Peter S. Petraitis, Harrison Liu, and Erika C. Rhile. 2008. Densities and cover data for intertidal organisms in the Gulf of Maine, USA, from 2003 to 2007. *Ecology* **89:588.**

INTRODUCTION

Mussel beds and seaweed stands dominate sheltered intertidal shores in New England and it has been hypothesized that these two distinct communities represent different stable community states (Petraitis and Latham 1999). The switch between mussel beds and seaweed stands is thought to be mediated by ice scour, which can be destructive in sheltered bays and can remove established communities. Once an area is cleared by ice, re-colonization by mussels or seaweeds could lead to a divergence to different community states. Experimental clearings of different sizes were created in 1996–1997 to mimic the effects of ice scour on *Ascophyllum nodosum* stands and to see if some clearings would switch to mussel beds without any other intervention. The experimental plots were established at twelve mid intertidal sites with three sites in each of four sheltered bays on Swan's Island, Maine. At each site, four clearings (1, 2, 4, and 8 m in diameter) and an uncleared control plot were set up (see Petraitis and Vidargas 2006 for details).

Data provided here and in Petraitis and Vidargas (2006) represent one of the longest running tests of the theory of multiple stable states in natural ecosystems. Small temporary changes in environmental conditions can unexpectedly tip one community type to another, and such shifts in community composition are known to occur in many well known ecosystems such as grasslands (van de Koppel et al. 1997, Suding et al. 2004), freshwater lakes and ponds (Scheffer et al. 1993, Carpenter et al. 1999, Chase 2003), coral reefs (Hughes 1994, Bellwood et al. 2004), and kelp forests (Simenstad et al. 1978, Estes et al. 1998). These rapid and often irreversible shifts are intriguing because they are consistent with the theory that ecosystems can contain multiple stable points (Lewontin 1969, May 1977), but tests for multiple stable states are often inconclusive (Connell and Sousa 1983, Petraitis and Dudgeon 2004*a*, Suding et al. 2004, Schröder et al. 2005).

METADATA CLASS I. DATA SET DESCRIPTORS

A. Data set identity: Abundance and percentage cover of organisms on sheltered intertidal shores in the Gulf of Maine 2003–2007

B. Data set identification code: Succession_sampling_03-07_data.txt

C. Data set description

Principal Investigator: Peter S. Petraitis, Department of Biology, University of Pennsylvania, Philadelphia, PA 19104-6018 USA. Queries regarding the data set can be directed to: ppetrait@sas.upenn.edu

Abstract: Experimental clearings in macroalgal (*Ascophyllum nodosum*) stands were made in 1996 to determine if mussel beds and macroalgal stands on protected intertidal shores in New England represent alternative community states. Uncleared control plots and four sizes of circular clearings, which mimicked ice scour events, were established in *A. nodosum* stands at 12 sites on Swan's Island, Maine, USA. The purpose of this data set is to provide access to data on densities and percent cover in the 60 experimental plots from 2003 to 2007 and to update data from 1996 to 2002 that are already published in *Ecological Archives*. Data include densities of mussels (*Mytilus edulis* and *Modiolus modiolus*), an herbivorous limpet (*Tectura testudinalis*), herbivorous snails (*Littorina littorea*, *Littorina obtusata*), a predatory snail (*Nucella lapillus*), a barnacle (*Semibalanus balanoides*), and fucoid algae (*Ascophyllum nodosum* and *Fucus vesiculosus*), and percent cover by mussels, barnacles, fucoids, and other sessile organisms.

D. *Key words:* *alternative stable states; community ecology; Gulf of Maine; LTREB data; marine algae; marine invertebrates; mussels; rocky intertidal shores; succession..*

CLASS II. RESEARCH ORIGIN DESCRIPTORS

A. Overall project description

Identity: Abundance and percentage cover of organisms on sheltered intertidal shores in the Gulf of Maine 2003–2007

Originator: Peter Petraitis, Department of Biology, University of Pennsylvania, Philadelphia, PA 19104-6018.

Period of Study: 1996–2007 (ongoing); this file contains data from 2003–2007; for data from 1996–2002 see Petraitis and Vidargas (2006).

Objectives: To use successional changes in experimental clearings to test hypotheses concerning alternative community states.

Abstract: same as above.

Source(s) of funding: All data collection has been supported by NSF (DEB LTREB 03-14980).

B. Specific subproject description

Site description: Experimental clearings were established at 12 replicate sites in four bays on Swan's Island, Maine, USA with three sites nested in each bay. The bays are Mackeral Cove and Seal Cove, which are on the north side of the island, and Burnt Cove Harbor and Toothacker Cover, which are on the south side of the island (see Dudgeon and Petraitis 2001, Fig. 2, for map with locations of sites and bays).

Site type: The sites are in the mid-intertidal zones of sheltered bays, and experimental clearings are between 0.3 and 1.0 m above mean low water.

Geography: Swan's Island is located at 44°10' N, 68°25' W in the Gulf of Maine, USA. The island is approximately 36 square kilometers in area with a highly irregular coastline.

Habitat: The mid-intertidal shores are protected from wave surge and dominated by the rockweed *A. nodosum*.

Geology: The shoreline surfaces at the different sites are a mixture of granite and basalt outcrops, boulder fileds, and some muddy patches in the most protected sites.

Watersheds/hydrology: The exposure to waves at these sites ranges from extremely protected (i.e., no wave surge and a small boat is easy to land) to moderately protected (i.e., occasional wave surge and difficult to land a boat).

Site history: N/A.

Climate: Coastal northeastern USA. The nearest buoy that monitors ocean conditions is the Eastern Maine Shelf buoy (GoMOOS I01) and is approximately 30 km SSE of Swan's Island. Hourly data are available from the Gulf of Maine Ocean Observing System (www.gomoos.org).

Experimental design: Full description of the design can be found elsewhere (Petraitis and

Dudgeon 1999, Dudgeon and Petraitis 2001, Petraitis and Dudgeon 2005, Petraitis and Vidargas 2006). Briefly, at the 12 sites, four circular experimental plots — 1, 2, 4, and 8 in diameter clearings — and a control plot were established in June–August 1996. Plots were re-scaped during the 1996–1997 winter to mimic ice events and were left unmanipulated thereafter.

Design characteristics: The experimental set-up is a partially nested design with clearing size fully crossed with bays and sites, and sites nested within bays. Sites and bays are considered random effects and clearing size is a fixed treatment effect. The design is fully discussed in Petraitis and Dudgeon (2004*b*).

Sampling methods: Abundance and percentage cover of the most common species have been sampled at least once per year since 1996. This data set contains summer data from 2003 to 2007. For most variables, the methods used in 2003–2007 were identical to the methods described in Petraitis and Vidargas (2006) and so are not given here in full. Changes in methods are noted.

Abundance of mussels (*Mytilus edulis* and *Modiolus modiolus*), gastropods (*Tectura testudinalis*, *Littorina littorea*, *Littorina obtuscata*, and *Nucella lapillus*), and fucoid algae (*Ascophyllum nodosum* and *Fucus vesiculosus*) were counted using the methods described in Petraitis and Vidargas (2006). All were counted using five 50×50 cm quadrats per plot in 2003 (as done in 1996–2002) and using three quadrats per plot in 2004-2007. For data collected in 2005–2007, fucoids and mussels were also divided into young and old individuals (young fucoids < 1 cm, young mussels < 0.5 cm in length). The barnacle Semibalanus balanoides was counted in two 2×2 cm squares per 50×50 cm quadrat, and counts were divided into the current year's recruits and older individuals.

Percent cover data were collected for fucoids, barnacles, mussels, other sessile organisms, and bare space. Cover was estimated in the manner as described in Petraitis and Vidargas (2006). In 2003, *Ascophyllum nodosum* cover was estimated as canopy and everything else as understory (i.e., *Fucus vesiculosus*, *Semibalanus balanoides*, *Mytilus edulis*, and bare space). By 2004, it became clear that *F. vesiculosus* was becoming a canopy species, and so methods were modified to count all species in both the canopy and the understory. For canopy counts, fucoid fronds were left undisturbed and cover was estimated for all species. Thus some typical understory species, such as *S. balanoides*, were counted as canopy if visible through openings of the fucoid canopy. For understory counts, the fucoid canopy cover was pulled back, and fucoids, mussels, and barnacles were re-counted as "understory." From 1996 to 2004, percent cover by all other species, which were usually rare or common in only a few quadrats, and cover by bare space were split into unoccupied space, the red algae *Chondrus crispus* and *Mastocarpus stellata*, other algal species, and other sessile invertebrate species. For 2005–2007, *C. crispus* and *M. stellata* were lumped with other algal species.

Taxonomy and systematics: Names for algae follow usage in Taylor (1957) and for invertebrates follow usage in Gosner (1971) except for the limpet, which has been revised from *Acmaea testudinalis* to *Tectura testudinalis* (current name retrieved 30 November 2005 from the Integrated Taxonomic Information System; www.itis.usda.gov; taxonomic serial number: 204945).

Permit history: Clearings were made under permit from the State of Maine's Department of Marine Resources.

Legal/organizational requirements: None.

Project personnel: Peter Petraitis, Steve Dudgeon, Erika Carlson Rhile, Nick Vidargas, and Harrison Liu.

CLASS III. DATA SET STATUS AND ACCESSIBILITY

A. Status

Latest Update: The data spans the period of 2003–2007. Data collection is ongoing through the present and will be added as collected and verified.

Latest Archive date: 22 July 2007

Metadata status: The metadata are complete and up to date.

Data verification: Original data entries in Excel files are checked prior to calculation of averages. Averages are screened for outliers, which are then re-checked by comparing hand-written entries on original data books against entries in Excel files.

B.Accessibility

Storage location and medium: (Ecological Society of America data archives http://esapubs.org/archive, URL published in each issue of its journals). Original data file exists on author's personal computer and on CD in MSExcel format.

Contact person: Peter Petraitis, e-mail: ppetrait@sas.upenn.edu, Tel. 215.898.4207, Department of Biology, University of Pennsylvania, Philadelphia, PA 19104-6018, USA.

Copyright restrictions: None.

Proprietary restrictions: None.

Costs: None.

CLASS IV. DATA STRUCTURAL DESCRIPTORS

A. Data Set File

Identity: Succession_sampling_03-07_data.txt

Size: 300 records, not including header row.

Format and Storage mode: ASCII text, tab delimited. No compression scheme was used.

Header information: See variable names in Section B.

Alphanumeric attributes: mixed.

Special characters/fields: Missing data denoted as -999.9.

Authentication procedures: See Table D1 for sums of the numeric columns.

B. Variable information: The first 22 columns of data are arranged to match the columns of the text provided in Petraitis and Vidargas (2006) and thus the 2003–2007 data file can be merged seamlessly with the 1996–2002 data file.

> **Latitude and longitude:** Latitude and longitude of reference bolts in experimental plots in degrees and decimal minutes. Positions were determined in the summer of 2005 using a handheld GPS-WAAS receiver (Lowrance iFinder) with accuracy within 2 m. Note that

position of the 4-m plot at JL is incorrect in Petraitis and Vidargas (2006) and has been changed here.

Date: Date on which plots were sampled.

Yr_code: Yr_code gives year of sampling; note that the suffixes "a" for spring samples and "b" for summer samples used in Petraitis and Vidargas (2006) have been dropped.

Bay: Names of bays are consistent with names on U. S. Geological Survey 7.5 minute topographic quadrangle for Swan's Island. Codes for bay names are: BC = Burnt Coat Harbor, MC = Mackerel Cove, SC = Seal Cove, and TC = Toothacker Cove.

Site: Site names were assigned based on either names that appear on USGS maps or were named by Petraitis (see Petraitis and Vidargas 2006 for details of names).

Size: Diameter of experimental clearings. Uncleared control plots are given as 0.

Numeric variables: Variables of interest are densities and percent cover per plot, and so the data set contains the average densities and average percent cover per plot based on five (in 2003) or three (2004 onwards) quadrats per plot (see Petraitis and Vidargas 2006 for more details).

TABLE D1. Summary of variable information. Previous variable names are the variable names used in Petraitis and Vidargas (2006). Comment column gives relationship among variables. Column labeled "Authen." is the sum of the numeric variable columns including missing data values (i.e., -999.9) and should be used for authentication.

Variable name	Previous variable name	Variable definition	Units	Storage type	Range numeric values	Missing value codes	Comments	Authen
Latitude	Latitude	Latitude	Degrees decimal minutes	Character	N/A	N/A		
Longitude	Longitude	Longitude	Degrees decimal minutes	Character	N/A	N/A		
Date	Date	Sampling date	N/A	Character	N/A	N/A		
Yr_code	Yr_code	Year	N/A	Character	N/A	N/A		
Bay	Bay	Bay	N/A	Character	N/A	N/A		
Site	Site	Site	N/A	Character	N/A	N/A		
Size	Size	Diameter of clearing	N/A	Character	N/A	N/A		
LL	LL	Abundance: *L. littorea*	Number 0.25 m^{-2}	Floating Point	3.67–184.33	-999.9		10086.13
LO	LO	Abundance: *L. obtusata*	Number 0.25 m^{-2}	Floating Point	0.00–72.67	-999.9		-1204.27
NL	NL	Abundance: *N. lapillus*	Number 0.25 m^{-2}	Floating Point	0.00–27.67	-999.9		-3569.13
TT	TT	Abundance: *T. testudinalis*	Number 0.25 m^{-2}	Floating Point	0.00–4.33	-999.9		-3884.13
FV_tot	FV	Abundance: *F. vesiculosus*, total number of individuals	Number 0.25 m^{-2}	Floating Point	0.00–310.00	-999.9	FV_lg + FV_sm	4829.40

AN_tot	AN	Abundance: *A. nodosum,* total number of individuals	Number 0.25 m^{-2}	Floating Point	0.00–135.00	-999.9	AN_lg + AN_sm	-633.60
ME_tot	ME	Abundance: *M. edulis,* total number of individuals	Number 0.25 m^{-2}	Floating Point	0.00–5250.00	-999.9	ME_lg + ME_sm	64012.40
MM	MM	Abundance: *M. modiolus*	Number 0.25 m^{-2}	Floating Point	0.00–9.20	-999.9		-3974.00
OSB	OSB	Abundance: *S. balanoides,* old individuals	Number 4 cm^{-2}	Floating Point	0.00–20.30	-999.9		-3433.13
NSB	NSB	Abundance: *S. balanoides,* young individuals	Number 4 cm^{-2}	Floating Point	0.00–33.83	-999.9		-2521.23
pSB_u	PSB	Understory cover: *S. balanoides*	Percentage	Floating Point	0.00–100.00	-999.9		7966.40
pFV_c	PFV	Canopy cover: *F. vesiculosus*	Percentage	Floating Point	0.00–100.00	-999.9		6726.80
pAN_c	PAN	Canopy cover: *A. nodosum*	Percentage	Floating Point	0.00–100.00	-999.9		4506.53
pME_u	PME	Understory cover: *M. edulis*	Percentage	Floating Point	0.00–84.00	-999.9		-1473.87
pBR_u_tot	PBR	Understory cover: sum of bare space, *C. crispus, M. stellata,* rare species	Percentage	Floating Point	0.00–100.00	-999.9	pBR_u + pOT_u	7533.47
FV_lg	N/A	Abundance: *F. vesiculosus,* individuals > 1 cm in length	Number 0.25 m^{-2}	Floating Point	0.00–90.00	-999.9		-120749.37
FVS_sm	N/A	Abundance: *F. vesiculosus,* individuals ≤ 1 cm in length	Number 0.25 m^{-2}	Floating Point	0.00–156.67	-999.9		-120694.37
AN_lg	N/A	Abundance: *A. nodosum,* individuals > 1 cm in length	Number 0.25 m^{-2}	Floating Point	0.00–21.67	-999.9		-122421.03
AN_sm	N/A	Abundance: *A. nodosum,* individuals ≤ 1 cm in length	Number 0.25 m^{-2}	Floating Point	0.00–131.67	-999.9		-121322.70
ME_lg	N/A	Abundance: *M. edulis,* individuals > 0.5 cm in length	Number 0.25 m^{-2}	Floating Point	0.00–5250.00	-999.9		-101704.37
ME_sm	N/A	Abundance: *M. edulis,* individuals ≤ 0.5 cm in length	Number 0.25 m^{-2}	Floating Point	0.00–4396.67	-999.9		-92884.37
pFV_u	N/A	Understory cover: *F. vesiculosus*	Percentage	Floating Point	0.00–60.00	-999.9		-63517.60
pAN_u	N/A	Understory cover: *A. nodosum*	Percentage	Floating Point	0.00–40.00	-999.9		-63637.60
pBR_u	N/A	Understory cover: bare space	Percentage	Floating Point	0.00–100.00	-999.9		-57894.93
		Understory cover: *C.*		Floating	0.00–		pCC_u +	-

pOT_u	N/A	*crispus, M. stellata,* rare species	Percentage	Point	98.67	-999.9	pAL_u + pIN_u	119319.70
pCC_u	N/A	Understory cover: C. crispus and *M. stellata*	Percentage	Floating Point	0.00–22.67	-999.9		-240862.57
pAL_u	N/A	Understory cover: rare algae	Percentage	Floating Point	0.00–93.33	-999.9		-239805.23
pIN_u	N/A	Understory cover: rare invertebrates	Percentage	Floating Point	0.00–32.00	-999.9		-240830.57
pSB_c	N/A	Canopy cover: *S. balanoides*	Percentage	Floating Point	0.00–100.00	-999.9		-60590.93
pME_c	N/A	Canopy cover: *M. edulis*	Percentage	Floating Point	0.00–49.33	-999.9		-63546.93
pBR_c_tot	N/A	Canopy cover: sum of bare space, *C. crispus, M. stellata,* rare species	Percentage	Floating Point	0.00–98.67	-999.9	pBR_c + pOT_c	-59819.03
pBR_c	N/A	Canopy cover: bare space	Percentage	Floating Point	0.00–98.67	-999.9		-61254.93
pOT_c	N/A	Canopy cover: *C. crispus, M. stellata,* rare species	Percentage	Floating Point	0.00–37.33	-999.9	pCC_c + pAL_c + pIN_c	-122551.70
pCC_c	N/A	Canopy cover: *C. crispus* and *M. stellata*	Percentage	Floating Point	0.00–2.67	-999.9		-240971.90
pAL_c	N/A	Canopy cover: rare algae	Percentage	Floating Point	0.00–36.00	-999.9		-240862.57
pIN_c	N/A	Canopy cover: rare invertebrates	Percentage	Floating Point	0.00–0.00	-999.9		-40975.90

CLASS V. SUPPLEMENTAL DESCRIPTORS

A.Data acquisition

Data forms: "Rite in the Rain" field log books.

Location of completed data forms: 330 Leidy Labs, Department of Biology, University of Pennsylvania, Philadelphia, PA 19104-6018 USA.

Data entry/verification procedures: Field crews were supplied with log books to record all data in the field. Data were then entered into a computer in the lab and double-checked. Files are stored on author's personal computer and on CD as MSExcel files. Log books are held at author's address.

B. Quality assurance/quality control procedures: See comments on data verification (Class III, Section A), data entry procedures (Class V, Section A), and computer programs and data processing algorithms (Class V, Section D).

C. Related material: Data on adult mussel mortality (1996, 1999, 2000, 2003, 2004, and 2007) and recruitment of barnacles, mussels, and fucoids (1997–2007) in the experimental clearings have been collected but have not been archived.

D. Computer programs and data processing algorithms: Averages were calculated using the "average" function in MSExcel. Checks for outliers in numeric variables used sort function in MSExcel to examine

extreme values and used "if" statements to check summations of percent cover.

E. Archiving: N/A

F. Publications using the data set:

Petraitis, P. S., and E. T. Methratta. 2006. Using patterns of variability to test for multiple community states on rocky intertidal shores. Journal of Experimental Marine Biology and Ecology 338:222–232.

G. Publications using the same sites:

Dudgeon, S.R., J.E. Kübler, W.A. Wright, R.L. Vadas, Sr., and P.S. Petraitis. 2001. Natural variability in zygote dispersal of *Ascophyllum nodosum* at small spatial scales. Functional Ecology 15:595–604.

Dudgeon, S.R., and P.S. Petraitis. 2001. Scale-dependent recruitment and divergence of intertidal communities. Ecology 82:991–1006

Dudgeon S. R., and P.S. Petraitis. 2005. First year demography of a foundation species, *Ascophyllum nodosum*, and its community implications. Oikos 109:405–415.

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Petraitis, P.S., and S.R. Dudgeon. 2005. Divergent succession and implications for alternative states on rocky intertidal shores. Journal of Experimental Marine Biology and Ecology 326:14–26.

H. History of data set usage

Data request history: N/A

Data set update history: N/A

Review history: N/A

Questions and comments from secondary users: N/A

ACKNOWLEDGMENTS

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