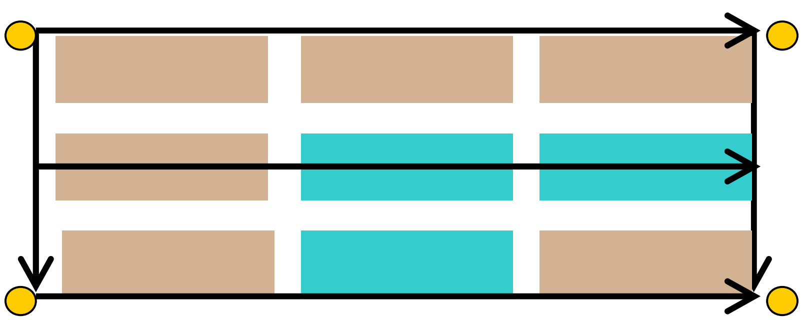


Figure B2. Example of the boat's movement over a potential site footprint while depth data were collected.

The depth data were analyzed using the following methods:

1. Depth was adjusted to account for tidal stage.
2. Slope (or the angle of inclination) was determined by calculating the difference between depths of measured points and the distance between those points (a right triangle), then taking the arctangent of the lengths to determine the angle.
3. Sites that were too deep or shallow (< 5 m or > 15.1 m) (according to our criteria) and sites that had slopes over 5º were eliminated from further consideration.

Substrate Data

Underwater surveys were conducted to determine the stability of the substrate at each site, as well as to classify and quantify the substrate at a finer scale. We qualitatively collected data on species abundance and diversity during these dives. These data allowed us to avoid placing the reef on pre-existing productive habitat and ensured that the reef would be placed on substrate that was expected to be strong enough to prevent the reef from descending into the sediment. GIS was used to determine our start and end waypoints for deploying 50-m transects for data collection on each site. We deployed two transects (A and B) from the boat at each potential reef site (Figure B3). Transects were placed across the potential reef footprint on a 45º angle to cover as much area as possible in two dives. Duration of the transect dives ranged from 15 - 40 minutes depending on the complexity of the habitat. A third diver videotaped the substrate along the transects. The following sections outline the steps necessary to collect these data on the potential sites.

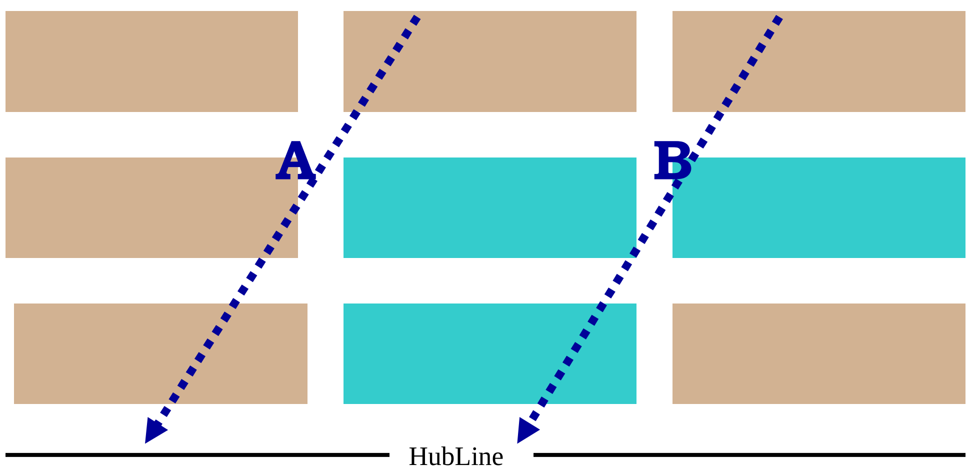


Figure B3. General transect direction and placement on a potential reef site.

<u>Deploying the Transect</u>

1. Required equipment: one 50-m sinking line marked every 5-m with flagging tape labeled with the meter mark, two 9-kg weights, and two surface buoys with enough line to reach from the surface to the bottom. The buoys and their surface lines were attached to the 9-kg weights. The weights were then attached to either end of the transect. Once the gear was attached, the surface lines and transect line were one continuous line, with weights at the start and end of the transect.
2. Using the GPS unit on the boat, we navigated to the starting waypoint for the transect.
3. Once on the waypoint, we dropped the 9-kg weight (with the surface buoy and transect tape attached) to mark the start of the dive/transect.
4. The transect line was fed out of the boat as we headed on the bearing that was necessary to set the transect on a 45º angle over the potential reef site (Figure B3). This bearing took us directly toward the end waypoint of the transect.

5. Once the transect line was taught, the other attached 9-kg weight (and surface buoy) was thrown in, marking the end of the transect. The waypoint where the weight was dropped was recorded in case there was discrepancy between the planned and actual ending waypoints.

<u>50-m Transect Surveys</u>

1. Divers descended on the origin buoy of the transect line to begin collecting data at the 0-m mark. If the current direction required it, divers would go down the buoy marking the end of the transect and work backwards. Before starting the data collection, divers usually set up current-assessment devices (see section below for this methodology). Once these instruments were arranged, divers began the transect dive. Equipment needed for the dive:
    a. Underwater slates
    b. "Substrate Swath Datasheet" (Appendix C)
    c. 2-m long PVC bar called the "swath bar"
2. Following the datasheet, divers would collect the starting depth and conduct the "hand burial test" at the 0-m mark
    a. *Depth*: Divers recorded depth from their dive computer. This depth was corrected for the tide MLW (date and time of dive was recorded on datasheet.
    b. *Hand Burial Test*: The diver made a fist and attempted to press their hand deep into the substrate. This method allowed us to obtaining a general idea of the strength of the substrate and whether or not the reef would sink into the sediment. Hand burial depth was coded as such:

        1 = Hand remains on surface
        2 = Half or whole hand buried
        3 = Hand and full wrist buried
3. From the 0-m mark, divers swam along the transect, with one diver on each side of the transect. Data were collected in 5-m swaths (essentially a 2 x 5-m quadrat). The first "swath" began at the 0-m mark and ended at the 5-m mark. Divers swam slowly along the transect holding the swath bar out in front of them to provide a 2-m width reference point and at the end of each 5-m section, record the substrate observed. Substrate data was coded by the following categories:
    a. *Primary substrate* = > 50% coverage. The primary substrate was the most common surficial substrate type, NOT the underlying substrate. Divers recorded the primary substrate as the rock type that covered more than 50% of the area. Underlying sand was recorded in the underlying substrate category (below).
    b. *Secondary substrate* = 10 - 50% coverage. This could be the same as the primary if the majority of the substrate was all the same type. For example, if a 2 x 5-m swath consisted of 95% sand and 5% shell litter - both the primary and secondary substrates were recorded as sand, while the shell litter was recorded as tertiary.
    c. *Tertiary substrate* = < 10% coverage. This category represented everything EXCEPT the primary and the secondary. For example, if one cobble was in a swath – it was recorded as a "tertiary" because it made up < 1% of the area.
    d. *Underlying substrate* = This was the type of substrate found underneath the surficial substrates. Rocks were lifted up or we shallowly dug underneath the sand or shell litter to identify the substrate below.

Substrate types were defined by the Wentworth Scale (Wentworth, 1922) as the following:

<u>Sediment Key</u>
BE = Bedrock
BO = Boulder (> 25.1 cm) head size or greater
CO = Cobble (6.1 – 25 cm) billiard ball to head size
PE = Pebble (0.5 – 6 cm) pea size to billiard ball
GR = Granule (0.2 – 0.4 cm) bee-bee size to pea size
SA = Coarse sand and find sand (bee-bee size to salt/sugar grain)

SD = Shell debris (broken-up shell fragments)
SH = Shack (whole or half shells)
CL = Clay
SI = Silt
Underlying = sediment underneath other substrate

4. In addition to collecting substrate, depth, and hand burial data, divers collected information on species sighted along the transect. Lobsters and other macrofauna were counted to qualitatively assess marine life on these transects. Divers also mentally noted all species (plant and animal) seen on the transect and recorded their presence/absence after completing the dive.
5. If wave ripples in the sand were present, they were noted on the datasheet as an indicator of wave action. Divers attempted to assess the height of the sand ripples.
6. Video data was collected whenever possible by a third diver over the entire length of the transect.
7. Upon completion of the dive, divers would complete a "Site Selection Presence/Absence Datasheet" (Appendix C). For algae, percent coverage across the entire transect was estimated. If algae were drift, divers recorded the percent coverage but made a note that the algae was drifting. For animals, divers estimated the count of all individuals of a particular species observed. Any species that were not listed on the datasheet but seen were written in on the datasheet.

Site Scoring and Weighting

In order to rank the remaining potential sites, *MarineFisheries* developed a weighting system to incorporate multiple aspects of the site selection criteria. Data used in this portion of the analysis included: primary and secondary surficial substrate, underlying substrate, sand ripple presence (an indicator of wave action), site proximity to the HubLine, and site proximity to cobble fill points along the HubLine. Although tertiary substrate data was collected, it was not used in these analyses due to their low percent coverage on the potential sites.

A six step approach was followed for this analysis:

1. For each potential site, a numerical score was assigned to every data category based upon how well the site met the selection criteria. The numerical scores ranged from 1 (poor site potential) to 3 (prime site potential). Categories possessing more than one type of classification (i.e. surficial substrates) were weighted by the areal proportion of that classification using the assigned numerical score.
2. An objective weighting system was developed where a percentage value was assigned to each data category based upon the relative importance of each criterion to the project objectives.
3. The numerical scores were "weighted" by multiplying the final score for each data category by the category's assigned percentage.
4. Final weighted scores from were summed for each site.
5. Sites were ranked, where sites with the highest scores had the majority of the required physical attributes for site selection.
6. Species presence/absence data were taken into account following the ranking analysis. These data could not be included in the ranking analysis because they were qualitative.

<u>Site Scoring</u>

For each site, a numerical score was assigned to every data category based upon how well the site met the selection criteria. Numerical values were used to represent prime (3), potential (2), or poor (1) suitability for reef placement. The following methods were used to assign these scores to the data:

Sediment data

Each site was classified by the primary, secondary, and underlying sediment types recorded in the area. Sediment types included boulder, cobble, pebble, granule, sand, shack (whole shells), shell debris, and silt. Sites with pebble, granule, sand, shack, or shell debris were preferred because these substrate types are more capable of supporting the weight of a reef and naturally tend to have lower species diversity than cobble or boulder.

Primary sediment data - Primary sediment types were assigned the following numerical categories based on their ability to support the weight of a reef and expected species abundance and diversity:

Category rating levels:

1 = Poor: boulder, cobble and silt
2 = Potential: mixed flat cobble
3 = Prime: pebble, granule, sand, shack, and shell debris

Secondary sediment data - Secondary sediment types were assigned the following numerical categories based on their suitability for reef placement:

Category rating levels:

1 = Poor: boulder and silt
2 = Potential: cobble
3 = Prime: pebble, granule, sand, shack, shell debris, and hard clay

Underlying sediment data - Underlying sediments included hard clay, soft clay, granule, sand, and silt. Underlying sediment types were assigned the following numerical categories based on their suitability for reef placement:

Category rating levels:

1 = Poor: soft clay and silt
3 = Prime: hard clay, granule, and sand

Each sediment proportion was multiplied by the assigned category rating of 1, 2, or 3. These values were then summed to provide a final underlying sediment rating for that site.

Sand ripple / wave action

The presence of sand ripples on a site was presumed to indicate areas of high wave energy which may be detrimental to reef placement. Therefore, sites were classified as either (3) low energy = no sand ripples, (2) moderate energy = small sand ripples (2.5 – 13 cm height) or (1) high energy = large sand ripples (> 13.1 cm height).

Proximity to HubLine

Sites that were closer to the HubLine were preferred. Therefore, sites were classified as either (3) adjacent to the HubLine pathway (< 30 m), (2) near the HubLine (30 – 152 m), or (1) far from the HubLine (152.1 – 304 m).

Proximity to fill points

Sites that were closer to fill points were preferred. These cobble fill points along the HubLine provided an area to compare the settlement and succession of species on cobble deployed two to three years prior to the artificial reef. Sites were classified as either (3) adjacent to a fill point (< 30 m), (2) near a fill point (30 – 152 m), or (1) far from a fill point (> 152 m).

<u>Assigning the Scale</u>

Each variable described above was weighted on a percentage scale according to its relative importance to the project objectives (Table B1). The primary substrate variable was assigned the largest weight at 50% because this substrate would need to support the majority of the reef's weight and would have the most impact on existing species. If the potential site had a high percentage of poor reef substrate this weighting category would automatically rank the site much lower than a site with mostly prime reef substrate. The other two substrate categories were assigned weights of 15% to represent their importance in supporting the weight of the reef, as well as avoiding productive habitat. A weight of 10% was assigned to the presence of sand ripples as an indicator of wave action in the area. Although this variable was not as crucial as substrate type, it was important to take wave action into account in terms of its ability to dislodge or bury the reef. It should be noted that wave action was previously taken into account by ensuring that the potential reef sites were located at depths > 5 m. Finally, proximity to the HubLine and fill points received 5% weighting to account for our goal to place the reef near these areas if all other site selection criteria were met.

Table B1: Weighting categories

Variables	Weight
Primary substrate	50%
Secondary substrate	15%
Underlying substrate	15%
Wave action	10%
HubLine proximity	5%
Fill point proximity	5%

Weighting and Summing the Scores
Numerical scores from each potential site's data categories were "weighted" by multiplying the score by the category's assigned percentage. Final weighted scores were then summed for each site.

Ranking the Sites
Scores of all 14 sites were ranked (Table 1.4 in Chap. 1). Sites with the highest scores best exhibited the physical attributes targeted for reef development Prior to making another round of site eliminations based on the ranking analysis, species presence and absence were taken into account.

Species Presence/Absence
Upon completion of the weighted ranking analysis, biological factors at the potential reef areas were considered. Species presence/absence data collected on each transect dive were reviewed. The number of species present on each site were standardized by the number of transects completed per site. This information was used to determine which sites to eliminate based on concerns of impacts to sites with relatively high species abundance or diversity.

Water Flow and Current Direction
Two underwater methods were used to evaluate current with respect to strength and direction. We constructed a current-direction meter to identify the predominant current direction at each of the potential sites. The predominant current direction was then compared to the site's orientation. If a site's rectangular footprint was not already perpendicular to the predominant current, it was shifted to be perpendicular. A flowmeter (General Oceanics) was also used to collect data on the water flow at the site.

Assessing Current Direction
We designed a simplistic low-cost instrument to evaluate current direction. The instrument assessed current direction in the north/south, east/west, northeast/southwest, and northwest/southeast directions.

1. Specifications of the Predominant Current Direction Indicator (PCDI)
    a. A thick cement base (43 x 43 x 12 cm) was set with a central vertical rebar stake attached to an internal rebar frame and a vertical eye bolt in each corner (Figure 1.4 in Chap. 1).
    b. Four 7.6-cm wide PVC pipes were cut to 30 cm long. Two small holes were drilled halfway down the length of the pipe on the top and bottom of each pipe (these were eventually used to suspend the plaster blocks inside the tube). The pipes were fastened, with the holes easily accessible, to the rebar stake with plastic-coated wire mesh, similar to what is used to make lobster traps. Each pipe faced a different direction: north/south, east/west, northeast/southwest, and northwest/southeast.
    c. In order to deploy and retrieve the PCDI, a rope bridle was attached to the eye bolts, which was long enough to avoid the PVC pipes.
    d. Plaster of Paris was poured into ice-cube trays with a wire penetrating the centers through the tray (a small hole was made in the bottom of each "cube mold") (Figure B4). The plaster was allowed to dry for four days. These blocks are commonly used by biologists

to obtain a relative estimate of water motion by measuring the starting and ending weight of the blocks once they have been exposed to water (Doty, 1971).

e. Dry blocks were weighed and filed to a weight between 30-33 grams. Final weights were recorded to the nearest tenth of a gram.

Figure B4. Making the plaster blocks for the predominant current direction meter.

2. Deploying the Predominant Current Direction Indicator
    a. Prior to deployment, blocks were suspended in each pipe on the PCDI (through the holes that were drilled in the PVC) using the wire in each cube, secured so that the blocks did not touch the sides of the tubes. Starting weights of each block and compass directions of each tube were recorded on the "Current Datasheet" (Appendix C).
    b. The PCDI was deployed along with two cinder blocks. One cinder block was used to suspend the flowmeter (explained below) and the other block weighted a surface buoy. The surface buoy marked the location of the equipment for easy retrieval.
    c. To deploy the PCDI, two 4.5-m lines (to be used as search lines) were attached to the eye bolts on opposite corners. Separate from the PCDI, the two cinder blocks were tied together for deployment with a short line and a surface line was attached to one cinder block. One of these cinder blocks had a small subsurface buoy on a 1-m long line attached to it. The PCDI was lowered on a separate surface line. A waypoint was recorded when the equipment reached the bottom.
    d. Divers positioned the PCDI on the bottom so that the uppermost PVC tube faced north/south and the compass-direction of each tube was recorded (on the "Current Datasheet"). The flowmeter was suspended between the cinder block and a subsurface buoy (floating about 1 m off the bottom). The bottom "search lines" were used to help locate the equipment during retrieval dives. Equipment needed to be placed far enough away from one another to avoid entanglement of lines during strong currents or storms.
    e. Two to three days later, divers collected the equipment. Waiting longer to retrieve the PCDI could have resulted in the complete dissolving of the block and loss of data.
3. Analysis of Current Direction
    a. Blocks were weighed pre- and post-deployment to determine relative dissolving rates. Blocks were weighed only after they had been given sufficient time to dry out in the same place where there were originally weighed (for similar humidity, etc). It usually took about four days to completely dry the blocks before weighing them. The block with the greatest dissolving rate indicated which tube was facing the predominant water current.

Upon completion of this analysis only one of our potential site footprints (Site 6 in Marblehead) had to be rotated in order for the reef to be oriented perpendicular to the predominant current. This orientation was preferred to optimize larval settlement. This site footprint was altered and further analyses on Site 6 were conducted using the new orientation.

<u>Measuring Flow</u>

Due to a defective flowmeter, data collected were not used but the methods are described below:

a. The flowmeter was attached to a cinder block with brass swivel-clips such that it could rotate in both the clockwise and counter-clockwise directions to face the current.
b. A subsurface buoy was attached to the dorsal surface of the meter and was used to suspend the flowmeter in the water column.
c. Start number was recorded after set-up; end number was recorded upon retrieval.

Larval Settlement Collectors

Larval Settlement Collector Specifications

1. A lobster trap building company was contracted to build 30 ½-m^2 collectors. Collectors were made from 3.8-cm coated wire and had open tops. They had the following dimensions: 0.7 m length x 0.7 m width x 0.3 m height (Figure B5).
2. Sides of the collectors were reinforced with a wooden frames secured with rubber strips (screwed into the wood with stainless steel screws) (Figure B5).
3. The bottom of the collectors were lined with Astroturf as an impermeable "substrate" that also provided some relief.
4. Collectors and Astroturf were left outside in a parking lot exposed to weather for one month in June, prior to deployment to reduce chemical residues and scents that lobsterman believe can decrease lobster catches.
5. Just prior to deployment, approximately 68 kg of cobble (5 – 25-cm diameter pieces) was placed into each collector. Rocks had been previously sorted (haphazardly) into 68-kg piles in fish totes, such that one fish tote carried the amount of rocks needed for one collector. This allowed us to easily move the rocks onto the vessel for collector deployment and placed most of the weight strain on fish totes, rather than the collectors.

Figure B5. Settlement collector ready to be filled with cobble and deployed

Collector deployment – A lobsterman was contracted to assist us in deployment and retrieval of the collectors because the weight of each collector (about 68 kg) required a heavy, stable platform and davit. The lobster boat provided deck space needed to conduct diving operations in addition to collector deployment and retrieval. Collectors were deployed in July to capture lobster settlement which was likely to occur in August. We expected that the extra few weeks soak time would allow the rocks to become slightly fouled and the collector habitat to be more desirable to larvae. In the future, we suggest placing a unique ID on each collector prior to deployment and recorded that ID along with the collector's deployment waypoint. The IDs would have made it easier upon retrieval, to determine which collectors had been recovered and which required search dives.

When the collectors were deployed, search lines were laid out between each collector such that during the retrieval work divers could follow search lines from one collector to another. Laying line on the seafloor in this area was problematic because of the concentrated lobster fishery in Massachusetts Bay. We did not want our lines to be directly attached to the collectors, in case a fisherman grappled in the area for a lost trawl. If he/she caught the search lines attached to the collectors, there was potential for the collectors to be flipped or moved. Therefore, the system we developed allowed us to set unattached search lines on the bottom. If a search line was lost under this system, the collector presumably would not be moved and divers could conduct a search dive on the collector's waypoint. Surface buoys were not used because of the likelihood that they would be moved or lost.

1. Equipment needed for settlement collector deployment at each site:
    a. 10 settlement collectors
    b. 10 surface lines about 18 m in length with an attached white buoy – each buoy had a unique number written clearly on it (1-10)
    c. 10 subsurface buoys
    d. 10 screw anchors or sand augers
    e. 3 coils of 160 m sinking line
    f. 14 plastic garden stakes
    g. 3 mesh gear bags
    h. 1 "Pendant Hobo" temp/light logger (Onset Corp.)
2. Surface preparation:
    a. Collectors were set in three long rows along the length of the 50 x 140 m reef footprint. The two outside rows had three collectors, while the inside row had four collectors (Figure B6). One row was set at a time on the waypoints that were selected (using GIS).
    b. Rocks were loaded into the collectors from the fish totes and the 10 loaded collectors were laid out on the deck of the vessel.
    c. Surface lines with their numbered buoys were tied onto the collector's bridles in a manner that set the collectors in order of their deployment (collectors #1, 2, 3 for the first line; 4, 5, 6, 7 for the middle line and; 8, 9, 10 for the last line).
    d. The "Pendant Hobo" temp/light logger was attached to one collector per site and the unique number of the collector carrying the logger was noted.
    e. One subsurface buoy was tied to the side of each collector with a bowline knot.
    f. A gear bag was attached to collector #1 containing three sand anchors, four garden stakes, and a rubber mallet for pounding stakes into the substrate. One gear bag was placed on each collector that started off the three-collector lines. For example, using Figure B6, collectors #1, 4, and 8 had gear bags attached to them before being deployed. For the line consisting of four collectors (starting with collector #4) the gear bag was packed with four sand anchors and six garden stakes.
    g. Collectors were carefully lowered one at a time on the designated waypoint.
    h. A waypoint was recorded for each collector when it reached the bottom in case the boat had drifted off the original waypoint. Exact coordinates were essential for reducing dive time if a search dive was needed to find a collector.
3. Setting-up collectors and search lines underwater (Figure B6)
    a. Divers found the gear bag containing the screw anchors, rubber mallet, and the garden stakes and screwed in a sand anchor next to the collector. The subsurface buoy was detached from the collector and retied to the sand anchor. The subsurface buoys were a

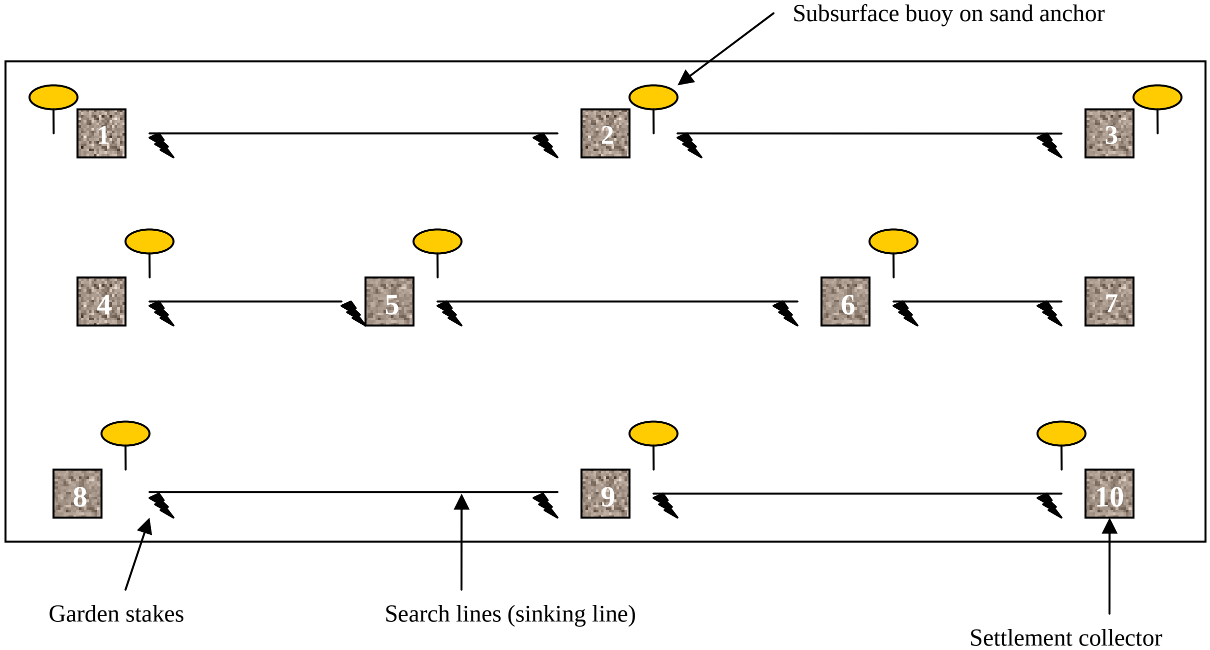


Figure B6. Arrangement of settlement collectors and search lines on a reef site footprint once divers completed equipment set-up.

search tool because they were easier to spot on dives than the low-lying collectors that blended in with the substrate.

b. The surface line was detached from the bridles and bridles were placed underneath the collector to keep the line from interfering with the open surface of the collector.
c. A series of search lines were deployed to aid in the east of settlement collector retrieval. Sinking search lines were attached to the seafloor between each collector (Figure B6). A garden stake was placed close to the first collector and the search line was attached. At the next collector another stake was placed and the line leading from the first collector was attached. The diver then went to the other side of the collector and drove another stake in, and repeated the process (Figure B6).

Settlement collector retrieval – Retrieval took place in mid-to late-September, after the majority of lobster settlement had occurred in Massachusetts Bay.

1. Equipment needed for retrieval:
   b. 10 lines with attached surface buoys.
   c. Mesh coverings large enough to wrap around the collectors completely without interfering with the bridle lines (Figure B7). Mesh coverings were used to prevent escapement of plants and animals in the collector during recovery.
   d. Eight bungee cords (two per collector). Each cord long to wrap around half the collector.
   e. Gear bags to retrieve line and sand anchors off the bottom.

Retrieving the collectors worked the best with two dive teams. One dive team started on one side of the reef footprint (aiming to find collectors #1, 2, and 3) and the other team started on the other side of the footprint (aiming to find collectors #8, 9, and 10). If all the search lines were intact underwater, it was possible to find all the collectors in one dive with two dive teams.

Lines with surface marker buoys were deployed at two collector waypoints.
2. Divers teams deployed, carrying multiple lines with surface marker buoys.
3. A line (with buoy) was attached to each collector.
4. Mesh coverings were secured around the collectors using bungee cords.
5. Search lines, garden stakes, sand anchors, subsurface buoys, and any collector-marking items were removed and brought to the surface.
6. Meshed collectors were then hauled.

Sample Processing - Astroturf and rocks in the collector were carefully inspected, and all flora and fauna found were counted and recorded on a suction sampling datasheet (Appendix C). Encrusting species and algae were recorded in the presence/absence section, while individuals of a species were enumerated. To remain consistent with the suction sampling data collection, we did not collect data on species of polychaetes except for scale worms. Species that were not readily identifiable in the field, usually small whelks or bivalves, were preserved in alcohol in small glass vials labeled with unique ID's on the lid. These ID's were recorded on the datasheets to track which site and collector the sample was found. These species were keyed out in the office following their collection.

Pre-Construction Site Survey
Prior to the start of construction, *MarineFisheries* collaborated with the United States Geological Survey (USGS) to collect georeferenced multibeam data on Site 29 and the surrounding area. The results of the survey confirmed our substrate dive survey results and showed that Site 29 was a non-descript flat area with little to no hard bottom habitat. The survey also confirmed the location of the HubLine and the cobble fill point near Site 29. Additionally, the survey verified that the reef would be near naturally occurring hard bottom areas (Figures 2.2 in Chap. 2). We assumed that naturally occurring hard bottom areas could provide the artificial reef with new juvenile settlers and potentially attract adults. *MarineFisheries* also planned to use these surrounding natural reefs for comparisons with our artificial reef during future monitoring.

Figure B7. Settlement collector retrieval.

REEF MONITORING PROTOCOLS

MarineFisheries initiated a monitoring program as soon as the artificial reef construction was complete. To evaluate the success of the reef project, we designed a structured monitoring program to characterize and track larval settlement, as well as the development of invertebrate and finfish populations on the reef. This program included seasonal visual dive surveys along permanent transects, semi-annual small fish trapping, annual larval suction sampling, and some monitoring of reef structure with multibeam technology. Each reef and sandy control unit will be referred to using its unique identification number assigned post-construction (Figure 2.1 in Chap. 2).

Temperature Monitors

Two permanent bottom temperature monitors were installed in the spring of 2006: one at the origin of Natural Reef transect #1 and one just east of the transect origin on artificial reef #8. A concrete base was constructed with an internal mesh wire frame and a central eye bolt for lowering the block to the seafloor. Two large bolt heads (with the threads exposed) were also installed into the concrete to allow for the permanent attachment of a large PVC tube (about 7.6 cm diameter, 45 cm long) to the base (Figure B8). The PVC tube had two holes, spaced about 15 cm apart and centered, drilled completely through both sides of the tube for running long bolts (with nuts attached to hold them in place) through. The temperature monitor (Pendant Hobo, Onset Corp.) was placed in a waterproof plastic housing and put inside the tube between the two bolts. The bolts secured the temperature logger in place. Divers switched the loggers out annually.

Figure B8. Permanent temperature monitoring station ready for deployment.
Note: buoys and dive weight were only used for deployment.

Permanent Transect Sampling

Installing Permanent Transects

1. Equipment needed to install one 40-m transect:
    a. GPS unit
    b. 40-m transect tape (Keson double-sided, Forestry Suppliers) with a 5-m leader line (sinking line) and brass clips on the leader line and the transect reel, or a 40-m transect tape without a leader line. The leader line gave the divers some distance before starting the transect, where they could disturb the bottom without disturbing the transect when setting up survey equipment. This was important on the natural reef sites where sponges and other fragile species could be inadvertently damaged. The leader line was not

necessary for the artificial reefs however, because divers could easily avoid disturbing the reef by staying off the reef on the surrounding sandy edge.

c. Five sand augers or cinder blocks for the natural reefs and sandy controls, and two sand augers for the HubLine fill points and artificial reefs. Note: sand augers are difficult to find – we purchased them from: http://www.shadeusa.com/beach_umbrella_holders.htm#EARTH%20ANCHORS.
d. A short rebar stake (used for installing the sand augers into the substrate).
e. Two subsurface buoys (we used half of a lobster buoy for each subsurface buoy) with 1.5 m of line tied to each buoy, the line ended in a loop large enough to fit the subsurface buoy through
f. Flagging tape with the site name/number written on it - tied to the subsurface buoys
g. 15 m of sinking line (for a search line) marked in the center (7.5-m mark) of the line with a cable tie used to mark the natural reefs and sandy controls
h. Two to three mesh gear bags
i. Pelican buoy (small yellow buoy and line that can be easily carried by divers and deployed to the surface to mark the end point of the 40-m transect)
j. Waypoint for start of transect
k. Pre-determined bearing

2. Field preparation on the surface to set-up a permanent transect:
    a. A 15-kg weight (drop weight) and a surface line with a buoy on it was set up to mark the start of the transect (marker buoy).
    b. Gear bags containing the following items were attached to the drop weight:
        i. Equipment for ORIGIN of the transect: four sand augers, short rebar stake, 15-m search line, subsurface buoy, and 40-m transect tape with or without leader line depending on the site
        ii. Equipment for FAR END of transect: sand auger, subsurface buoy, pelican buoy
        iii. If divers were collecting data on these dives, we attached the swath bars and the quadrats to the weight using loops in the line and brass clips.
    c. The weight and surface line with attached gear bags and were dropped on the waypoint.
3. Establishing the permanent transects underwater (Figure B9):
    a. A team of divers followed the marker buoy down to the origin.
    b. Divers used the "origin" gear bag containing all the equipment necessary to set-up the origin of the transect. If we were installing sites on the natural or sandy areas, the auger was installed directly next to where the drop weight fell. For the HubLine fill point, all sand augers were installed on the west side of the pipeline in a sandy area at the bottom of the cobble fill. Divers swam to the top of the mound parallel to the auger to begin transects. For the artificial reefs, the augers were centered at the northern edge of the reef. The sand augers are expected to remain in position for at least the next few years of monitoring. If the substrate type did not allow (i.e. too rocky) for installation of augers, cinder blocks were used to mark the start and end of the transects.
    c. The subsurface buoy was attached to the auger or the cinder block by running the buoy through the loop at the end of the buoy's line.
    d. A search line was then installed at the start of each natural reef and sandy control transect (no search line was necessary for the artificial reefs or the HubLine because they were not difficult to locate underwater):
        i. An auger was installed into the substrate near the subsurface buoy.
        ii. The 15-m search line was run through this auger until we found the cable tie marking the middle of the line. A knot was tied in the line with the cable tie.
        iii. Each diver took an auger and one end of the search line and swam out on a bearing perpendicular to the bearing of the transect. Divers placed the augers in the substrate and tied a knot to attach the line to the auger (Figure B9).

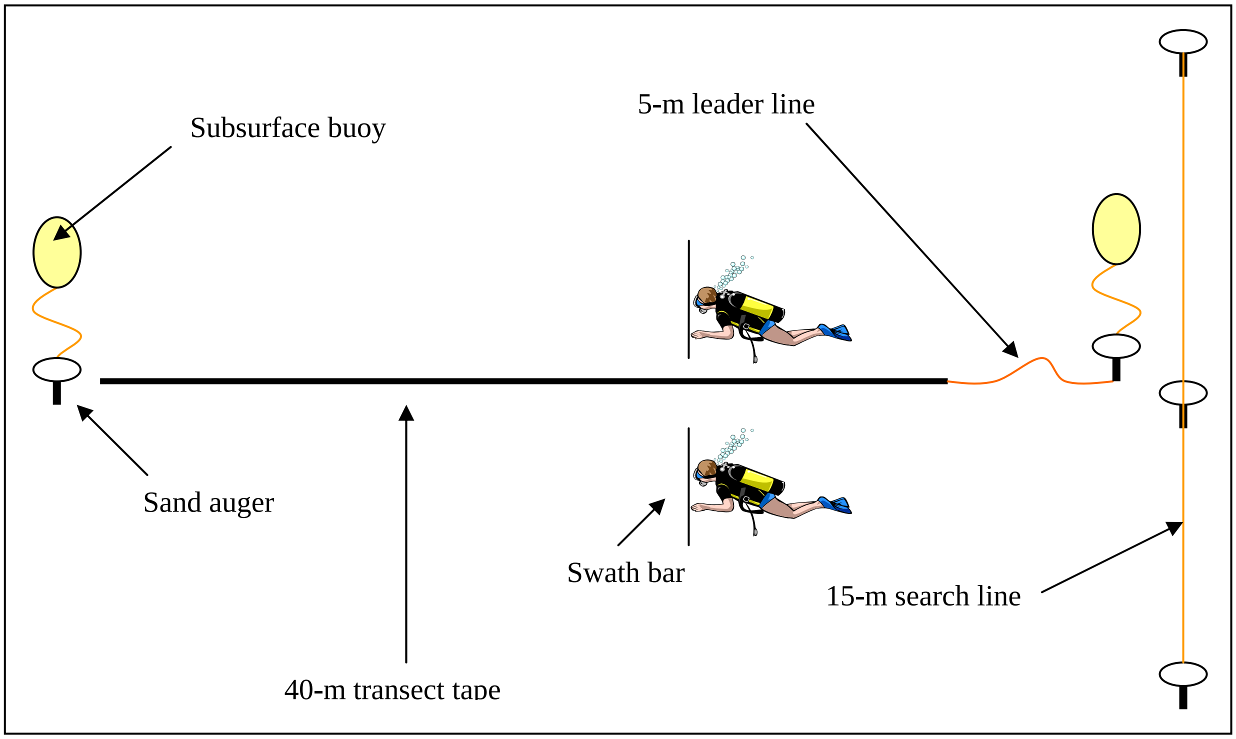


Figure B9. Permanent transect set-up and divers surveying the transect using swath bars.

e. Divers opened the far end gear bag and set out the transect tape along the designated bearing. (For the HubLine, sandy controls, and the artificial reefs a southwest bearing around 240º was usually used). The short rebar stake and the gear bag were carried.
f. Divers verified that depth did not vary drastically on a site (usually remained at the designated depth +/- 2 m).
g. Once at the 40-m mark, divers swam one more meter out to install the last sand auger.
h. The far end subsurface buoy was attached to the auger.
i. Divers clipped the transect line onto the auger and pulled slack out of the line.
j. The pelican buoy line was tied to the transect tape reel (not the auger) and the buoy was released to the surface. This allowed us to obtain a waypoint for the end of the transect from the boat (recorded on the Surface Datasheet, Appendix C).
k. Depending on air supply, divers began surveying the site using swath bars.

4. Resampling of the permanent transects (not installing gear):
    a. Divers threw a drop weight and marker buoy on the waypoint marking the origin of the transect. Attached to the weight were the following: one gear bag holding the transect tape and a pelican buoy, quadrats, and swaths.
    b. Divers swam down the line and looked for the search lines if they were on a natural reef or a sandy control. The search lines lead divers to the origin subsurface buoy. If divers were resampling the HubLine or the artificial reefs, divers searched for the rock structures and swam to the subsurface buoy location. The drop weight was moved to the origin sand auger so we had an easy line to follow to the surface at the end of the dive.
    c. Fouling organisms were cleaned off of search lines and subsurface buoys.
    d. The transect tape was clipped onto the marker buoy line, which was positioned at the start of the transect. Divers swam out the 40-m transect tape on the recorded bearing.

e. After reaching the 40-m mark, divers conducted a sweeping search to find the far end subsurface buoy and the far end of the transect tape was secured.
f. If we needed to surface from the far end of the transect, we tied the pelican buoy onto the transect tape reel and deployed to the surface. This provided divers with a line to follow back to the surface from the 40-m mark.

Swath Data Collection (Swath Monitoring Datasheet, Appendix C)

Macroinvertebrates and fishes were quantified in 2 x 5 m sections along the transect using 2-m long PVC "swath" bars once transect lines were laid out:

1. One diver ran out the transect tape while the other diver swam alongside holding two swath bars. Once the transect tape was in place, divers collected data from the 40-m mark to the 0-m mark.
2. One diver collected data on the right side, the other collected data on the left side of the transect Figure 2.6 in Chap. 2).
3. Holding a swath bar, each diver swam slowly along the transect, counting macroinvertebrates and vertebrates listed on the datasheet in 5-m increments (see swath datasheet Appendix C).
4. When sighted, pelagic fish were recorded. If the fish were schooling, their count was estimated. The majority of fishes sighted were benthic such as sculpin (*Myoxocephalus* sp.) or cunner (*Tautogolabrus adspersus*). Cunner were so numerous over the artificial reefs and the HubLine (in 2006) that we estimated the count within each 5-m swath.
5. On occasion some macroinvertebrates, such as solitary tunicates, were so numerous on the artificial reefs that it was not feasible to count them (i.e. *Ascidiella aspersa, Ciona* sp.). When necessary the number of individuals within the swath section were estimated.
6. Divers did *not* lift or turn over rocks but did look into interstitial spaces when possible.
7. Divers gently moved algae to check for benthic invertebrates or fishes underneath the algae.
8. At the end of the swath survey divers filled in any blanks on the datasheet with "0" to demonstrate that we looked for that species and found none.
9. Collecting these data took about 20 minutes on the sandy controls, and 35 – 50 minutes on the artificial reefs, natural reefs, and HubLine fill point.
10. On the surface, divers tallied their "tick marks" and circled the final count for a particular species in the swath section. Circling the final count allowed for easier data entry.

Quadrat Data Collection (Quadrat Monitoring Datasheet, Appendix C)

Divers used 1-m^2 quadrats with a ¼-m^2 inset quadrat to sample small invertebrates typically found in high densities (e.g. *Mytilus edilus*), substrate type, algal coverage, and encrusting or sessile invertebrate coverage (e.g. colonial tunicates or sponges). To obtain unbiased data yet avoid sampling the entire transect, we used systematic random sampling along the 40-m transect length. Each diver collected data in two quadrats every 10 meters, for a total of eight quadrats per diver and 16 quadrats per transect.

1. Prior to the dive, the meter mark of the quadrats that were to be sampled were filled in on the datasheet. Quadrat numbers were assigned using a random number table with numbers from zero to nine, and filled in the "sampling start mark" on the datasheet, labeled by columns Q1-Q5 (i.e. "Quadrat 1") (Figure B10). The space outside the parentheses was filled in with the quadrat number the diver was to collect data from, while the number inside the parentheses was their

Bearing ______Hour______ Left / Right Visit #_________Vis_____

Only count 1m quads if the abundance is very low

Quadrat (1/4 / 1meter^2)	Q1	Q2	Q3	Q4	Q5
Sampling Start Mark	3__(0)	_8_(6)	13_(16)	15_(19)	20__(24)
Modiolus modiolus	/	/	/	/	/
# clam siphons	/	/	/	/	/

Figure B10. Completed random number section on the quadrat datasheet.

buddy's location [e.g. ___(___)]. The first two random numbers from the table, for example 8 and 3, were re-ordered so that divers could swim in a constant direction [e.g. _3_(___) and _8_(___)]. The next two random numbers, for example 6 and 0, were filled in the blanks inside the parentheses [e.g. _3_(_0_) and _8_(_6_)]. On the dive buddy's datasheet, the numbers were reversed: _0_(_3_) and _6_(_8_). As we continued to assign quadrats, 10, 20, or 30 was added to the random number to move along the transect in 10-m increments (e.g. for 3 and 5 – the quadrats would be 13 and 15, and the next numbers 0 and 6 would be 20 and 26) (Figure B10).

2. Datasheets were photocopied as double-sided and flipped underwater collect data on all quadrats.
3. The datasheets also provided space for two extra quadrats, which was useful if one diver was faster at collecting data than the other. In this case, the faster diver would complete their buddy's last quadrat for them without having to obtain the slower diver's datasheet.
4. Divers usually started at the 0-m mark and worked to the 40-m mark, after having completed the swath data collection. Depending on time, this was done on the same or on a second dive.
5. One diver collected data on the right side, while the other diver collected data on the left side, as with the swaths. The side the diver was on was recorded as if the diver was swimming from the 0-m mark to the 40-m mark.
6. Correct quadrat use:
    a. 1-m^2 PVC quadrats were built with a ¼ m^2 corner inside the larger quadrat (Figure B11).
    b. When collecting data, divers placed the ¼ m^2 corner of the quadrat at the assigned quadrat number on their side of the transect (Figure B11).
    c. If a large boulder prevented the quadrat from lying flat on the substrate, divers did not move the quadrat. Data collection took place on an angle but in a method consistent with all other quadrats.

Small Fish Trap-Sampling and Tagging Study

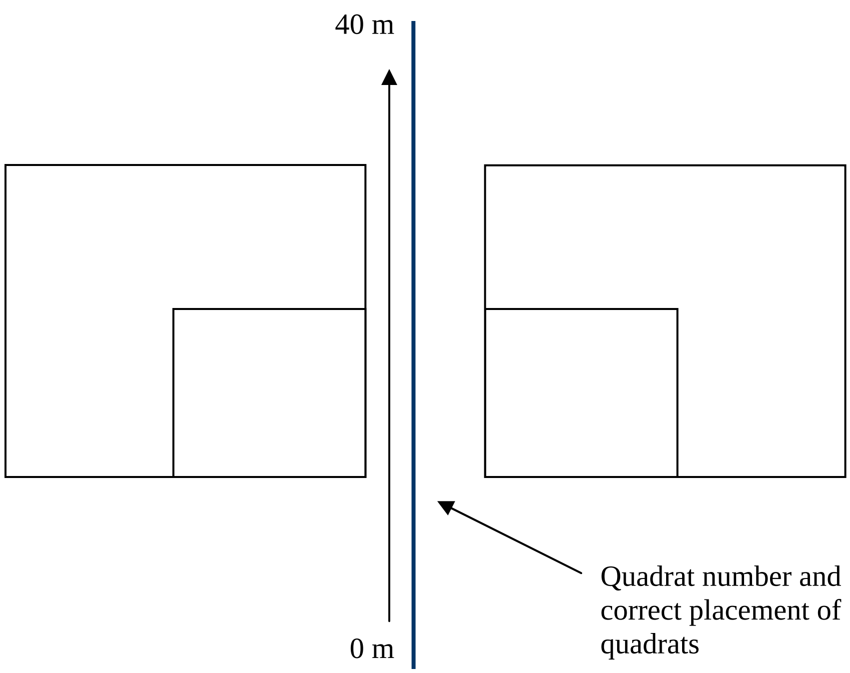


Figure B11. Transect line showing the correct placement of the quadrats next to the assigned quadrat numbers

Trap Design and Preparation

1. Commercially-purchased 30.5 cm length x 30.5 cm width x 58.4 cm height eel pots with 1.3 x 1.3 cm vinyl-clad wire mesh were used (Figure 2.8 in Chap.2). The door folded around the trap body on three edges so that small fish could not escape and was secured with a bungee-cord. The entry passage was a long funnel design.
2. Each trap was weighted with a brick secured inside the trap and rigged with 20 m of line and a surface buoy. Surface buoys were standard lobster-pot buoys that were halved and marked with a unique ID (1 through 30).
3. Traps were fitted with lobster trap identification plates listing ownership. These tags were also marked with a unique ID for each trap that matched its buoy ID. We also added flagging tape with the trap ID to each pot. The numbers were used to track trap deployment and hauls.
4. Herring was used to bait the traps. Whole frozen fish were quartered and separated into portions each weighting around 100-150 grams. Portions were placed into containers and re-frozen.
5. Prior to deploying each trap, one portion of fish was placed in a plastic mesh bait bag and suspended inside the trap by closing the door against the open end of the bag.

Trap Placement

1. GIS was used to select seven waypoints on each of the four areas: artificial reef, sandy control, natural reef, and HubLine (Figure 2.9 in Chap. 2).
    a. One trap was placed in the center of each artificial reef (areas #1, 3, 4, 7, 8, and 9) with the exception of reef #7, which had two traps set 19 m apart along the reef's center-line.
    b. Two traps were placed in each of the sandy control sites (areas #2, 5, and 6), with the exception of area #5, which had three traps. Each trap was at least 12 m apart, but most were 30 m apart.
    c. Seven traps were set in the natural reef area found during the site selection process at a depth similar to that of the artificial reefs. Traps were deployed immediately after structure/relief was detected on a bottom sounder to ensure the presence of hard substrate.
        i. In the fall, the location of the natural reef traps was changed because the site we used in the spring had limited hard substrate at depths similar to the artificial reefs. The spring site was also not the site that we eventually used for our permanent transect sampling. Additionally, the natural reef we used for our monitoring surveys had large amounts of cobble and boulder, whereas, we had not surveyed the area we set the traps in the spring. Therefore, in the fall we sampled the area we monitored. The natural reef used in the fall had a larger area at a similar depth to the reefs. Traps were spaced between 18 m and 84 m apart.
    d. Seven traps were deployed on the HubLine pathway on top of the cobble fill about 30 m apart from one another. We deployed each trap only if we saw the mound appear on the bottom sounder, which ensured proper placement.
2. Traps were deployed when the GPS indicated that we were within 3 m of the waypoint.
3. As the baited trap was released, its deployment location was marked on the GPS if it varied from the original waypoint. The label of the GPS point, ID of the trap, and time deployed were recorded (on the "Fish Pot Setting Datasheet," Appendix C).
4. Traps were soaked for two to six days.

Processing the Catch and Tagging Cunner

1. Traps were hauled by hand or with the assistance of a davit.
2. Captured fishes and crustaceans from one trap were emptied immediately into a cooler with habitat water and processed. The following data were recorded on waterproof paper (on the "Fish Pot Length Frequency Datasheet," Appendix C):
    a. Lobsters (*Homarus americanus*) – Carapace length was measured to the nearest 0.1 mm using vernier calipers. The lobster was then sexed and released. When tags were

available, lobster were tagged with cinch tags (containing unique ID numbers) placed around the knuckle (Figure 2.10 in Chap. 2). If the lobster were tagged, they were released over the waypoint where they were originally caught

b. Cancer crabs (*C. irroratus* and *C. borealis*) – Carapace width measured, then released.
c. Species other than cunner – Grubby sculpin (*Myoxocephalus aenaeus*), pollock (*Pollachius virens*), rock gunnel (*Pholis gunnellus*), and radiated shanny (*Ulvaria subbifurcata*) were occasionally captured. For these species, total length was measured to the nearest 0.1 mm using a measuring board and the fish was released.
d. Cunner (*Tautogolabrus adspersus*) – Total length (TL) was measured to the nearest 0.1 mm using a measuring board, then Floy® Fingerling tags were applied to each cunner with a TL of 7.5 mm or greater (we increased the minimum TL from 7.5 in the spring to 8.0 in the fall because cunner less than 8.0 mm had reduced survivorship compared with the larger individuals immediately following the tagging event).
    i. Floy Fingerling tags were pre-printed with unique three-character codes and came attached to elastic line which was threaded on a needle. We used the needle to pierce the fish's flesh a few mm below the anterior end of the dorsal fin. The elastic line was then threaded through the fish's flesh and the needle was removed. We secured the tag close to the fish's body with a surgeon's knot. Dangling thread was trimmed to reduce drag.
    ii. We released the live tagged fish over the waypoint where they were originally captured. A freshly-baited trap was also released on the site. Released cunner were observed and any that did not swim down were recovered and recorded.

Air-lift Sampling

Sampling and sample analysis was performed according to the procedures described previously under the "Benthic Air-lift Sampling." One major difference between air-lift sampling the artificial reefs and the annual coastal stations was the amount of time required to complete the procedure because (1) the greater depth caused divers and the suction pipe to expend air at a faster rate than at the shallow sites, which required more tank changes, and (2) divers had to swim farther along the bottom to arrive at sampling destinations. Techniques unique to each sample site were:

Artificial Reefs

1. Twenty-four samples were taken on the artificial reef. On each reef unit, a ½ m^2 quadrat was used to sample the four rock sizes (small cobble, large cobble, small boulder, and small boulder/small cobble mix). The two larger rock sizes (large boulder and large cobble/large boulder mix) were not sampled due to the impracticality of turning those rocks over.
    a. The quadrat was placed on either the western or eastern edge of the different size rock sections. Sampling side (east or west) was randomly assigned to later analyze variations in settlement due to prevailing east/west currents. We followed the "Underwater Reef Suction Protocol Datasheet" (Appendix C) while diving, which designated what locations to sample and also listed bearings to navigate from one reef to another. Samples in 2007 were taken from the opposite side of each rock size sampled in 2006. The break between years allowed for recovery of flora and fauna that were disturbed by air-lift sampling.
    b. Water-proof identification tags were placed in each sample bag underwater, immediately following the collection to identify which reef, rock size, and side of the reef (east/west) the sample was taken (e.g. Label = Site 1, 1W; interpretation = Site 1, small boulders on the west). One diver carried these tags on a looped cable tie. Tags had holes punched in the top corner so the diver could easily rip the tag off the cable tie and place it into the collection bag before closing the bag.
    c. Overturned rocks were replaced immediately after suctioning ceased at each quadrat.

2. In a single dive, we sampled between one and two reefs (four to eight samples), depending on tides and currents. Reefs were easy to locate underwater in the east-west direction but more difficult to find in the north-south direction, where the reefs have a shorter profile.
3. This task required three divers. For most of the annual air-lift sampling, the third diver replaced bags on the suction pipe. On the artificial reef dives, the third diver acted as the lead diver, instructing others on which quadrat to complete next and keeping track of the ID tags for each collection bag. The third diver used the underwater datasheet to mark which quadrats were complete and which needed to be sampled.
4. Bringing down two suction tanks fitted with first stages eliminated the need for divers to surface to switch out tanks but the added gear made swimming from one reef to another difficult.

<u>Sand Controls</u>
Twelve samples were taken on a sandy control site. We randomly chose to sample site #5 but any of the three sandy controls (areas numbered 2, 5, and 6 in Figure 2.1 Chap 2) could be used.

<u>HubLine Fill Point</u>
Twelve samples were taken on the HubLine (centered between the origin and far end of Transect 1). For each, the quadrat was placed on the edge of the rock mound and cobbles were turned out toward the sand. Six quadrats were sampled on the eastern edge of the HubLine and six on the western edge.

<u>Natural Reef</u>
Twelve samples were taken on the natural reef at a location past the far end of Natural Reef Transect 3 (Figure 2.5 Chap. 2). Quadrats were chosen using the routine suction sampling protocol.

Appendix IVB.C. Artificial Reef Site Selection and Monitoring Datasheets

Site Name ____________ TimeStart ______________
Date (yyyymmdd) ____________ RPM __________________
Recorder ____________

LatNW	
LonNW	
LatNE	
LonNE	
LatSW	
LonSW	
LatSE	
LonSE	
LatMN	
LonMN	
LatMS	
LonMS	

Time (seconds)	Depth	Direction of vessel movement

Time (cont)	Depth (cont.)	Direction of vessel movement

Figure C1. Depth survey datasheet used during site-selection.

Date(yyyymmdd)____________________ Site ID _______________________ Vis._____ **Transect Letter A / B (circle one)** Diver______________

Time (Hour)__________ Bearing____________ Left / Right (circle one) Buddy______________

	Start	0-5m	5-10m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m	45-50m
Depth											
Hand burial test											
Substrate											
Primary (>50%)											
Secondary (10-50%)											
Tertiary (<10%)											
Tertiary (<10%)											
Tertiary (<10%)											
Tertiary (<10%)											
Underlying											
Homarus americanus **(count if seen)**											

Additional notes:

Sediment Key

BE = Bedrock
BO = Boulder (>25.1cm) head size or greater
CO = Cobble (6.1-25cm) billiard ball to head size
PE = Pebble (0.5-6cm) pea size to billiard ball
GR = Granule (0.2-0.4cm) beebee size to pea size
SA = Coarse Sand and Fine Sand (beebee size to salt/sugar grain)
SD = Shell Debris (broken-up shell fragments)
SH = Shack (whole or half shells)
CL = Clay
SI = Silt

Underlying =sediment underneath other substrate

Hand burial codes:
1 = Remains on surface
2 = Half or whole hand buried
3 = Hand and full wrist buried

Figure C2. Datasheet for substrate surveys of prospective sites, using swath bars.

Date (yyyymmdd) ________________ Swath Divers ____

Site ID_________________________ Video Diver ____

Transect **A / B** (circle one)

Percent Cover

Algae	0	<1	1-5	6-10	11-25	26-50	51-100
Kelp (*Laminaria sp., Agarum sp., Alaria sp*.)							
Filamentous browns and reds (*Desmarestia*)							
Red blades *(Palmaria sp.,* etc.)							
Encrusting coralline algae							
Drift algae - green							
Drift algae - browns							
Drift algae - reds							

Estimated Count

INVERTEBRATES	0	1	2-5	6-10	11-50	51-100	101-500	501-1000	1001+
Homarus americanus									
Libinia emarginata (Spider crabs)									
Cancer sp. (Rock and Jonah crabs)									
Neopanope sp. (Mud crabs)									
Large whelks (*Busycon, Buccinum*)									
S. droebachiensis									
Asterid sea stars (*Asterias, Leptasterias*)									
Hermit crabs - *Pagarus sp., etc.*									
Anemones (*Metridium sp.*)									
Bivalves (specify)									
Other bivalves (specify)									
Tunicates (specify)									

FISH									
Tautogolabrus sp. (Cunner)									
Myoxocephalus sp. (Sculpin)									
Tautoga onitis (tautog)									
Gadus Mohua (Atlantic cod)									
Policius veins (Pollack)									
Winter flounder									
Skates									

Figure C3. Datasheet for presence/absence of species sighted during site-selection dive surveys.

Site ID: ______________________________

Placed near what (Reef? Sandy control?)____________________

Placed near **origin** (0m mark) or **far end** (50m mark) (circle one)

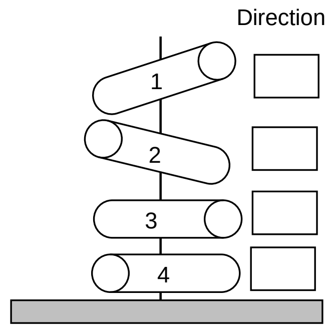
Lat: ______________________________ **Lon:** ______________________________

Divers: ____

Dimond Design

Start Date	End Date	Start Time	End Time

	Start Weight	End Weight	Direction
Block 1			
Block 2			
Block 3			
Block 4			



Flowmeter

Start Date	End Date	Start Time	End Time

Start Read: ______________________________

End Read: ______________________________

Additional Notes:

FigureC4. Current-direction meter datasheet.

Date (yyyymmdd) ______________________

SiteID ______________________

Surface Observer1 ______________________

Surface Observer2 ______________________

Transcect (circle one) 1 2 3	
Bearing (dive direction)	
Average Depth (from boat data)	
0m depth	
50m depth	
Time Divers In	
Time Divers Out	

Surface Conditions:	
Surface Current Direction	
Estimated speed (if possible)	
Wind Speed	
Wind direction	
Cloud cover	

Lat West end 0 / 140m?	
Lon W end	

Lat East end 0 / 140m?	
Lon E end	

Additional Notes:

Transect (circle one) 1 2 3	
Bearing (dive direction)	
Average Depth (from boat data)	
0m depth	
50m depth	
Time Divers In	
Time Divers Out	

Surface Conditions:	
Surface Current Direction	
Estimated speed (if possible)	
Wind Speed	
Wind direction	
Cloud cover	

Lat West end 0 / 140m?	
Lon W end	

Lat East end 0 / 140m?	
Lon E end	

Additional Notes:

Figure C5. Site-selection surface datasheet for 140-m transect diver surveys.

Site #	Diver	Transect #	Bearing
Date	Buddy	Visibility	Time

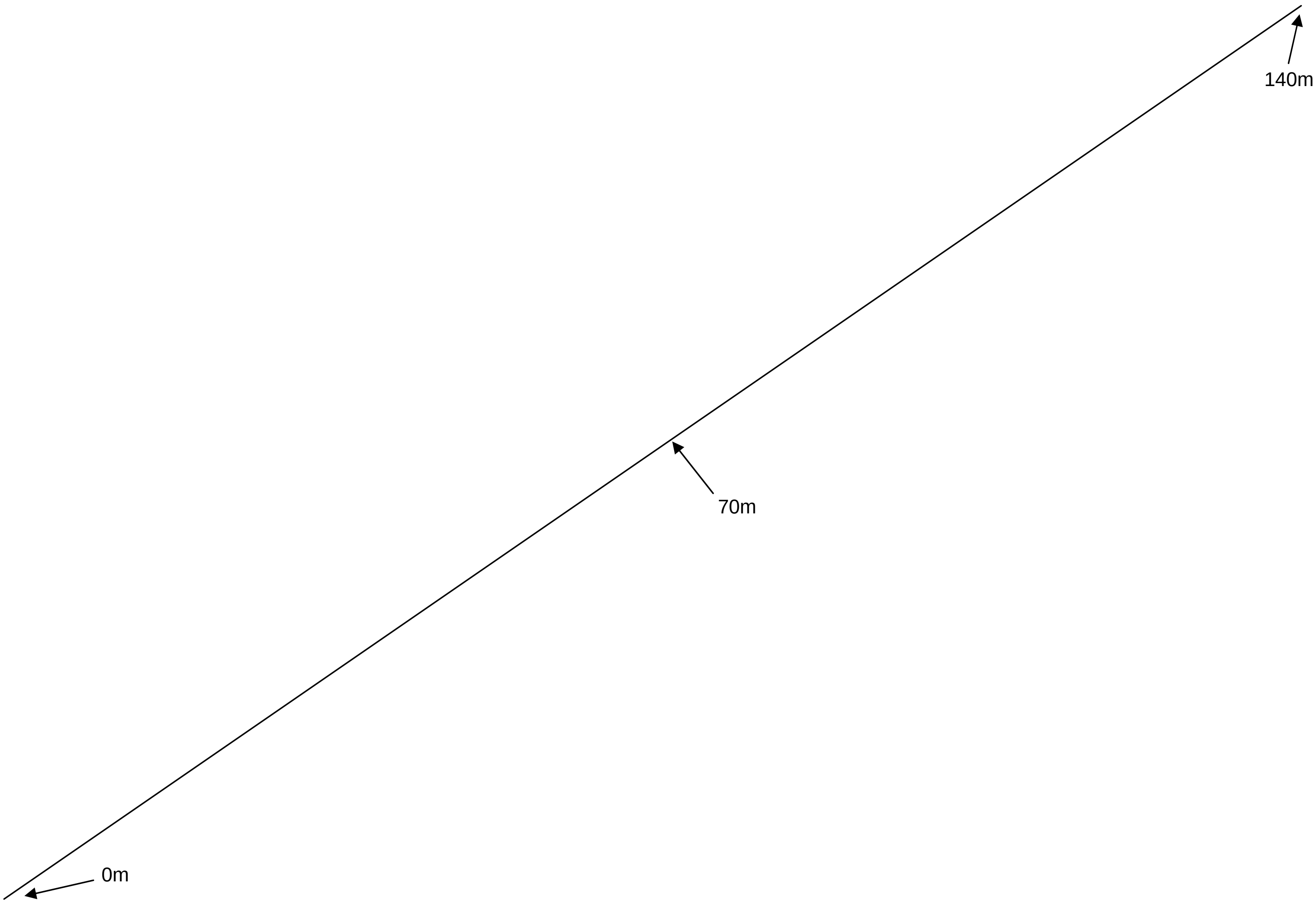


Figure C6. Datasheet for 140-m transect observations during site-selection.

Site ID ____________ Divers ____________

Date ____________ Reef or Sample ID ____________

Species ID - closest ID as possible / notes & descriptions	**Count**

Presence / Absence (for sp. in #s logistically too high to count or questionable in sampling) **Circle if present or write in!**

Algae	**Sponges**	**Annelids**
Codium fragile	*Halichondria panicea*	*Spirorbis borelis*

Date (yyyymmdd) ____________ **Surface Observer1** ____________

SiteID ____________ **Surface Observer2** ____________

Visit # ____________

Transect ID: ____________

Bearing (from 0m mark to 40m mark) ____________

Corrected Depth of Site ____________

Tide Description Dive #1 Ebb / Flood High Slack / Low Slack What type of data was collected on this dive?

Tide Description Dive #2 Ebb / Flood High Slack / Low Slack What type of data was collected on this dive?

Tide Description Dive #3 Ebb / Flood High Slack / Low Slack What type of data was collected on this dive?

Average visibility on dives ____________

Longitude Start (0m) -- ____________

Latitude Start (0m) ____________

Longitude End (40m) -- ____________

Latitude End (40m) ____________

Additional Notes (site gear and biological notes)

Date(yyyymmdd)______________________ Site ID______________________ Diver______________ Bearing________

Hour_____________ Depth_________________ Left / Right Vis.________ Buddy_____________

Visit #____________ Transect# ___________

		0-5m	5-10m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m
Arthropods	Homarus americanus (American lobster)								
	Cancer irroratus (Rock crab - sharp point carapace)								
	Cancer borealis (Jonah crab)								
	Family Majidae (Libina/Hyas - spider crabs)								
	Large hermit crabs (width of large chelae >1.5 cm)								
Cnidarian/Tunicates	Metridium senile (frilled anemone)								
	Northern cerianthid (Cerianthus borealis)								
	Molgula sp. (sea grape)								
	Ciona intestinalis (sea squirt with yellow rim)								
	Styela sp. (warty, knobby sea squirt)								
Echinoderms	Stronglyocentrotus droebachiensis (green urchin)								
	Henricia sp. (Blood star)								
	Asterias forbesi (orange madreporite)								
	Asterias vulgaris (white madreporite, row spines down arms)								
Gastropods	Lunatia heros (Moon snail)								
	Buccinum undatum (waved whelk)								
	Sea scallop (Placopecten magellanicus)								
Fish	Cunner (estimate)								
	Myoxocephalus sp.(shorthorn, grubby & longhorn)								
	Winter flounder (*P. americanus*)								
	Radiated shanny								

Other species to count: Crangon sp. (sand shrimp - dorsally flattened), Pandalus sp. (shrimp), nudibranchs, sea cucumbers, Solaster endeca (Sunstar), Crossaster papposus (Spiny sunstar), Neptunea lyrata (ten-ridged whelk), Colus stimpsoni (slender whelk), Razor clams, Quahogs, Surf clams, sand dollars, Goulds pandora clam, all solitary tunicates, summer flounder, spiny dogfish, other flatfish, Lumpfish, Cod, Tautog, Sea raven, Raja (skate)

Figure C9. Swath survey datasheet for mobile macroinvertebrates and solitary tunicates used during monitoring dives.

Date(yyyymmdd)__________________ Site ID ________ Transect ID________ Diver__________________ Depth________

Bearing ______Hour______ Left / Right Visit #_________Vis_____ Buddy__________________

Only count 1m quads if the abundance is very low

Quadrat (**1/4 / 1**meter^2)	Q1	Q2	Q3	Q4	Q5
Sampling Start Mark	___( )	___( )	___( )	___( )	___( )
Modiolus modiolus	/	/	/	/	/
Mytilus edilus Blue mussel	/	/	/	/	/
# of clam siphons	/	/	/	/	/
	/	/	/	/	/
	/	/	/	/	/
	/	/	/	/	/

Substrate

Quadrat (**1** meter^2)	Q1	Q2	Q3	Q4	Q5
Sampling Start Mark	___( )	___( )	___( )	___( )	___( )
Primary (>50%)					
Secondary (10-50%)					
Tertiary (<10%)					
Tertiary (<10%)					
Tertiary (<10%)					
Tertiary (<10%)					
Underlying (what you can see)					

BE drock

BO ulder (>25cm) head size or greater

CO bble (6-25cm) billiard ball to head size

PE bble (0.4-6cm) pea size to billiard ball

GR anule (0.2-0.4cm) bb size to pea size

SA = Coarse and Fine Sand (beebee size to salt/sugar)

SH = Shack (whole or half shells)

CL = Clay

SI = Silt

SD = Shell Debris (broken-up shell fragment)

Notes:

Quadrat (**1** meter^2)	Q1	Q2	Q3	Q4	Q5
Sampling Start Mark	___( )	___( )	___( )	___( )	___( )

Remember - if it is **drift algae,** no stipe count is recorded - only % cover with a "D" next to it. Count dead kelp stipes separately.

Brown Algae (#stipes/percent cover w/in 1 meter^2)

Agarum cribrosum (kelp with holes)	/	/	/	/	/
Laminaria sp. (thick blade)	/	/	/	/	/
Alaria sp. (mid-rib)	/	/	/	/	/
Unid filamentous browns					

Reds (if you can ID *Chondrus* separately, please estimate % cover separately)

RedFilamentous/Foliose					
Red Blade (*Palmaria)*					
Red Coralline Crust					
Chondrus crispus					
Membranoptera alata (leafy red blade)					

Greens

Ulva lactuca (green blade -prob. drift)					
Fucus sp. (branching green, prob. drift)					

Sessile Inverts (count / percent cover) No slash = only percent cover

Bugula (Tufted bryozoan)					
Palmate sponge *(Isodictya sp.)*	/	/	/	/	/
Crumb Bread Sponge (*Halichondria sp.*)					
Botrylloides violaceus (orange, white tunicate)					
Botryllus schlosseri (star tunicate)					
Barnacles					
Haliclona oculata (deadmans fingers)	/	/	/	/	/
Tubularia (hydroid with pink)					
Didemnum sp. (snotty gray tunicate)					

Other stuff to count: Encrusting Tunicates, Sea pork (white blob tunicate), Cryptosula sp. (red encrusting bryozoan) Membranipora (encrusting bryoz) or Electra pilosa (lacy bryoz), Broken kelp stipe, Green filamentous algae, Codium *sp* ., Didemnum albidum (white, non-invasive), Clathrina sp. (white stringy sponge) other encrusting species, Haliclona

Figure C10. Quadrat survey datasheet for bivalves, substrate, and species assessed by percent cover used during monitoring dives.

Presence/Absence

Date (yyyymmdd) ______________ Visit # ______

Site ______________

Transect ID ______________

ALGAE **P=Percent Cover**

Brown	0	<1	1-5	6-10	11-25	26-50	51-100	100-500	501-1000	1000+	**Drift?**
Laminaria sp. (thick blade)											
Alaria sp. (mid-rib)											
Agarum cribrosum (seive kelp, w/ holes)											
Brown filamentous (wiry)											
Other											
Red											
Chondrus crispus (foliose)											
Palmaria palmata (red blade)											
Red coralline crust											
Membranoptera alata (flattened leafy red blade)											
Corallina officinalis (branching corraline red alga)											
Red filamentous											
Green											
Ulva lactuca (blade)											
Codium fragile (branching)											
Fucus sp. (drift, rockweed)											
Chaetomorpha linum (filamentous green, wiry)											
Ascophyllum nodosum (drift, knotted wrack)											
Green filamentous algae											
Zostera sp. (eelgrass)											

INVERTEBRATES - ***P = Percent Cover*** **and** ***C=Count***

Porifera **= P**										
Isodictya sp. (palmate, conspicuous oscula)										
Halichondria panicea (crumb of bread)										
Haliclona oculata (deadman's fingers, narrow stalk, our "purple sponge")										
Suberites ficus (fig sponge, smooth, yellowish, ball-like)										
Microciona prolifera (red beard, tiny oscula)										
Clathrina sp. (stringy white sponge)										
Other (describe)										

Cnidarians = **P or C**										
P =*Tubularia crocea* (pink tubularian hydroid)										
P =*Obelia geniculata* (threadlike runner, stalked)										
C =*Metridium senile* (frilled anemone)										
C =*Cerianthus borealis* (northern cerianthid)										
Other										

Figure C11. Datasheet for presence/absence of species sighted on the artificial reefs, natural reef, and HubLine sighted during monitoring dives, filled out post-dive.

Site ID ______________________ Transect ID _____ Visit # ______

	0	<1	1-5	6-10	11-25	26-50	51-100	100-500	501-1000	1000+
Bryozoans **= P**										
Membranipora membranacea (sea lace)										
Bugula turrita (sprial tufted bryozoan)										
Cryptosula pallasiana (red crust)										
Molluscs - Gastropods										
P = *Crepidula plana* (flat, whitish slipper shell)										
P = *Crepidula fornicata* (slipper shell, more mottled and raised)										
C = *Lunatia heros* (moon snail)										
C = *Euspira triseriata* (spotted moon snail)										
C = *Anomia* sp. (jingle shell)										
C = *Cerostoderma pinnulatum* (northern dwarf cockle)										
C = *Acmaea testudinalis* (limpet)										
C = *Buccinum undatum* (waved whelk, aperture shining white, short canal)										
C = *Neptunea lyrata decemcostata* (ten-ridged whelk)										
C = *Colus stimpsoni* (slender whelk, long siphonal canal)										
C = *Nassarius trivattata* (New England dog whelk)										
C = *Lacuna vincta* (northern lacuna snail)										
C = *Mitrella lunata* (lunar dove snail)										
C = *Flabellina pellucida* (red-gilled nudibranch)										
C = Dorid nudibranch										
C = *Dendronotus sp.* (Dendronid nudibranch)										
C = *Tonicella* sp. (chiton)										
Other										
Molluscs - Bivalvia **= C**										
Modiolus modiolous (northern horse mussel)										
Mytilus edulis (blue mussel)										
Placopecten magellanicus (sea scallop)										
Mercenaria mercenaria (northern quahog)										
Pitar morrhuanus (false quahog)										
Spisula solidissima (surf clam)										
Ensis directus (common razor clam)										
Astarte undata (wavy astarte clam)										
Petricola pholadiformis (false angel wing)										
Pandora gouldiana (Gould pandora, saddle-shaped flat shell)										
Annelids **= C**										
Spirorbis borealis (sinistral spiral tube worm, on seaweed)										
Myxicola infundibulum (slime fan worm)										
Scale worm										
Arthropods - Crustaceans										
P = Barnacles - Order Thoracica										

Figure C11. continued.

Site ID ______________________ Transect ID _____ Visit # ______

Arthropods - Crustaceans	0	<1	1-5	6-10	11-25	26-50	51-100	100-500	501-1000	1000+
C = *Homarus americanus* (American lobster)										
C = *Cancer irroratus* (rock)										
C = *Cancer borealis* (Jonah)										
C = *Mysid* sp. (mysid shrimp, dorsoventrally flattened)										
C = *Crangon septemspinosa* (sand shrimp, short rostrum, clear w/ blk spots)										
C = *Pandalus montagui* (Montague's shrimp, pink to red or red stripes)										
C = *Lebbeus polaris* (reddish-brown to red, transparent)										
C = Caprellid shrimp (skeleton shrimp)										
C = *Upogebia affinis* (ghost shrimp)										
C = *Pagurus sp.* (hermit crabs)										
C = *Libinia emarginata* (common spider crab)										
C = *Hyas* sp. (toad crab, decorator)										
C = *Neopanope* sp. (mud crab)										

Enchinoderms **= C**

Henricia sanguinolenta (blood sea star)										
Asterias vulgaris (northern sea star, yellow/white madreporite, row spines)										
Asterias forbesi (Forbes sea star, orange madreporite)										
Asterias sp.										
Subclass Ophiuroidea (brittle star)										
Cucumaria frondosa (orange-footed cucumber)										
Chiridota laevis (silky sea cucumber, pink/whitish)										
Stronglyocentrotus droenbachiensis (green urchin)										
Echinarachnius parma (common sand dollar)										
Solaster endeca (smooth sunstar)										
Crossaster papposus (spiny sunstar, bristles)										

CHORDATES

Tunicates

P = *Botryllus schlosseri* (golden star tunicate)										
C = *Molgula* sp. (sea grape)										
P = *Botrylloides violaceus* (orange/maroon/white sheath tunicate, colonial)										
P = *Didemnum albidum* (northern white crust)										
C = *Boltenia ovifera* (stalked tunicate, orange/yellow)										
C = *Halocynthia* sp. (sea peach tunicate)										
C = *Ciona intestinalis* (sea vase tunicate)										
C = *Styela clava* (club tunicate)										
P = Didemnum sp. (invasive tunicate)										
P = Unidtunicate, "white blob" possibly sea pork?										
Other tunicate species										

Figure C11. continued.

Site ID ______________________ Transect ID _____ Visit # ______

Fishes - continuous dorsal (cont) **= C**	0	<1	1-5	6-10	11-25	26-50	100	500	1000	1000+
Pholis gunnellus (rock gunnel)										
Ulvaria subbifurcata (radiated shanny)										
Macrozoarces americanus (ocean pout)										
Pseudopleuronectes americanus (winter flounder)										
Paralichthys denatus (summer flounder)										
Tautogolabrus adspersus (cunner)										
Tautoga onitis (tautog)										
Cyclopterus lumpus (lumpfish)										
Liparis sp. (snailfishes)										
Raja sp. (skates)										
Fishes - two dorsals **= C**										
Myoxocephalus aenaeus (grubby sculpin)										
Myoxocephalus octodecemspinosus (longhorn sculpin)										
Myoxocephalus scorpius (shorthorn scuplin)										
Myoxocephalus sp.										
Hemitripterus americanus (sea raven)										
Morone saxatilis (striped bass)										
Urophycis chuss (red hake, red-brown, feeler w/yellow, long dorsal thread)										
Urophycis tenuis (white hake, grey/purplish, short dorsal thread)										
Squalus acanthias (spiny dogfish)										
Fishes - three dorsals **= C**										
Melanogrammus aeglefinus (haddock)										
Pollachius virens (pollock)										
Gadus morhua (atlantic cod)										
Unid fish (describe)										

Figure C11. continued.

Date:
Observers:
Bait:

(only take a new waypoint if the trap is set far off it's intended waypoint)

FishPotID	Lon	Lat	Waypoint Set #	Trap Buoy ID #	Time Deployed
FFred1	-70.90680	42.34390			
FMrS2A	-70.90649	42.34391			
FMrS2B	-70.90668	42.34371			
FBarney3	-70.90639	42.34371			
FWilma4	-70.90714	42.34353			
FDino5A	-70.90686	42.34352			
FDino5B	-70.90704	42.34332			
FDino5C	-70.90693	42.34343			
FGazoo6A	-70.90662	42.34344			
FGazoo6B	-70.90681	42.34322			
FPeble7A	-70.90759	42.34302			
FPebble7B	-70.90747	42.34316			
FBetty8	-70.90727	42.34305			
FBamm9	-70.90706	42.34295			
FHub1	-70.90555	42.34433			
FHub2	-70.90580	42.34398			
FHub3	-70.90608	42.34363			
FHub4	-70.90636	42.34327			
FHub5	-70.90672	42.34279			
FHub6	-70.90711	42.34233			
FHub7	-70.90656	42.34303			
FNat1	-70.91173	42.33779			
FNat2	-70.91173	42.33804			
FNat3	-70.91134	42.33777			
FNat4	-70.91268	42.33832			
FNat5	-70.91310	42.33854			
FNat6	-70.91189	42.33790			
FNat7	-70.91330	42.33867			

Notes:

Figure C12. Small fish tagging study datasheet for recording location and time of fish pot sets.

Fish Potting Length Frequency / Tagging Datasheet

Site or Plot: ____________ Pot #:: ____________

Date Pot Placed: ____________ Time Pot Placed: ____________

Date Pot Removed: ____________ Time Pot Removed: ____________

CUNNER		RECAPTURED CUNNER		Other
Tag # / Color	Measurement	Tag # / Color	Measurement	SPECIES
/		/		
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Do not tag fish smaller than 8.0 cm

Tag color code: P = Pink, B = Blue, Gr = Green, W = White, Y = Yellow, R = Red, I = Ivory, Go = Gold

Figure C13. Small fish tagging study datasheet for tagged and recaptured fishes and lobster.

Methods for Suction Sampling Boston Harbor Artificial Reefs

Sample all 6 artificial reefs, 3 sandy controls, 1 hubline, and 1 natural reef

- Artificial Reefs:
  - o Sample one quadrat in each of four rock sizes:
    - ▪ Small cobble, large cobble, small boulder, small boulder/cobble mix
  - o Place quadrat on right or left edge of rock type section according to plan (see figure below), L/R assigned randomly and recorded
    - ▪ Next year, sample opposite side (L/R) of each section
- Sandy Controls:
  - o Sample with 12 quadrats

- Hubline:
  - o Sample with 12 quadrats **-** place six on western edge/ six on eastern edge

- Natural Reef:
  - o Sample with 12 quadrats – place all past far end point of "Natural Reef 3" transect (N 42.33814 W 070.9119)

Lg Boulder →	Site 1	X		Site 2 – Sand			Site 3	X
Sm Boulder →	**1 W**						**1 W**	
Lg Cobble →	**2 W**						**2 W**	
Sm Cobble →		**3 E**						**3 E**
Sm Mix →	**4 W**							**4 E**
Lg Mix →	X	X					X	X
Lg Boulder →	Site 4	X		Site 5 – Sand			Site 6 – Sand	
Sm Boulder →		**1 E**						
Lg Cobble →		**2 E**						
Sm Cobble →		**3 E**						
Sm Mix →	**4 W**							
Lg Mix →	X	X						
Lg Boulder →	Site 7	X		Site 8	X		Site 9	X
Sm Boulder →		**1 E**			**1 E**			**1 E**
Lg Cobble →	**2 W**				**2 E**		**2 W**	
Sm Cobble →	**3 W**				**3 E**		**3 W**	
Sm Mix →		**4 E**		**4 W**			**4 W**	
Lg Mix →	X	X		X	X		X	X

Figure C14. Schematic of artificial reef air-lift sampling locations on each reef used to direct divers while underwater.

Site ID: ____
Transect ID: ____
Logger ID: ____
Date Logger Placed: ____
Time Logger Placed: ____
Time Logger Retrieved: ____
Date Logger Retrieved:

Site ID: ____
Transect ID: ____
Logger ID: ____
Date Logger Placed: ____
Time Logger Placed: ____
Time Logger Retrieved: ____
Date Logger Retrieved:

Site ID: ____
Transect ID: ____
Logger ID: ____
Date Logger Placed: ____
Time Logger Placed: ____
Time Logger Retrieved: ____
Date Logger Retrieved:

Site ID: ____
Transect ID: ____
Logger ID: ____
Date Logger Placed: ____
Time Logger Placed: ____
Time Logger Retrieved: ____
Date Logger Retrieved:

Site ID: ____
Transect ID: ____
Logger ID: ____
Date Logger Placed: ____
Time Logger Placed: ____
Time Logger Retrieved: ____
Date Logger Retrieved:

Site ID: ____
Transect ID: ____
Logger ID: ____
Date Logger Placed: ____
Time Logger Placed: ____
Time Logger Retrieved: ____
Date Logger Retrieved:

Site ID: ____
Transect ID: ____
Logger ID: ____
Date Logger Placed: ____
Time Logger Placed: ____
Time Logger Retrieved: ____
Date Logger Retrieved:

Site ID: ____
Transect ID: ____
Logger ID: ____
Date Logger Placed: ____
Time Logger Placed: ____
Time Logger Retrieved: ____
Date Logger Retrieved:

Figure C15. Temperature monitor datasheet.

Appendix IVC2.1. Smelt Fyke Net Field Sampling and Data Collection Protocol

Sampling Period. March 4th - May 16th.

Fyke Net. The net had six hoops (2.5 ft. diameter) attached to a box frame (4x4 ft.). Throats were attached to second hoop inside mouth and fourth hoop. Box frame wings (4x4 ft.) were attached to both sides of the box frame mouth. All meshes were 1/4 inch. Wing poles were set 8.2 ft. (2.5 m) apart.

Deployment. The fyke nets were set overnight in the mid-channel location of each river and hauled near low tide the next day. Sample dates were randomly selected because of the complexity of coordinating traffic, tide, and other tasks. The setting and hauling of nets occurred near lower tides, therefore tide stage was important for scheduling deployments. Three overnight sets were made each week (11 weeks, 33 sets) at each station.

Sampling Stations. The sampling stations were located at the lower end of spawning habitat where tidal influence was present. The Jones River (Kingston), Fore River (Braintree), Saugus River (Saugus), and Parker River (Newbury) served as population index stations. The Crane River (Danvers) and North River (Salem) were sampled with the same methodology as restoration river stations. In addition, two Buzzards Bay stations (Weweantic River, Wareham; and the East Branch of the Westport River, Westport) were added in 2008 for consideration as long-term population index stations.

Catch Processing. The net cod-end was emptied into buckets, contents separated by species, and all fish counted, measured (TL, mm), and released. All decapods were counted and released. Eels were measured to nearest cm. A random sample of up to 20 fish were measured for large catches of mummichogs or sticklebacks.

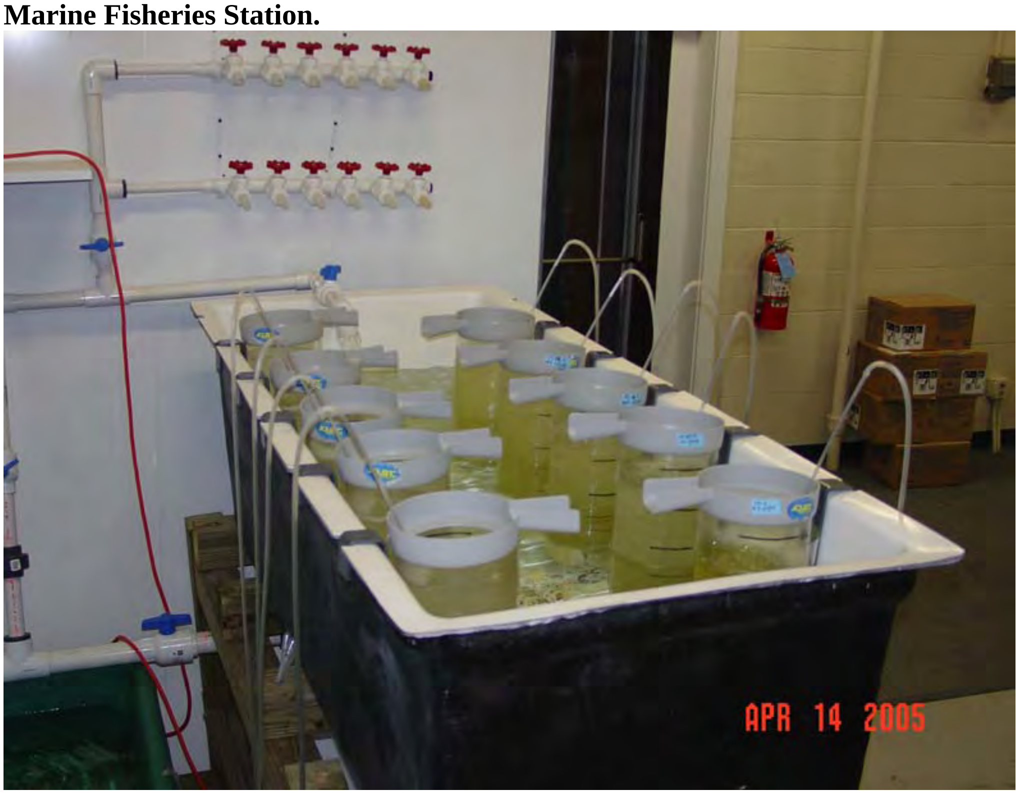
Field Data Recording. Net soak time (nearest 0.25 hour), tide stage, moon stage, river discharge and water chemistry with YSI sonde (temp., pH, conductivity, D.O., and turbidity)

Age/Sex Sub-sample. A weekly age sample of live smelt was collected only in the Fore and Saugus rivers when catch $\geq$20. Smelt were tallied by sex and 1-cm intervals, selecting up to 5 smelt per sex per cm for the age sample. Large catches of >100 smelt were subsampled with buckets to ensure random samples. Once an age subsample was saved, up to 80 randomly selected smelt were measured, sexed, and released. Any remaining smelt were counted and released. Smelt that died in the net were saved for age samples if additional samples were needed.

Laboratory Processing. Following net collections, the smelt saved for age subsamples were processed that day or the next in laboratory. The following data were collected: sex, maturity, total length, weight, and scales. Fin clips were saved in 95% EtOH for genetic analysis; attempted to collect 50 females and 50 males from each river, and save clips in individual micro-centrifuge vials.

Appendix Figure IVC2.2. Smelt fyke net in the Fore River, Braintree.

Appendix Figure IVC2.3. Smelt egg incubation jars at Annisquam River Marine Fisheries Station.



Appendix Table IVC2.4. Fyke net catch in the Parker River, Newbury, 2005-2007 (78 total hauls).

Species Name	Scientific Name	Type	2005 (No.) (26 hauls)	2006 (No.) (29 hauls)	2007 (No.) (23 hauls)	Total FOC (%)	Total CPUE
rainbow smelt	*Osmerus mordax*	Diadromous	924	123	563	60.3	20.6
American eel	*Anguilla rostrata*	Diadromous	9	12	3	24.4	0.3
sea lamprey	*Petromyzon marinus*	Diadromous	15	17	38	37.2	0.9
alewife	*Alosa pseudoharengus*	Diadromous	1		6	5.1	0.1
white perch	*Morone americanus*	Diadromous		7	12	6.4	0.2
blueback herring	*Alosa aestivalis*	Diadromous			1	1.3	0.0
mummichog	*Fundulus heteroclitus*	Estuarine	10	7	1	15.4	0.2
fourspine stickleback	*Apeltes quadracus*	Estuarine	222	122	33	75.6	4.8
threespine stickleback	*Gasterosteus aculeatus*	Estuarine	11	59	94	39.7	2.1
killifish	*Fundulus majalis*	Estuarine			2	2.6	0.0
Atlantic silverside	*Mendia menidia*	Estuarine		2		1.3	0.0
yellow perch	*Perca flavens*	Freshwater	2		11	14.1	0.2
white sucker	*Catostomus commersoni*	Freshwater	30	5	1	23.1	0.5
yellow bullhead	*Ameiurus natalis*	Freshwater	4	2	4	11.5	0.1
redfin pickerel	*Esox americanus americanus*	Freshwater	2	10	2	14.1	0.2
banded sunfish	*Enneacanthus obesus*	Freshwater		7	6	14.1	0.2
pumpkinseed	*Lepomis gibbosus*	Freshwater	2		3	5.1	0.1
golden shiner	*Notemigonus crysoleucas*	Freshwater	13	6	77	33.3	1.2
green crab	*Carcinus maenas*	Arthropod			2	2.6	0.0
crayfish	*Cambarus sp.*	Arthropod	3	3	4	11.5	0.1
sand shrimp	*Crangon septemspinosa*	Arthropod			1	1.3	0.0
Total Fish Catch			1245	379	857		

Appendix Table IVC2.A5. **Fyke net catch in the Crane River, Danvers, 2005-2007 (84 total hauls).**

Species Name	Scientific Name	Type	2005 (No.) (27 hauls)	2006 (No.) (28 hauls)	2007 (No.) (29 hauls)	Total FOC (%)	Total CPUE
rainbow smelt	*Osmerus mordax*	Diadromous	6	74	6	27.4	1.0
American eel	*Anguilla rostrata*	Diadromous	6	3	2	13.1	0.1
mummichog	*Fundulus heteroclitus*	Estuarine	58	333	157	73.8	6.5
threespine stickleback	*Gasterosteus aculeatus*	Estuarine	14	220	51	66.7	3.4
fourspine stickleback	*Apeltes quadracus*	Estuarine	5	22	11	35.7	0.5
banded sunfish	*Enneacanthus obesus*	Freshwater			5	6	0.1
golden shiner	*Notemigonus crysoleucas*	Freshwater			16	7.1	0.2
yellow perch	*Perca flavens*	Freshwater		6	17	10.7	0.3
pumpkinseed	*Lepomis gibbosus*	Freshwater			2	2.4	0.0
sand shrimp	*Crangon septemspinosa*	Arthropod		18		7.1	0.2
crayfish	*Cambarus sp.*	Arthropod		1		1.2	0.0
Total Fish Catch			89	658	267		

Appendix Table IVC2.A6. Fyke net catch in the North River, Salem, 2005-2007 (85 total hauls).

Species Name	Scientific Name	Type	2005 (No.) (27 hauls)	2006 (No.) (28 hauls)	2007 (No.) (30 hauls)	Total FOC (%)	Total CPUE
rainbow smelt	*Osmerus mordax*	Diadromous	5	43	12	29.4	0.7
American eel	*Anguilla rostrata*	Diadromous	16	15	22	29.4	0.6
white perch	*Morone americanus*	Diadromous		1		1.2	0.0
mummichog	*Fundulus heteroclitus*	Estuarine	76	7553	884	87.1	100.2
threespine stickleback	*Gasterosteus aculeatus*	Estuarine	20	294	332	74.1	7.6
fourspine stickleback	*Apeltes quadracus*	Estuarine	1	20	9	25.9	0.4
ninespine stickleback	*Pungitius pungitius*	Estuarine			1	1.2	0.0
golden shiner	*Notemigonus crysoleucas*	Freshwater	4	1	5	8.2	0.1
banded sunfish	*Enneacanthus obesus*	Freshwater	1		7	7.1	0.1
redfin pickerel	*Esox americanus americanus*	Freshwater					
yellow perch	*Perca flavens*	Freshwater			3	3.5	0.0
yellow bullhead	*Ameiurus natalis*	Freshwater	1			1.2	0.0
green crab	*Carcinus maenas*	Arthropod		1	1	2.4	0.0
sand shrimp	*Crangon septemspinosa*	Arthropod		2	1	3.5	0.0
grass shrimp	*Palaemonetes pugio*	Arthropod			1	1.2	0.0
Total Fish Catch			124	7927	1275		

Appendix Table IVC2.A7. Fyke net catch summary for the Saugus River, Saugus, 2005-2007 (94 total hauls).

Species Name	Scientific Name	Type	2005 (No.) (32 hauls)	2006 (No.) (30 hauls)	2007 (No.) (32 hauls)	Total FOC (%)	Total CPUE
rainbow smelt	*Osmerus mordax*	Diadromous	141	1458	2433	67.0	42.9
white perch	*Morone americanus*	Diadromous	12	66	6	21.3	0.9
alewife	*Alosa pseudoharengus*	Diadromous	11	3	7	11.7	0.2
American eel	*Anguilla rostrata*	Diadromous	8	12	9	23.4	0.3
blueback herring	*Alosa aestivalis*	Diadromous		1	1	2.1	0.0
brown trout (salter)	*Salmo trutta*	Diadromous		1		1.1	0.0
mummichog	*Fundulus heteroclitus*	Estuarine	21	268	21	41.5	3.3
fourspine stickleback	*Apeltes quadracus*	Estuarine	185	257	63	83.0	5.4
threespine stickleback	*Gasterosteus aculeatus*	Estuarine	63	83	14	63.8	1.7
yellow perch	*Perca flavens*	Freshwater	50	26	6	30.9	0.9
white sucker	*Catostomus commersoni*	Freshwater	37	42	3	31.9	0.9
redfin pickerel	*Esox americanus americanus*	Freshwater	4	1	1	6.4	0.1
chain pickerel	*Esox niger*	Freshwater		3		2.1	0.0
banded sunfish	*Enneacanthus obesus*	Freshwater			2	2.1	0.0
yellow bullhead	*Ameiurus natalis*	Freshwater			3	3.2	0.0
golden shiner	*Notemigonus crysoleucas*	Freshwater		1	2	3.2	0.0
white crappie		Freshwater			2	1.1	0.0
crayfish	*Cambarus sp.*	Arthropod	1		3	4.3	0.0
sand shrimp	*Crangon septemspinosa*	Arthropod			1	1.1	0.0
Total Fish Catch			532	2222	2573		

Appendix Table IVC2.A8. Fyke net catch summary for the Fore River, Braintree, 2005-2007 (91 total hauls).

Species Name	Scientific Name	Type	2005 (No.) (30 Hauls)	2006 (No.) (29 Hauls)	2007 (No.) (32 hauls)	Total FOC (%)	Total CPUE
rainbow smelt	*Osmerus mordax*	Diadromous	2131	1014	3435	86.8	72.3
American eel	*Anguilla rostrata*	Diadromous	44	60	83	39.6	2.1
alewife	*Alosa pseudoharengus*	Diadromous		1		1.1	0.0
Atlantic tomcod	*Microgadus tomcod*	Diadromous	19	16	10	29.7	0.5
striped bass	*Morone saxilitus*	Diadromous			1	1.1	0.0
blueback herring	*Alosa aestivalis*	Diadromous			1	1.1	0.0
mummichog	*Fundulus heteroclitus*	Estuarine	45	38	3	34.1	0.9
fourspine stickleback	*Apeltes quadracus*	Estuarine	77	36	1	42.9	1.3
threespine stickleback	*Gasterosteus aculeatus*	Estuarine	6	26	48	31.9	0.9
killifish	*Fundulus majalis*	Estuarine	1	1	1	3.3	0.0
red hake	*Urophycis chuss*	Estuarine		1		1.1	0.0
Atlantic silverside	*Mendia menidia*	Estuarine		1	1	2.2	0.0
bluegill	*Lepomis macrochirus*	Freshwater	3			3.3	0.0
yellow perch	*Perca flavens*	Freshwater	8			6.6	0.1
banded sunfish	*Enneacanthus obesus*	Freshwater			1	1.1	0.0
sand shrimp	*Crangon septemspinosa*	Arthropod	27	223	33	45.1	3.1
grass shrimp	*Palaemonetes pugio*	Arthropod		46	16	22.0	0.7
green crab	*Carcinus maenas*	Arthropod		33	10	16.5	0.5
horseshoe crab	*Limulus polyphemus*	Arthropod	1	1		2.2	0.0
crayfish	*Cambarus sp.*	Arthropod	1		2	3.3	0.0
Total Fish Catch			2334	1194	3585		

Appendix Table IVC2.A9. **Fyke net catch summary for the Jones River, Kingston, 2005-2007 (93 total hauls).**

Species Name	Scientific Name	Type	2005 (No.) (32 hauls)	2006 (No.) (29 hauls)	2007 (No.) (32 hauls)	Total FOC (%)	Total CPUE
rainbow smelt	*Osmerus mordax*	Diadromous	489	614	103	71.0	13.0
American eel	*Anguilla rostrata*	Diadromous	12	16	2	19.4	0.3
white perch	*Morone americanus*	Diadromous	5	6	2	11.8	0.1
alewife	*Alosa pseudoharengus*	Diadromous	2	3		4.3	0.1
Atlantic tomcod	*Microgadus tomcod*	Diadromous	2	15	4	15.1	0.2
blueback herring	*Alosa aestivalis*	Diadromous	1	1	1	3.2	0.0
sea lamprey	*Petromyzon marinus*	Diadromous		1	1	2.2	0.0
mummichog	*Fundulus heteroclitus*	Estuarine	27	44	2	26.9	0.8
fourspine stickleback	*Apeltes quadracus*	Estuarine	31	13	2	29.0	0.5
threespine stickleback	*Gasterosteus aculeatus*	Estuarine	5	11	2	15.1	0.2
Atlantic herring	*Clupea harengus*	Estuarine	3	4	4	5.4	0.1
ninespine stickleback	*Pungitius pungitius*	Estuarine		1		1.1	0.0
smooth flounder	*Liopsetta putnami*	Estuarine		1		1.1	0.0
winter flounder	*Pseudopleuronectes americanus*	Estuarine		1		1.1	0.0
Atlantic silverside	*Mendia menidia*	Estuarine	2	89		14.0	1.0
bluegill	*Lepomis macrochirus*	Freshwater	39	2		9.7	0.4
yellow perch	*Perca flavens*	Freshwater	31	20	2	15.1	0.6
brown trout	*Salmo trutta*	Freshwater		1		1.1	0.0
chain pickerel	*Esox niger*	Freshwater		1		1.1	0.0
pumpkinseed	*Lepomis gibbosus*	Freshwater	23			4.3	0.2
green crab	*Carcinus maenas*	Arthropod	10	9	8	17.2	0.3
sand shrimp	*Crangon septemspinosa*	Arthropod	2	123	1	16.1	1.4
Total Fish Catch			672	844	125		

Appendix IVD.A. 2006 Shellfish Enhancement Site Sampling Summary

Site	Net	Seed Date	Sample Date	Ave. Clam Length	Standard Deviation	Total # of Clams
Bathing Beach, Hingham	A1	6/22/2006	1/11/2007	30.8	4.4	102
Bathing Beach, Hingham	A2	6/22/2006	1/11/2007	29.2	4.6	45
Bathing Beach, Hingham	A3	6/22/2006	1/11/2007	30.4	5.1	64
Bathing Beach, Hingham	B1	6/22/2006	1/11/2007	30.1	3.9	81
Bathing Beach, Hingham	B2	6/22/2006	1/11/2007	33.2	3.0	50
Bathing Beach, Hingham	B3	6/22/2006	1/11/2007	32.5	4.6	65
Bathing Beach, Hingham	C1	6/22/2006	12/29/2006	32.3	3.4	86
Bathing Beach, Hingham	C2	6/22/2006	1/11/2007	32.0	4.2	116
Bathing Beach, Hingham	C3	6/22/2006	12/29/2006	33.8	3.1	37
Bathing Beach, Hingham	D1	6/22/2006	1/11/2007	31.7	3.8	47
Bathing Beach, Hingham	D2	6/22/2006	1/11/2007	33.0	4.7	49
Bathing Beach, Hingham	D3	6/22/2006	1/11/2007	31.7	3.5	57
Bathing Beach, Hingham	E	6/22/2006	1/11/2007	33.6	5.0	160
Quincy	L	10/13/2006	12/29/2006	24.0	3.1	71
Abigail Adams Park, Weymouth	A	7/25/2006	12/29/2006	22.4	3.3	11
Abigail Adams Park, Weymouth	B	7/25/2006	12/29/2006			
Abigail Adams Park, Weymouth	C	7/25/2006	12/29/2006			
Bathing Beach, Hingham	A1	6/22/2006	5/14/2007	34.9	4.7	67
Bathing Beach, Hingham	A2	6/22/2006	5/14/2007	36.3	5.3	78
Bathing Beach, Hingham	A3	6/22/2006	5/14/2007	38.0	5.8	63
Bathing Beach, Hingham	B1	6/22/2006	5/14/07;5/20/07	34.1	5.1	79
Bathing Beach, Hingham	B2	6/22/2006	5/14/07;5/20/07	38.6	5.8	68
Bathing Beach, Hingham	B3	6/22/2006	5/20/2007	36.7	5.6	112
Bathing Beach, Hingham	C1	6/22/2006	5/20/2007	36.4	4.2	74
Bathing Beach, Hingham	C2	6/22/2006	5/20/2007	37.6	4.6	65
Bathing Beach, Hingham	C3	6/22/2006	5/20/2007	35.5	4.7	131
Bathing Beach, Hingham	D1	6/22/2006	5/22/07;5/31/07	38.8	3.9	60
Bathing Beach, Hingham	D2	6/22/2006	5/22/2007	37.8	4.7	78
Bathing Beach, Hingham	D3	6/22/2006	5/22/2007	41.9	4.0	59
Bathing Beach, Hingham	E	6/22/2006	5/14/2007	41.0	4.7	83
Quincy	L	10/13/2006	5/9/2007	33.2	4.4	60
Abigail Adams Park, Weymouth	A	7/25/2006	5/29/2007	28.4	6.2	4
Abigail Adams Park, Weymouth	B	7/25/2006	5/29/2007	28.4	5.3	30
Abigail Adams Park, Weymouth	C	7/25/2006	5/29/2007	26.9	3.4	64

Appendix IVD.A. (continued)

Site	Net	Seed Date	Sample Date	Ave. Clam Length	Standard Deviation	Total # of Clams
Bathing Beach, Hingham	A1	6/22/2006	11/8/2007	46.3	3.7	63
Bathing Beach, Hingham	A2	6/22/2006	11/28/2007	49.7	5.2	96
Bathing Beach, Hingham	A3	6/22/2006	11/28/2007	51.0	4.6	55
Bathing Beach, Hingham	B1	6/22/2006	11/28/2007	50.8	5.3	88
Bathing Beach, Hingham	B2	6/22/2006	11/28/2007	52.9	5.6	64
Bathing Beach, Hingham	B3	6/22/2006	11/28/2007	52.6	5.3	55
Bathing Beach, Hingham	C1	6/22/2006	11/28/2007	47.3	3.4	55
Bathing Beach, Hingham	C2	6/22/2006	12/7/2007	49.0	4.1	76
Bathing Beach, Hingham	C3	6/22/2006	12/7/2007	51.8	5.0	62
Bathing Beach, Hingham	D1	6/22/2006	12/7/2007	54.1	5.4	49
Bathing Beach, Hingham	D2	6/22/2006	12/7/2007	54.2	5.7	72
Bathing Beach, Hingham	D3	6/22/2006	12/7/2007	55.4	5.9	72
Bathing Beach, Hingham	E	6/22/2006	11/8/2007	53.9	6.3	61
Quincy	L	10/13/2006	10/29/2007	50.2	5.4	24
Abigail Adams Park, Weymouth	A	7/25/2006	10/31/2007	33.6	6.0	6
Abigail Adams Park, Weymouth	B	7/25/2006	10/31/2007	40.5	5.0	15
Abigail Adams Park, Weymouth	C	7/25/2006	10/31/2007	39.1	5.8	38

Appendix IVD.B. 2007 Shellfish Enhancement Site Sampling Summary

Site	Sample Date	Net	Ave. Length	Std Dev	# Samples	# of Seed	Damaged Seed	Total # of Seed Clams	Total # of Clams
Court Rd., Winthrop	7/6/2007	A1	15.3	1.2	1	25	0	25	31
Court Rd., Winthrop	12/28/2007	A1	33.8	4.2	1	118	5	123	123
Court Rd., Winthrop	4/23/2008	A1	35.2	5.0	1	91	12	103	104
Court Rd., Winthrop	10/31/2007	A2	32.2	5.6	2	40	14	54	67
Court Rd., Winthrop	12/28/2007	A2	34.3	5.3	2	106	11	117	120
Court Rd., Winthrop	4/23/2008	A2	39.9	6.9	1	65	10	75	77
Court Rd., Winthrop	11/14/2007	B1	37.1	3.6	2	39	11	50	61
Court Rd., Winthrop	12/28/2007	B1	36.0	5.1	1	58	2	60	62
Court Rd., Winthrop	4/23/2008	B1	41.6	5.7	2	76	7	83	85
Court Rd., Winthrop	7/6/2007	B2	14.4	2.3	1	101	1	102	102
Court Rd., Winthrop	9/7/2007	B2	32.7	5.7	1	14	0	14	14
Court Rd., Winthrop	12/28/2007	B2	37.6	4.3	2	75	12	87	92
Court Rd., Winthrop	4/23/2008	B2	40.4	5.9	2	63	6	69	74
Court Rd., Winthrop	10/31/2007	C1	34.9	4.5	2	18	7	25	40
Court Rd., Winthrop	12/28/2007	C1	37.6	3.6	2	56	14	70	80
Court Rd., Winthrop	4/23/2008	C1	42.5	5.1	2	85	18	103	104
Court Rd., Winthrop	7/6/2007	C2	16.2	3.2	1	9	0	9	9
Court Rd., Winthrop	12/28/2007	C2	38.2	4.2	1	59	8	67	75
Court Rd., Winthrop	4/23/2008	C2	42.6	6.2	2	86	10	96	98
Snake Island, Winthrop	9/28/2007	1	34.5	4.2	1	7	0	7	11
Snake Island, Winthrop	11/21/2007	1	46.9	4.4	2	53	0	53	59
Snake Island, Winthrop	6/3/2008	1	44.1	4.5	1	158	5	163	167
Snake Island, Winthrop	9/28/2007	2	39.7	2.4	1	9	1	10	12
Snake Island, Winthrop	11/21/2007	2	45.2	6.0	2	56	0	56	58
Snake Island, Winthrop	6/3/2008	2	51.8	5.5	3	39	1	40	44
Snake Island, Winthrop	7/20/2007	3	13.9	1.7	1	59	0	59	59
Snake Island, Winthrop	11/21/2007	3	39.9	4.5	3	75	0	75	76
Snake Island, Winthrop	6/3/2008	3	44.3	5.6	1	68	6	74	94
Snake Island, Winthrop	7/20/2007	4	15.0	1.7	2	66	0	66	66
Snake Island, Winthrop	11/21/2007	4	33.8	4.7	3	70	0	70	70
Snake Island, Winthrop	6/3/2008	4	43.5	5.4	1	93	4	97	119
Snake Island, Winthrop	7/20/2007	5	13.4	1.4	2	109	0	109	109
Snake Island, Winthrop	11/21/2007	5	37.0	4.7	3	65	0	65	65
Snake Island, Winthrop	6/3/2008	5	42.6	4.1	1	64	10	74	81
Snake Island, Winthrop	7/20/2007	6	14.7	1.6	2	21	0	21	21
Snake Island, Winthrop	11/21/2007	6	36.5	3.5	2	73	0	73	75
Snake Island, Winthrop	6/3/2008	6	44.0	5.7	1	70	7	77	89

Appendix IVD.B.
(continued)

Site	Sample Date	Net	Ave. Length	Std Dev	# Samples	# of Seed	Damaged Seed	Total # of Seed Clams	Total # of Clams
Terne Road, Quincy	8/14/2007	A1	18.8	0.3	1	3	0	3	3
Terne Road, Quincy	1/7/2008	A1	31.4	5.6	5	169	14	183	186
Terne Road, Quincy	5/8/2008	A1	34.7	4.1	1	77	1	78	78
Terne Road, Quincy	8/14/2007	A2	16.9	1.9	1	5	0	5	5
Terne Road, Quincy	1/7/2008	A2	31.5	4.0	2	160	17	177	180
Terne Road, Quincy	5/8/2008	A2	34.6	5.4	1	100	10	110	110
Terne Road, Quincy	8/14/2007	B1	0.0	0.0	1	0	0	0	0
Terne Road, Quincy	1/7/2008	B1	35.1	3.4	1	62	4	66	68
Terne Road, Quincy	5/8/2008	B1	38.3	4.3	1	84	15	99	99
Terne Road, Quincy	8/14/2007	B2	21.7	2.3	1	49	0	49	51
Terne Road, Quincy	1/7/2008	B2	29.8	4.7	1	77	4	81	81
Terne Road, Quincy	5/8/2008	B2	39.2	4.1	2	70	11	81	82
Terne Road, Quincy	8/14/2007	C1	0.0	0.0	1	0	0	0	0
Terne Road, Quincy	1/7/2008	C1	29.8	3.8	1	113	4	117	119
Terne Road, Quincy	5/8/2008	C1	38.4	5.5	2	82	8	90	90
Terne Road, Quincy	8/14/2007	C2	20.5	2.6	2	395	0	395	395
Terne Road, Quincy	1/7/2008	C2	35.5	4.6	2	66	10	76	77
Terne Road, Quincy	5/8/2008	C2	40.4	4.5	2	78	8	86	89
Post Island Road, Quincy	9/14/2007	D	18.3	1.5	1	12	1	13	13
Post Island Road, Quincy	9/24/2007	D	19.2	2.6	1	15	0	15	15
Post Island Road, Quincy	1/16/2008	D	20.2	2.3	1	61	0	61	61
Post Island Road, Quincy	5/8/2008	D	28.3	3.5	3	10	1	11	12
Post Island Road, Quincy	9/24/2007	E	22.8	1.0	1	4	0	4	4
Post Island Road, Quincy	1/16/2008	E	25.5	1.0	3	4	0	4	5
Post Island Road, Quincy	5/8/2008	E	0.0	0.0	3	1	0	1	2
Post Island Road, Quincy	9/24/2007	F	0.0	0.0	1	0	0	0	0
Post Island Road, Quincy	1/16/2008	F	24.7	2.5	1	16	1	17	17
Post Island Road, Quincy	5/8/2008	F	32.6	4.2	3	70	1	71	77
Post Island Road, Quincy	9/24/2007	G	23.1	3.8	1	19	4	23	23
Post Island Road, Quincy	1/16/2008	G	28.2	3.2	1	169	4	173	173
Post Island Road, Quincy	5/8/2008	G	33.7	4.0	1	73	2	75	79
Post Island Road, Quincy	9/24/2007	H	23.2	2.7	1	11	2	13	13
Post Island Road, Quincy	1/11/2008	H	28.8	3.2	3	87	5	92	92
Post Island Road, Quincy	5/8/2008	H	34.1	4.3	1	64	4	68	68
Post Island Road, Quincy	9/24/2007	I	23.7	4.1	1	8	0	8	8
Post Island Road, Quincy	1/11/2008	I	24.8	3.1	3	12	1	13	13
Post Island Road, Quincy	5/8/2008	I	33.1	3.6	1	91	3	94	95

Appendix IVD.B.
(continued)

Site	Sample Date	Net	Ave. Length	Std Dev	# Samples	# of Seed	Damaged Seed	Total # of Seed Clams	Total # of Clams
Laundry Cove, Weymouth	10/9/2007	A1	21.8	1.9	2	36	3	39	44
Laundry Cove, Weymouth	1/16/2008	A1	25.2	2.9	2	103	1	104	110
Laundry Cove, Weymouth	6/11/2008	A1	34.6	3.7	1	73	6	79	96
Laundry Cove, Weymouth	10/9/2007	A2	27.3	5.7	2	11	1	12	13
Laundry Cove, Weymouth	1/16/2008	A2	27.5	3.6	2	86	0	86	87
Laundry Cove, Weymouth	5/21/2008	A2	35.1	5.5	1	95	0	95	100
Laundry Cove, Weymouth	10/9/2007	A3	0.0	0.0	2	0	0	0	2
Laundry Cove, Weymouth	1/16/2008	A3	0.0	0.0	3	1	0	1	1
Laundry Cove, Weymouth	5/21/2008	A3	23.0	2.0	1	3	4	7	25
Laundry Cove, Weymouth	10/9/2007	B1	22.0	3.4	2	22	0	22	23
Laundry Cove, Weymouth	1/16/2008	B1	25.4	3.6	1	96	2	98	100
Laundry Cove, Weymouth	6/11/2008	B1	35.5	5.0	1	66	8	74	82
Laundry Cove, Weymouth	10/9/2007	B2	23.8	4.0	2	44	1	45	45
Laundry Cove, Weymouth	2/20/2008	B2	29.4	3.2	2	80	3	83	91
Laundry Cove, Weymouth	6/11/2008	B2	38.0	5.5	1	78	6	84	109
Laundry Cove, Weymouth	10/30/2007	B3	26.3	4.3	2	3	0	3	4
Laundry Cove, Weymouth	2/20/2008	B3	30.0	3.0	3	8	0	8	10
Laundry Cove, Weymouth	5/21/2008	B3	34.0	8.6	1	11	4	15	28
Broad Cove, Hingham	10/12/2007	F1	0.0	0.0	1	0	1	1	2
Broad Cove, Hingham	12/18/2007	F1	19.6	2.6	1	99	1	100	102
Broad Cove, Hingham	4/11/2008	F1	22.6	3.2	1	75	0	75	75
Broad Cove, Hingham	10/25/2007	F2	18.8	3.3	2	19	0	16	20
Broad Cove, Hingham	12/18/2007	F2	20.7	2.6	3	92	0	92	94
Broad Cove, Hingham	4/11/2008	F2	22.0	3.0	1	87	1	88	88
Broad Cove, Hingham	10/12/2007	G1	17.6	0.0	1	1	0	1	1
Broad Cove, Hingham	12/18/2007	G1	21.0	2.5	1	86	0	86	87
Broad Cove, Hingham	4/11/2008	G1	22.1	2.7	1	60	1	61	61
Broad Cove, Hingham	10/25/2007	G2	18.7	2.7	2	8	0	7	8
Broad Cove, Hingham	12/20/2007	G2	21.0	2.7	1	108	0	108	109
Broad Cove, Hingham	4/11/2008	G2	24.4	3.3	1	87	1	88	89
Broad Cove, Hingham	10/12/2007	H1	18.3	2.2	1	11	0	11	13
Broad Cove, Hingham	12/20/2007	H1	28.9	2.4	1	63	0	63	63
Broad Cove, Hingham	4/11/2008	H1	22.4	2.8	1	88	1	89	92
Broad Cove, Hingham	10/25/2007	H2	18.8	2.2	2	27	0	28	30
Broad Cove, Hingham	12/20/2007	H2	19.5	2.3	3	83	2	85	98
Broad Cove, Hingham	4/11/2008	H2	22.4	3.5	3	58	2	60	62
Broad Cove, Hingham	10/25/2007	H3	19.2	2.1	2	43	1	44	46
Broad Cove, Hingham	12/20/2007	H3	20.2	2.9	1	174	0	174	176
Broad Cove, Hingham	4/11/2008	H3	23.1	2.6	1	108	1	109	109

Appendix IVD.B.
(continued)

Site	Sample Date	Net	Ave. Length	Std Dev	# Samples	# of Seed	Damaged Seed	Total # of Seed Clams	Total # of Clams
Casey's Beach East, Hull	10/29/2007	A1	41.6	6.7	2	43	7	50	56
Casey's Beach East, Hull	1/27/2008	A1	40.3	5.5	1	98	8	106	108
Casey's Beach East, Hull	5/22/2008	A1	38.5	4.6	1	177	25	202	211
Casey's Beach East, Hull	8/7/2007	A2	32.2	3.4	1	33	0	33	33
Casey's Beach East, Hull	1/27/2008	A2	40.1	5.1	1	106	10	116	118
Casey's Beach East, Hull	5/22/2008	A2	43.7	6.7	1	94	8	102	107
Casey's Beach East, Hull	10/29/2007	A3	40.4	4.4	2	44	4	48	50
Casey's Beach East, Hull	1/27/2008	A3	37.8	5.7	1	91	6	97	99
Casey's Beach East, Hull	5/22/2008	A3	42.1	7.3	1	113	6	119	126
Casey's Beach East, Hull	10/29/2007	B1	38.6	5.5	2	41	0	41	44
Casey's Beach East, Hull	1/18/2008	B1	42.6	4.6	2	95	12	107	107
Casey's Beach East, Hull	5/22/2008	B1	42.5	5.9	1	86	6	92	94
Casey's Beach East, Hull	10/29/2007	B2	40.7	5.1	2	85	0	85	90
Casey's Beach East, Hull	1/18/2008	B2	41.2	5.5	2	94	9	103	109
Casey's Beach East, Hull	5/22/2008	B2	45.7	4.5	1	86	0	86	90
Casey's Beach East, Hull	8/7/2007	B3	33.1	3.4	1	27	0	27	28
Casey's Beach East, Hull	1/18/2008	B3	40.6	5.0	1	83	10	93	96
Casey's Beach East, Hull	5/22/2008	B3	44.8	4.6	1	69	8	77	80
Casey's Beach West, Hull	8/2/2007	C1	31.8	4.8	1	36	0	36	36
Casey's Beach West, Hull	1/18/2008	C1	39.1	5.3	1	94	5	99	101
Casey's Beach West, Hull	5/22/2008	C1	44.6	6.1	1	72	7	79	84
Casey's Beach West, Hull	8/2/2007	C2	31.0	3.3	1	35	0	35	35
Casey's Beach West, Hull	1/18/2008	C2	37.4	5.3	2	64	1	65	65
Casey's Beach West, Hull	5/22/2008	C2	44.1	4.3	1	67	7	74	74
Casey's Beach West, Hull	7/3/2007	C3	23.6	3.1	1	17	0	17	17
Casey's Beach West, Hull	8/2/2007	C3	30.1	3.9	1	22	0	22	23
Casey's Beach West, Hull	1/18/2008	C3	39.2	4.2	1	63	5	68	68
Casey's Beach West, Hull	5/22/2008	C3	48.1	4.2	2	65	3	68	69
Casey's Beach West, Hull	7/3/2007	D1	22.5	2.8	1	22	0	22	22
Casey's Beach West, Hull	8/2/2007	D1	31.5	3.1	1	32	3	35	35
Casey's Beach West, Hull	1/18/2008	D1	39.3	5.3	1	75	0	75	75
Casey's Beach West, Hull	5/22/2008	D1	43.2	5.3	1	63	1	64	65
Casey's Beach West, Hull	7/3/2007	D2	22.6	2.4	1	16	0	16	16
Casey's Beach West, Hull	8/2/2007	D2	31.2	4.0	1	64	7	71	73
Casey's Beach West, Hull	1/18/2008	D2	40.4	5.4	1	76	4	80	81
Casey's Beach West, Hull	5/22/2008	D2	43.2	5.4	1	74	7	81	84
Casey's Beach West, Hull	8/2/2007	D3	31.6	3.6	1	27	2	29	29
Casey's Beach West, Hull	1/18/2008	D3	39.2	5.6	1	88	6	94	94
Casey's Beach West, Hull	5/22/2008	D3	45.4	5.4	1	64	7	71	71

Appendix IVD.C. 2007 Wild Spat Collector Sampling Summary.

Enhancement Site	Sample Date	Collector ID	Number of Samples	Average Clam Length (mm)	Std Dev	Total Number of Clams
Snake Island, Winthrop	11/21/2007	A	1	15.1	3.1	29
Snake Island, Winthrop	11/21/2007	B	3	22.1	8.4	3
Terne Road, Quincy	11/20/2007	1	4	0.0	0.0	0
Terne Road, Quincy	11/20/2007	2	4	0.0	0.0	0
Terne Road, Quincy	11/20/2007	3	5	0.0	0.0	0
Terne Road, Quincy	11/20/2007	4	5	20.3	11.4	4
Terne Road, Quincy	11/27/2007	5	2	32.6	0.0	1
Terne Road, Quincy	11/27/2007	6	2	0.0	0.0	0
Terne Road, Quincy	11/27/2007	7	2	0.0	0.0	0
Post Island Road, Quincy	11/27/2007	8	2	0.0	0.0	0
Post Island Road, Quincy	11/27/2007	9	2	0.0	0.0	0
Post Island Road, Quincy	1/11/2008	10	2	29.0	0.0	1
Post Island Road, Quincy	11/28/2007	11	2	0.0	0.0	0
Post Island Road, Quincy	11/27/2007	12	2	0.0	0.0	0
Post Island Road, Quincy	1/11/2008	13	2	29.0	0.0	1
Post Island Road, Quincy	1/16/2008	14	4	0.0	0.0	0
Post Island Road, Quincy	11/28/2007	15	2	0.0	0.0	0
Laundry Cove, Weymouth	12/19/2007	1	2	0.0	0.0	0
Laundry Cove, Weymouth	12/19/2007	2	2	39.9	14.8	6
Laundry Cove, Weymouth	12/19/2007	3	2	0.0	0.0	0
Laundry Cove, Weymouth	12/19/2007	4	2	32.8	12.9	8
Laundry Cove, Weymouth	12/19/2007	5	4	68.6	26.0	4
Laundry Cove, Weymouth	12/19/2007	6	2	41.9	5.0	2
Laundry Cove, Weymouth	12/19/2007	7	2	22.1	0.0	1
Great Esker Park, Weymouth	12/31/2007	1	5	42.1	23.1	5
Great Esker Park, Weymouth	12/31/2007	2	2	60.1	0.0	1
Great Esker Park, Weymouth	12/31/2007	3	2	0.0	0.0	0
Great Esker Park, Weymouth	12/31/2007	4	4	53.8	11.4	10
Great Esker Park, Weymouth	12/31/2007	5	4	54.3	16.7	17
Great Esker Park, Weymouth	12/31/2007	6				
Great Esker Park, Weymouth	12/31/2007	7				

Appendix IVD.C.
(continued)

Enhancement Site	Sample Date	Collector ID	Number of Samples	Average Clam Length (mm)	Std Dev	Total Number of Clams
Broad Cove, Hingham	12/18/2007	1	4	23.0	10.2	3
Broad Cove, Hingham	12/18/2007	2	2	25.2	4.7	15
Broad Cove, Hingham	12/18/2007	3	2	66.9	0.8	3
Broad Cove, Hingham	12/18/2007	4	2	19.1	3.4	5
Broad Cove, Hingham	12/18/2007	5	2	32.0	12.2	2
Broad Cove, Hingham	11/28/2007	6	2	0.0	0.0	0
Broad Cove, Hingham	11/28/2007	7	2	0.0	0.0	0
Broad Cove, Hingham	11/28/2007	8	4	37.5	12.5	10
Barnes Wharf, Hingham	12/28/2007	1	3	61.5	2.7	2
Barnes Wharf, Hingham	12/28/2007	2	2	32.4	0.0	1
Barnes Wharf, Hingham	12/28/2007	3	2	25.3	15.3	2
Barnes Wharf, Hingham	12/28/2007	4	4	52.2	27.5	2
Barnes Wharf, Hingham	12/28/2007	5	6	33.3	4.4	7
Barnes Wharf, Hingham	12/28/2007	6	2	0.0	0.0	0
Barnes Wharf, Hingham	12/28/2007	7	4	79.4	0.0	1