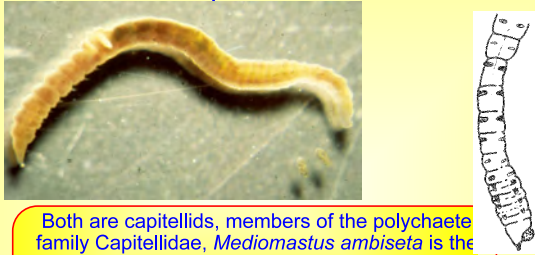
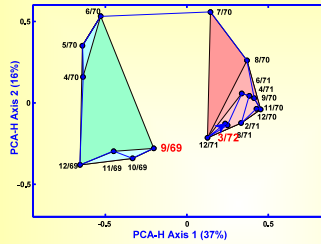


<div data-bbox="233 184 760 470"> <h2>High Deep-Sea Diversity, Effects of Pollution on Benthic Community Structure: West Falmouth Oilspill & Boston Harbor</h2> <h3>Pearson & Rosenberg vs. Hubbell's neutral model</h3> </div> <div data-bbox="363 487 769 541"> <p>Class 15: Tu Oct 21, 2008</p> <p>EEOS630</p> </div>	<div data-bbox="824 134 1409 281"> <h3>Slide 1 High Deep-Sea Diversity, Effects of Pollution on Benthic Community Structure: West Falmouth Oilspill & Boston Harbor</h3> </div> <div data-bbox="824 310 1386 378"> <p>Pearson & Rosenberg vs. Hubbell's neutral model</p> </div> <div data-bbox="824 470 938 499"> <p>NOTES:</p> </div>
<div data-bbox="233 806 769 1184"> <h3>Projects</h3> <ul style="list-style-type: none"> I'm working on datasets and references for the topic, "Assessing the effects of OCS oil drilling on marine benthos" You will have 1 month once the final papers and topics are assigned (Project 2 will be reduced in scope & intensity) <ul style="list-style-type: none"> I am working on the Matlab datasets and programs. Using Matlab will be one of the options. I'll introduce the topic with a movie. I hope to have the projects posted this week. The first Matlab session will be Thursday night, starting at 7. Log on anytime until 10. EEOS630 </div>	<div data-bbox="824 772 1052 806"> <h3>Slide 2 Projects</h3> </div> <div data-bbox="824 898 938 928"> <p>NOTES:</p> </div>
<div data-bbox="233 1289 769 1667"> <h3>Background papers</h3> <p>Bell, G. 2001. Neutral macroecology. Science 293: 2413-2418.</p> <p>Hughes, R. G. 1986. Theories and models of species abundance. Amer. Natur. 128: 879-899.</p> <p>EEOS630</p> </div>	<div data-bbox="824 1268 1208 1302"> <h3>Slide 3 Background papers</h3> </div> <div data-bbox="824 1386 938 1415"> <p>NOTES:</p> </div>

<div data-bbox="235 163 760 506"> <h3>Goals of today's class</h3> <p>Effects of pollution on benthic communities</p> <ul style="list-style-type: none"> • Overall theory: Pearson & Rosenberg vs. Hubbell's neutral model of biodiversity • How can you determine whether a pollutant has affected community structure? <ul style="list-style-type: none"> ▸ BACI designs: before-after controlled impact experiments ▸ Benthic index development <ul style="list-style-type: none"> ▪ EMAP approach ▪ Southern California Bight Index ▪ Borjas European index </div>	<div data-bbox="824 134 1234 170"> <h3>Slide 4 Goals of today's class</h3> </div> <div data-bbox="824 258 938 291"> <p>NOTES:</p> </div>										
<div data-bbox="235 653 760 1031"> <h3>Pearson & Rosenberg vs. Hubbell</h3> <p>Hubbell & Bell's neutral models: not successional</p> <table border="1"> <thead> <tr> <th>Pearson & Rosenberg, Rhoads et al. (1978)</th> <th>Hubbell's Neutral model</th> </tr> </thead> <tbody> <tr> <td>• Unidirectional Succession</td> <td>• Ecological drift; stochastic equilibrium</td> </tr> <tr> <td>• Opportunistic species replaced by equilibrium species</td> <td>• All individuals & all species equivalent</td> </tr> <tr> <td>• No metacommunity dynamics</td> <td>• Emphasis on metacommunity dynamics</td> </tr> <tr> <td>• Relatively silent on species diversity, except for SAB curves</td> <td>• A theory for species abundance curves</td> </tr> </tbody> </table> </div>	Pearson & Rosenberg, Rhoads et al. (1978)	Hubbell's Neutral model	• Unidirectional Succession	• Ecological drift; stochastic equilibrium	• Opportunistic species replaced by equilibrium species	• All individuals & all species equivalent	• No metacommunity dynamics	• Emphasis on metacommunity dynamics	• Relatively silent on species diversity, except for SAB curves	• A theory for species abundance curves	<div data-bbox="824 625 1403 661"> <h3>Slide 5 Pearson & Rosenberg vs. Hubbell</h3> </div> <div data-bbox="824 808 938 842"> <p>NOTES:</p> </div>
Pearson & Rosenberg, Rhoads et al. (1978)	Hubbell's Neutral model										
• Unidirectional Succession	• Ecological drift; stochastic equilibrium										
• Opportunistic species replaced by equilibrium species	• All individuals & all species equivalent										
• No metacommunity dynamics	• Emphasis on metacommunity dynamics										
• Relatively silent on species diversity, except for SAB curves	• A theory for species abundance curves										
<div data-bbox="235 1144 760 1522"> <h3>West Falmouth Oilspill</h3> <p>St. 9: Capitella → Mediomastus</p> <div data-bbox="235 1213 766 1465">  </div> <p>Both are capitellids, members of the polychaete family Capitellidae. <i>Mediomastus ambiseta</i> is the most abundant macrofaunal species in the EMAP Virginian province (Nantucket to Virginia)</p> </div>	<div data-bbox="824 1117 1258 1152"> <h3>Slide 6 West Falmouth Oilspill</h3> </div> <div data-bbox="824 1236 938 1270"> <p>NOTES:</p> </div>										

Station 9: heavily oiled

PCA-H display CNESS distances, $m=18$, Cluster membership as hulls: A unidirectional succession, see Grassle & Smith (1976)



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Slide 7 Station 9: heavily oiled

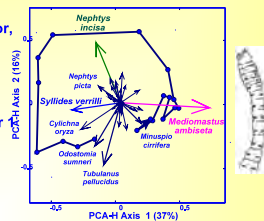
NOTES:

West Falmouth Oilspill

Station 9: a heavily oiled nearshore station

Patterns

- Initial amphipod mortality
- Early *Capitella* dominance
- Syllides verrilli*, perhaps a predator, & 2 gastropods (*Cylichna oryza* & *Odostomia sumneri*) increased in relative
- Another capitellid, *Mediomastus ambiseta*, the natural dominant in Buzzards Bay increased after year
- Diversity
 - Species richness remained high
 - Evenness strongly affected
 - Drastic departures from log-series expectation
- Very rapid succession

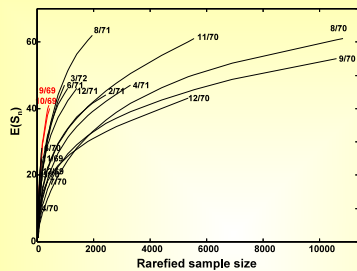


Slide 8 West Falmouth Oilspill

NOTES:

Rarefaction, Station 9

Highest alpha diversity immediately after the spill!



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Slide 9 Rarefaction, Station 9

NOTES:

<p>West Falmouth: Station 9</p> <p>Major effects on evenness (not richness) 1 y after spill; Note: Shannon's H' is sensitive to evenness</p> <p>Day</p> <p>EEOS630</p>	<p>Slide 10 West Falmouth: Station 9</p> <p>NOTES:</p>
<p>Stn 35: less affected than Stn 9</p> <p>Succession is seasonal, not unidirectional; noted by Grassle & Smith (1976, Oecologia)</p> <p>PCA Axis 1 (32%)</p> <p>PCA Axis 2 (16%)</p>	<p>Slide 11 Stn 35: less affected than Stn 9</p> <p>NOTES:</p>
<p>Pearson & Rosenberg vs. Hubbell</p> <p>Directional succession vs. Hubbell's neutral theory/ecological drift</p> <p>EEOS630</p>	<p>Slide 12 Pearson & Rosenberg vs. Hubbell</p> <p>NOTES:</p>

Hubbell's (2001) neutral model

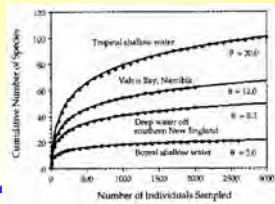
Fisher's $\alpha \approx \theta = \text{Fundamental Biodiversity Number}$

- Fisher's $\alpha \approx \text{Hubbell's } \theta = 2 J_m v$
 - θ = Fundamental Biodiversity Number
 - J_m = metapopulation size
 - v = speciation rate

- On the local scale, species are drawn from the metacommunity, with a rate set by the migration rate, an m of 0.9 indicates that 90% of the individuals on the local scale are drawn from the regional pool & 10% from local reproduction

- Ecological drift alters species abundance distribution from log-series like to log-normal (S-shaped dominance curves)
 - Ecological drift with relatively low migration rates leads to the local loss of singleton species
 - A high frequency of singletons can only be modeled with high migration, m

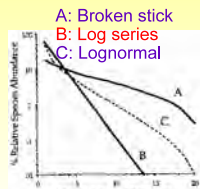
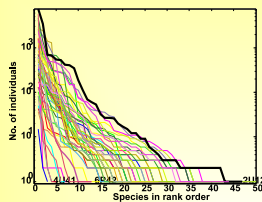
- Close fit to the log series indicates high immigration



Slide 13 Hubbell's (2001) neutral model

NOTES:

Dominance curves for Boston Harbor



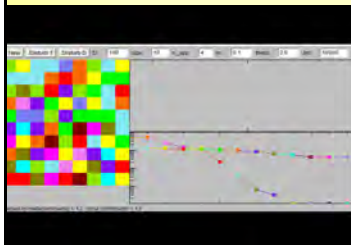
Fisher et al. (1943): log series; Preston lognormal, Caswell's neutral model: log series; Gray: benthic communities are lognormal; Hubbell's (2001) neutral model predicts S-shaped curves; Hughes (1984, 1986): Benthic dominance curves are usually **concave up**, not log series & certainly not lognormal

Slide 14 Dominance curves for Boston Harbor

NOTES:

Simulation of Hubbell's Neutral model

Simulation from U. Washington Ecology website



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Slide 15 Simulation of Hubbell's Neutral model

NOTES:

Neutral model programs

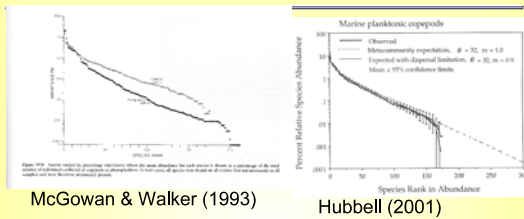
Based on Hubbell (2001)

- Hubbell (2001) described algorithms but did not provide programs
- Oksanen provides R programs to simulate Hubbell's neutral model. See his website for an exposition of the model
<http://cc.oulu.fi/~jarioksa/index.html>
- McGill (2003) criticized the neutral model and provided Matlab software to fit the model
 - McGill, B. J. 2003. A test of the unified neutral theory of biodiversity. *Nature* 422: 881-885.
 - <http://www.brianmcgill.org/zsmcode.html>
- Volkov et al. (2003) propose analytical solution
 - Volkov, I. J. R. Banavar, S. P. Hubbell, and A. Maritan. 2003. Neutral theory and relative species abundance in ecology. *Nature* 424: 1035-1037.
 - Volkov et al. Provide c routines to generate distribution
 - McGill programs Volkov et al. Analytical solution in Matlab & provides copies on website (see above)
- Chisholm & Burgman (2004) *Ecology* 85: 3172 argued that disturbance recovery needed to be a parameter in the model
- Hubbell & Borda-de-Agua (2004) *Ecology* 85: 3175. defended theory & provided 2 C routines for Hubbell (2001) model

Slide 16 Neutral model programs

NOTES:

Zooplankton data appear to fit the neutral model



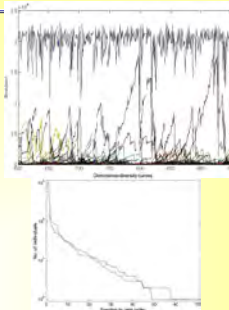
EEOS630

Slide 17 Zooplankton data appear to fit the neutral model

NOTES:

Spector's neutralized Hughes (2005) model

- Hughes, R. G. 1984. A model of the structure and dynamics of benthic marine invertebrate communities. *Mar. Ecol. Prog. Ser.* 15: 1-11.
- Cited by Hubbell (2001) as offering a dynamic model with some similar predictions to the universal neutral diversity model
- Lotka-Volterra like dynamics
 - Gregarious larval settlement from an external pool of larvae
 - Random catastrophes key to producing concave up dominance curves
- Like Huston's dynamic model for deep-sea diversity, disturbance plays a key role in maintaining the relative abundance of species
- Spector: "...the concave-up pattern resulted from random catastrophe disrupting the deterministic forces of the model, which would, in the absence of catastrophe, produce a flat dominance-diversity curve."



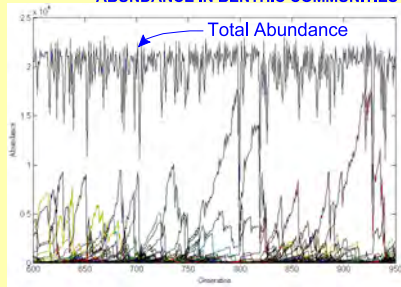
Slide 18 Spector's neutralized Hughes (2005) model

NOTES:

Spector (2005 M.Sc.)

NEUTRALIZING HUGHES'S 1984 MODEL FOR RELATIVE SPECIES

ABUNDANCE IN BENTHIC COMMUNITIES



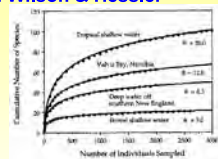
Slide 19 Spector (2005 M.Sc.)

NOTES:

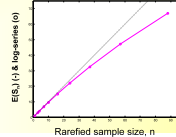
Non-dimensional diversity

Comparison of Sanders rarefaction to log series Echo-1 deep-sea data from Wilson & Hessler

- Non-dimensional diversity curves
 - Generate a rarefaction curve
 - Generate the log-series rarefaction
 - Divide the observed diversity at each n by the log-series expectation
 - Non-dimensionalize & scale by dividing numbers by the species total and expected species by observed total species
- Straight line indicates log-series fit
- A deeply dipping curve indicates less evenness than log series



As noted by May (1975), Hughes (1984) & Hubbell (2001), Benthic communities follow a modified log series distribution

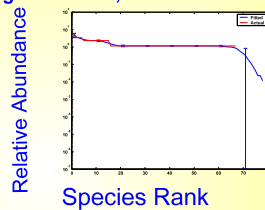
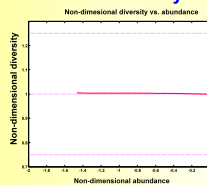


Slide 20 Non-dimensional diversity

NOTES:

Wilson & Hessler's deep-sea data, close fit to log series & neutral model

McGill 2003 algorithm: $[J=88, S=65]; \theta=148, m=0.99$
The long tail of singletons, 52 in this sample, can only be met by immigration=0.99; $\alpha=128 \pm 16$



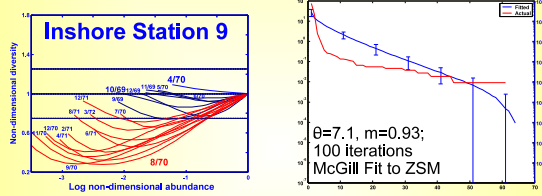
Slide 21 Wilson & Hessler's deep-sea data, close fit to log series & neutral model

NOTES:

<div data-bbox="318 168 704 205" data-label="Section-Header"> <h3>Non-dimensional diversity</h3> </div> <div data-bbox="303 214 704 262" data-label="Text"> <p>Samples <0.75 or >1.25 may indicate severe disturbance</p> </div> <div data-bbox="251 277 737 485" data-label="Figure"> </div> <div data-bbox="654 512 769 541" data-label="Text"> <p>EEOS630</p> </div>	<div data-bbox="816 132 1320 172" data-label="Section-Header"> <h3>Slide 22 Non-dimensional diversity</h3> </div> <div data-bbox="816 256 940 291" data-label="Text"> <p>NOTES:</p> </div>
<div data-bbox="362 655 639 690" data-label="Section-Header"> <h3>Oct. 1969 Station 9</h3> </div> <div data-bbox="282 701 737 789" data-label="Text"> <p>Fit with McGill's (2003, Nature) Matlab program of Hubbell's neutral model 13 of 40 species are singletons Fisher's $\alpha = 11.0 \pm 1.7$</p> </div> <div data-bbox="235 789 526 1020" data-label="Figure"> </div> <div data-bbox="263 938 467 1001" data-label="Text"> <p>$\theta = 12.17$, $m = 0.6$; 500 iterations</p> </div> <div data-bbox="552 802 769 982" data-label="Text"> <p>Volkov et al.'s (2003, Nature) analytical model allows theta and m to be fit without random simulations, but there is still a lot of computer time involved</p> </div>	<div data-bbox="816 621 1218 659" data-label="Section-Header"> <h3>Slide 23 Oct. 1969 Station 9</h3> </div> <div data-bbox="816 743 940 779" data-label="Text"> <p>NOTES:</p> </div>
<div data-bbox="318 1144 695 1180" data-label="Section-Header"> <h3>West Falmouth April 1970</h3> </div> <div data-bbox="295 1188 719 1218" data-label="Text"> <p>Fisher's $\alpha = 3.8 \pm 1.2$; 10 species, 50 individuals</p> </div> <div data-bbox="222 1232 745 1457" data-label="Figure"> </div> <div data-bbox="518 1390 667 1442" data-label="Text"> <p>$\theta = 5.5$, $m = 0.9$; 100 iterations</p> </div> <div data-bbox="654 1488 769 1518" data-label="Text"> <p>EEOS630</p> </div>	<div data-bbox="816 1110 1321 1148" data-label="Section-Header"> <h3>Slide 24 West Falmouth April 1970</h3> </div> <div data-bbox="816 1232 940 1268" data-label="Text"> <p>NOTES:</p> </div>

August 1970, Station 9, Heavily Impacted; Oil affected 1970 recruitment

10826 individuals, 61 species, 17 singletons;
Fisher's $\alpha = 8.5 \pm 1.1$; $\theta = 7.1$, immigration rate is 93%, but the fit is very poor; **extreme dominance by *Mediomastus ambiseta***

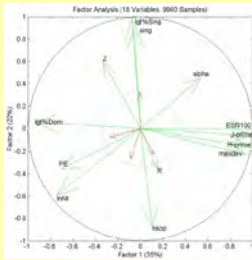


Slide 25 August 1970, Station 9, Heavily Impacted; Oil affected 1970 recruitment

NOTES:

What causes deviations from log series? Disturbance.

Time since disturbance seems to be a major factor.
Spector (2005)



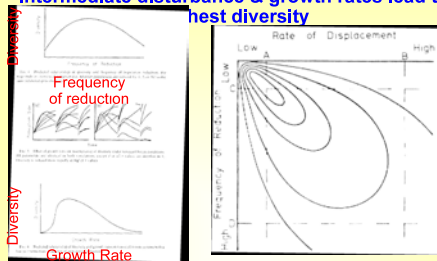
EEOS630

Slide 26 What causes deviations from log series? Disturbance.

NOTES:

Huston's 1979 dynamic (non- equilibrium) model

Based on Lotka-Volterra competition equations;
Intermediate disturbance & growth rates lead to highest diversity



Slide 27 Huston's 1979 dynamic

(non- equilibrium) model

NOTES:

Station 9, Theta & m for Station 9

Joan Tracey Seguin: theta is nearly always equal to Fisher's alpha for benthic communities and m is usually > 0.9

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Slide 28 Station 9, Theta & m for Station 9

NOTES:

Station 35 fit to the neutral model

Fisher's alpha \approx Hubbell's theta

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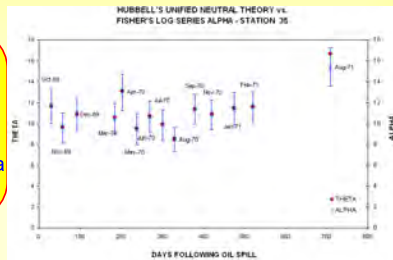
Slide 29 Station 35 fit to the neutral model

NOTES:

Hubbell natural theory: Fisher's alpha vs. Hubbell's theta, Stn 35

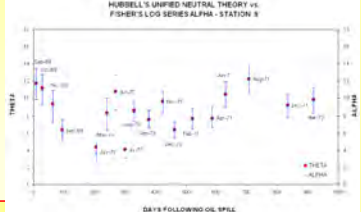
Joan Tracey Seguin 2006 UMB M.Sc.

Relatively unpolluted Station 35
Fisher's alpha (x) and Hubbell's theta (●)






Slide 30 Hubbell natural theory: Fisher's alpha vs. Hubbell's theta, Stn 35

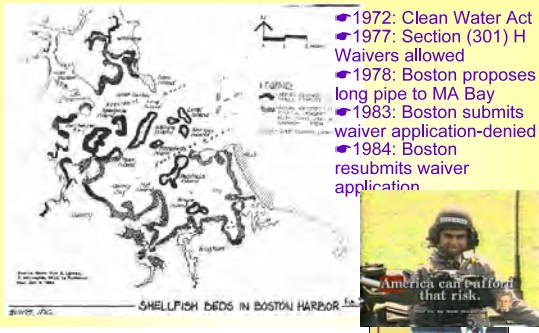
NOTES:

<p>Hubbell natural theory: Fisher's alpha vs. Hubbell's theta</p> <p>Joan Tracey Sequin 2006 UMB M.Sc.</p> <p>Heavily impacted Station 9: Fisher's alpha (x) and Hubbell's theta (●)</p>  <p>Note that largest effects on species richness were 7-10 months after spill</p> <p>EEOS630</p>	<p>Slide 31 Hubbell natural theory: Fisher's alpha vs. Hubbell's theta</p> <p>NOTES:</p>
<p>Conclusions on West Falmouth</p> <p>The September 1969 spill had long-lasting effects</p> <ul style="list-style-type: none"> Species richness remained relatively high throughout the Sanders & Grassle's monitoring <ul style="list-style-type: none"> Similar pattern found in Amoco Cadiz oilspill "Species diversity, richness and evenness if anything increased after the spill, and remained at a higher level than the pre-spill conditions until the end of the sampling period." Dauvin (1984) after the Amoco Cadiz spill Major effects nearly 1 year after the oil spill: Extreme dominance by <i>Mediomastus ambiseta</i> & <i>Nephtys incisa</i>, normal numerical dominance of the Buzzards Bay benthos (dominants in Sanders' Station R surveys) Major effects on species evenness 	<p>Slide 32 Conclusions on West Falmouth</p> <p>NOTES:</p>
<p>Case Study: the recovery of Boston Harbor benthic communities in the 1990s</p> <p>Pearson & Rosenberg vs. Hubbell's (2001) unified neutral model</p> <p>EEOS630</p>	<p>Slide 33 Case Study: the recovery of Boston Harbor benthic communities in the 1990s</p> <p>NOTES:</p>

<div data-bbox="360 168 649 210" data-label="Section-Header"> <h3>Geology of MA Bay</h3> </div> <div data-bbox="232 239 769 543" data-label="Figure"> </div> <div data-bbox="654 514 769 543" data-label="Text"> <p>EEOS630</p> </div>	<div data-bbox="816 134 1229 176" data-label="Section-Header"> <h3>Slide 34 Geology of MA Bay</h3> </div> <div data-bbox="816 258 941 294" data-label="Text"> <p>NOTES:</p> </div>
<div data-bbox="214 651 774 1031" data-label="Figure"> </div>	<div data-bbox="816 623 937 659" data-label="Section-Header"> <h3>Slide 35</h3> </div> <div data-bbox="816 743 941 779" data-label="Text"> <p>NOTES:</p> </div>
<div data-bbox="282 1144 753 1182" data-label="Section-Header"> <h3>William Wood's Boston Harbor</h3> </div> <div data-bbox="357 1186 657 1220" data-label="Text"> <p>New England's Prospect (1634)</p> </div> <div data-bbox="224 1243 466 1442" data-label="List-Group"> <ul style="list-style-type: none"> ■ Mudflats ■ Soft-shelled clams as big as a loaf of English whitebread ■ Oysters as half as big around as a keg ■ Shore birds so numerous that in flight they darken the sky </div> <div data-bbox="485 1236 781 1459" data-label="Image"> </div> <div data-bbox="654 1488 769 1518" data-label="Text"> <p>EEOS630</p> </div>	<div data-bbox="816 1110 1403 1148" data-label="Section-Header"> <h3>Slide 36 William Wood's Boston Harbor</h3> </div> <div data-bbox="816 1232 941 1268" data-label="Text"> <p>NOTES:</p> </div>

<p>17-18th Century pollution problems</p> <p>Mill Creek, Site of offal discharge 1656</p>  <p>EEOS630</p>	<p>Slide 37 17-18th Century pollution problems</p> <p>NOTES:</p>
<p>Calf Pasture Pumping station</p> <p>Boston's first sewage plant: opened January</p>  <p>EEOS630</p>	<p>Slide 38 Calf Pasture Pumping station</p> <p>NOTES:</p>
<p>Boston Harbor 1630 to present</p> <p>From "Mapping Boston"</p>  <p>Rivers dammed, Mudflats filled</p> <p>EEOS630</p>	<p>Slide 39 Boston Harbor 1630 to present</p> <p>NOTES:</p>

Harbor of Shame: Raw sewage, closed *Mya* beds, closed beaches & flounder liver cancer

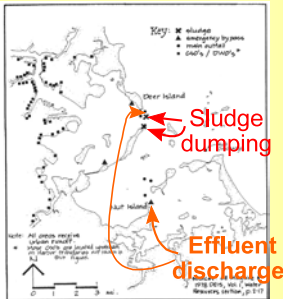


Slide 40 Harbor of Shame: Raw sewage, closed *Mya* beds, closed beaches & flounder liver cancer

NOTES:

Boston Harbor in the 1980s

- 250-500 mgd sewage effluent, only primary treated, discharged at Deer & Nut Islands
- 20 tons sludge daily in Presidents Roads
 - A high percentage of the sludge (30%) remained in the harbor
- >90% *Capitella* in Inner Harbor & Deer Island Sediments
- Few *Ampelisca*
- 17% of Winter flounder with active liver cancer

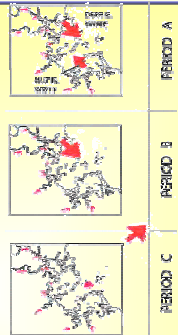


Slide 41 Boston Harbor in the 1980s

NOTES:

Key dates in the harbor cleanup

- Period A**
 - 1991 Sludge dumping ended
 - 1991 & 1992 Monitoring of Harbor & Bay began
 - 1996 New primary treatment facility at Deer Island
 - 1997-2001 Upgrade to secondary treatment at Deer Island
- 1998 Period B. Inter-island transfer tunnel to Deer Island**
- September 2000 Period C. Offshore 15 km outfall**



Slide 42 Key dates in the harbor cleanup

NOTES:

<div data-bbox="352 245 678 329" data-label="Section-Header"> <h2>The Actors in this Ecological Play</h2> </div> <div data-bbox="652 512 771 541" data-label="Text"> <p>EEOS630</p> </div>	<div data-bbox="815 134 1354 210" data-label="Section-Header"> <h3>Slide 43 The Actors in this Ecological Play</h3> </div> <div data-bbox="815 294 940 327" data-label="Text"> <p>NOTES:</p> </div>
<div data-bbox="271 686 753 766" data-label="Section-Header"> <h3>The most common animals in Boston Harbor & MA Bay sediments: Spionid polychaetes</h3> <p>Millions per m² on Boston mudflats</p> </div> <div data-bbox="240 772 730 1068" data-label="Image"> </div>	<div data-bbox="815 659 1362 772" data-label="Section-Header"> <h3>Slide 44 The most common animals in Boston Harbor & MA Bay sediments: Spionid polychaetes</h3> </div> <div data-bbox="815 856 940 890" data-label="Text"> <p>NOTES:</p> </div>
<div data-bbox="279 1264 732 1323" data-label="Section-Header"> <h3>Chaetozone, new species, a common polychaete in Boston Harbor</h3> </div> <div data-bbox="267 1327 753 1354" data-label="Text"> <p>Feeds on mud at the sediment-water interface</p> </div> <div data-bbox="248 1356 743 1633" data-label="Image"> </div> <div data-bbox="430 1598 628 1623" data-label="Text"> <p>Jim Blake image, ENSR</p> </div> <div data-bbox="737 1602 771 1629" data-label="Text"> <p>30</p> </div>	<div data-bbox="815 1224 1347 1297" data-label="Section-Header"> <h3>Slide 45 Chaetozone, new species, a common polychaete in Boston Harbor</h3> </div> <div data-bbox="815 1381 940 1415" data-label="Text"> <p>NOTES:</p> </div>

Capitella sp. la, flounder food

Can reach 9 cm, dominant in Boston's Inner Harbor & Nut Island



Slide 46 Capitella sp. la, flounder food

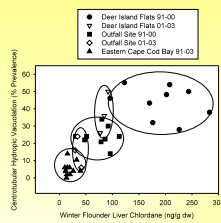
NOTES:



Capitella sp. la
Deer Island 1988



M. Moore Photo



Moore, M., Lefkowitz, L., Hall, M., Hillman, R., Mitchell, D., and Burnett, J. 2004. Reduction in organic contaminant exposure and resultant hepatic hydropic vacuolation in winter flounder (*Pseudopleuronectes americanus*) following improved effluent quality and relocation of the Boston sewage outfall into Massachusetts Bay, USA: 1987-2003. *Marine Pollution Bulletin*. In Press

Slide 47

NOTES:

Capitella fecal pellets

30-70% of the mass of some harbor sediments

High percentage of pelletized sediments in Inner Harbor & Peddocks Island deposition areas (Nut Island Sludge)

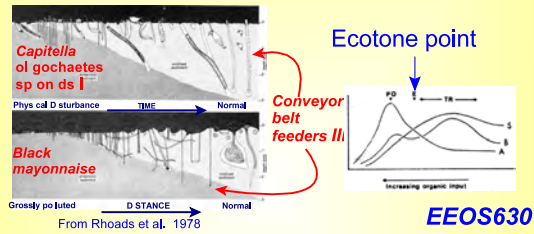


Slide 48 Capitella fecal pellets

NOTES:

Pearson & Rosenberg's model used in the 1983 EPA waiver rejection

MA Bay already at a Pearson & Rosenberg (1978) ecotone point; additional organic enrichment will lead to an opportunist-dominated community

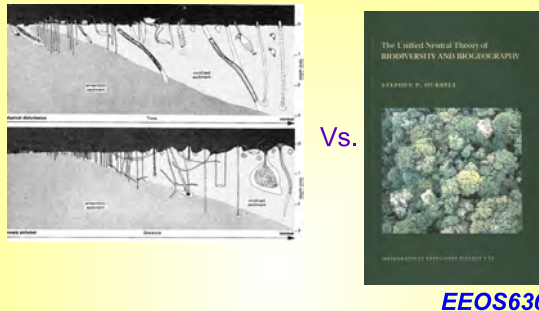


Slide 49 Pearson & Rosenberg's model used in the 1983 EPA waiver rejection

NOTES:

Pearson & Rosenberg vs. Hubbell

Directional succession vs. The Neutral Theory



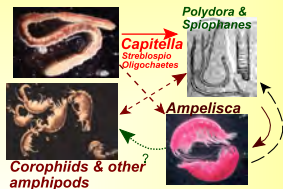
Slide 50 Pearson & Rosenberg vs. Hubbell

NOTES:

Why use Hubbell's neutral model for Boston Harbor?

Certainly, species & individuals are not identical!

- It provides a null expectation for species richness, based on Fisher's α diversity index
- It incorporates the regional metacommunity biodiversity in the analysis
- It has the potential to explain the effects of ecological drift on species composition & succession



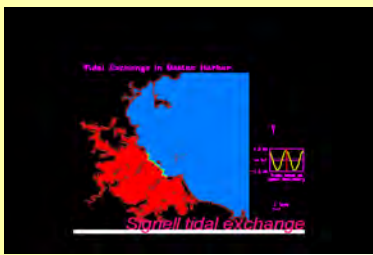


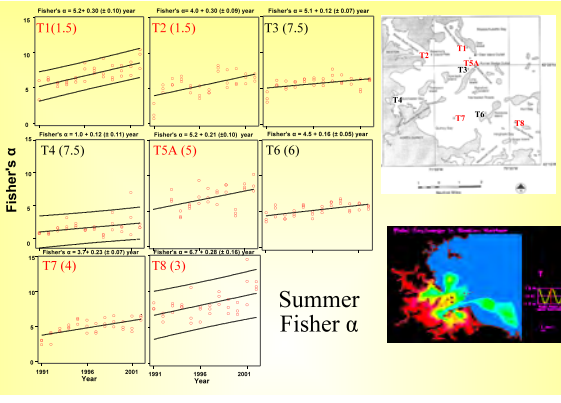
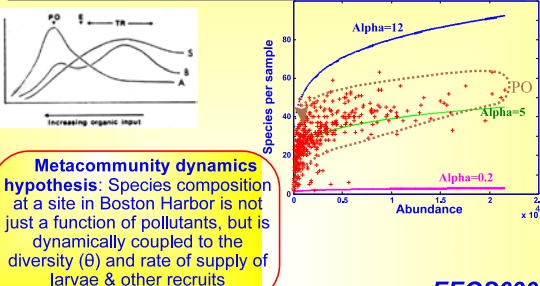
Slide 51 Why use Hubbell's neutral model for Boston Harbor?

NOTES:

<div data-bbox="315 168 706 207" data-label="Section-Header"> <h3>MWRA Sampling Stations</h3> </div> <div data-bbox="248 214 750 262" data-label="Text"> <p>8 Stations, May & Aug 3 replicate 0.043-m² Ted Young grabs; 300-µm sieves</p> </div> <div data-bbox="233 258 472 512" data-label="List-Group"> <ul style="list-style-type: none"> • T1: Deer Island • T2: Governor's Island Flats • T3: Long Island • T4: Savin Hill Cove • T5A: Presidents Road • T6: Peddocks Island • T7: Quincy Bay • T8: Hingham/Hull Bay • NI: Nut Island • DI: Deer Island </div> <div data-bbox="493 266 758 512" data-label="Figure"> </div> <div data-bbox="656 514 769 541" data-label="Text"> <p>EEOS630</p> </div>	<div data-bbox="816 134 1326 174" data-label="Section-Header"> <h3>Slide 52 MWRA Sampling Stations</h3> </div> <div data-bbox="816 258 940 291" data-label="Text"> <p>NOTES:</p> </div>
<div data-bbox="264 655 769 701" data-label="Section-Header"> <h3>Inner Harbor: Still degraded</h3> </div> <div data-bbox="233 707 456 993" data-label="Figure"> </div> <div data-bbox="464 707 758 894" data-label="Image"> </div> <div data-bbox="464 905 626 1024" data-label="Image"> </div> <div data-bbox="656 1003 769 1029" data-label="Text"> <p>EEOS630</p> </div>	<div data-bbox="816 623 1360 661" data-label="Section-Header"> <h3>Slide 53 Inner Harbor: Still degraded</h3> </div> <div data-bbox="816 743 940 777" data-label="Text"> <p>NOTES:</p> </div>
<div data-bbox="324 1142 693 1180" data-label="Section-Header"> <h3>Peddock's Island, 1989</h3> </div> <div data-bbox="266 1188 763 1234" data-label="Text"> <p><i>Capitella</i> prior to 1989; After 1989: No <i>Capitella</i> Fecal pellets (% Dry Weight)</p> </div> <div data-bbox="238 1234 516 1518" data-label="Figure"> </div> <div data-bbox="524 1220 747 1339" data-label="Image"> </div> <div data-bbox="524 1339 747 1491" data-label="Image"> </div> <div data-bbox="656 1491 769 1518" data-label="Text"> <p>EEOS630</p> </div>	<div data-bbox="816 1110 1274 1148" data-label="Section-Header"> <h3>Slide 54 Peddock's Island, 1989</h3> </div> <div data-bbox="816 1293 940 1327" data-label="Text"> <p>NOTES:</p> </div>

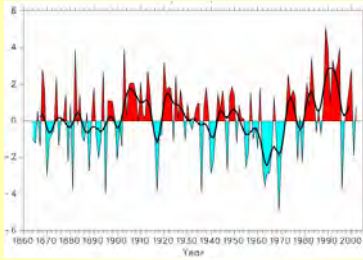
<p>Infaunal Abundance in the 90s</p> <p>Summer increase largely due to <i>Ampelisca abdita</i></p>  <p>Abundance (0.43 m²)</p> <p>Year</p> <p>EEOS630</p>	<p>Slide 55 Infaunal Abundance in the 90s</p> <p>NOTES:</p>
<p>Boston Harbor <i>Ampelisca</i></p> <p><i>Ampelisca</i> mats rare in 1982, Sludge dumping stopped Dec. 1991, amphipods abundant by 1991, peak in 1997, nearly gone by 2001, but back in 2002 & 2003; gone in 2006, 2007</p>  <p>EEOS630</p>	<p>Slide 56 Boston Harbor <i>Ampelisca</i></p> <p>NOTES:</p>
<p>Sediment Profile Imaging</p> <p>Rhoads' Type II <i>Ampelisca</i> assemblage, Hull Bay (1997)</p>  <p>Image from R. Diaz & ENSR</p> <p>EEOS630</p>	<p>Slide 57 Sediment Profile Imaging</p> <p>NOTES:</p>

<div data-bbox="235 157 771 241"> <h3>Ampelisca mats</h3> <p>Near Peddocks Island in Quincy Bay</p> </div> <div data-bbox="267 247 706 556">  </div>	<div data-bbox="824 136 1172 172"> <h4>Slide 58 Ampelisca mats</h4> </div> <div data-bbox="824 256 938 291"> <p>NOTES:</p> </div>
<div data-bbox="235 640 771 724"> <h3>Peddocks Island, affected by Nut Island sewage</h3> <p>From Capitella to amphipods in late 1980s</p> </div> <div data-bbox="251 745 747 1024">  </div>	<div data-bbox="824 619 1409 697"> <h4>Slide 59 Peddocks Island, affected by Nut Island sewage</h4> </div> <div data-bbox="824 781 938 816"> <p>NOTES:</p> </div>
<div data-bbox="235 1165 771 1228"> <h3>Boston Harbor tidal currents</h3> </div> <div data-bbox="227 1270 597 1522">  </div> <div data-bbox="662 1528 771 1558"> <p>EEOS630</p> </div>	<div data-bbox="824 1144 1356 1180"> <h4>Slide 60 Boston Harbor tidal currents</h4> </div> <div data-bbox="824 1264 938 1299"> <p>NOTES:</p> </div>

 <p>Summer Fisher α</p>	<p>Slide 61</p> <p>NOTES:</p>
<p>Metacommunity terms</p> <p>Holyoak et al. 2005. Metacommunities.</p> <ul style="list-style-type: none"> • Community The individuals of all species that potentially interact within a single patch or local area of habitat • Metacommunity A set of local communities that are linked by dispersal of multiple potentially interacting species • Mass effect A mechanism for spatial dynamics in which there is a net flow of individuals created by differences in population size or density 	<p>Slide 62 Metacommunity terms</p> <p>NOTES:</p>
<p>Reconciling Pearson and Rosenberg (1976, 1978) & Hubbell</p>  <p>Metacommunity dynamics hypothesis: Species composition at a site in Boston Harbor is not just a function of pollutants, but is dynamically coupled to the diversity (H) and rate of supply of larvae & other recruits</p> <p>EEOS630</p>	<p>Slide 63 Reconciling Pearson and Rosenberg (1976, 1978) & Hubbell</p> <p>NOTES:</p>

<div data-bbox="259 165 776 207" data-label="Section-Header"> <h3>Boston Harbor Species richness</h3> </div> <div data-bbox="254 207 771 262" data-label="Text"> <p>31% annual increase in median species richness per year, apparently coupled to MA Bay cycle</p> </div> <div data-bbox="266 256 764 543" data-label="Figure"> </div> <div data-bbox="656 516 769 543" data-label="Text"> <p>EEOS630</p> </div>	<div data-bbox="816 134 1398 174" data-label="Section-Header"> <h3>Slide 64 Boston Harbor Species richness</h3> </div> <div data-bbox="816 258 940 294" data-label="Text"> <p>NOTES:</p> </div>
<div data-bbox="339 655 672 697" data-label="Section-Header"> <h3>MA Bay Fisher's alpha</h3> </div> <div data-bbox="243 745 742 995" data-label="Figure"> </div> <div data-bbox="656 1003 769 1031" data-label="Text"> <p>EEOS630</p> </div>	<div data-bbox="816 623 1278 663" data-label="Section-Header"> <h3>Slide 65 MA Bay Fisher's alpha</h3> </div> <div data-bbox="816 745 940 781" data-label="Text"> <p>NOTES:</p> </div>
<div data-bbox="285 1144 745 1184" data-label="Section-Header"> <h3>Deer Island species richness</h3> </div> <div data-bbox="259 1188 766 1222" data-label="Text"> <p>Median Fisher's α increasing 30% per year at T1</p> </div> <div data-bbox="217 1218 709 1524" data-label="Figure"> </div>	<div data-bbox="816 1113 1343 1152" data-label="Section-Header"> <h3>Slide 66 Deer Island species richness</h3> </div> <div data-bbox="816 1234 940 1270" data-label="Text"> <p>NOTES:</p> </div>

NAO Index, note 1996 Negative NAO

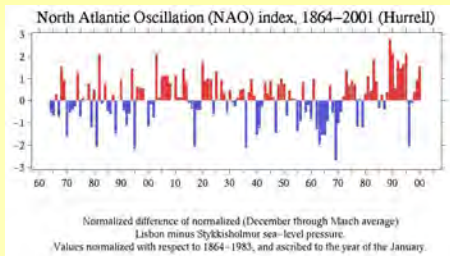


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Slide 67 NAO Index, note 1996 Negative NAO

NOTES:

Hurrell NAO index Dec-March



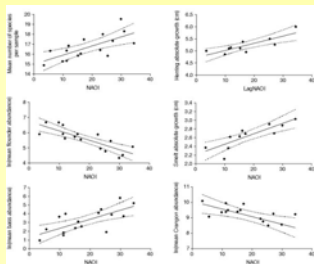
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Slide 68 Hurrell NAO index Dec-March

NOTES:

NAO on European fish stocks

Atrill & Power (2001) Nature



EEOS630

Slide 69 NAO on European fish stocks

NOTES:

European *C. finmarchicus* & NAO



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Slide 70 European *C. finmarchicus* & NAO

NOTES:

High NAO & the Gulf of Maine



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Slide 71 High NAO & the Gulf of Maine

NOTES:

Low NAO & the Gulf of Maine



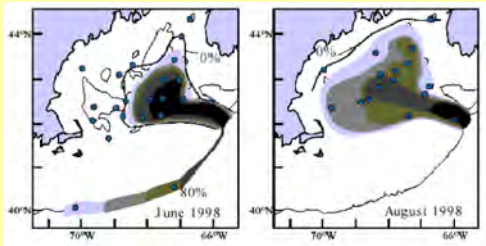
EEOS630

Slide 72 Low NAO & the Gulf of Maine

NOTES:

1996-1998 Negative NAO event

Labrador Current water, cold, low salinity, nutrient poor



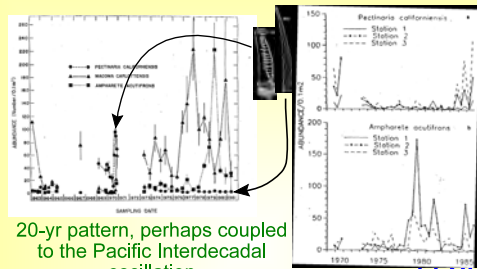
EEOS630

Slide 73 1996-1998 Negative NAO event

NOTES:

Long-term change in Puget Sound; Coupled to PDA

Fred Nichols, USGS, 200-m station

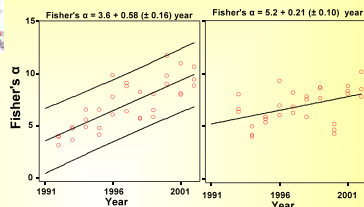


EEOS630

Slide 74 Long-term change in Puget Sound; Coupled to PDA

NOTES:

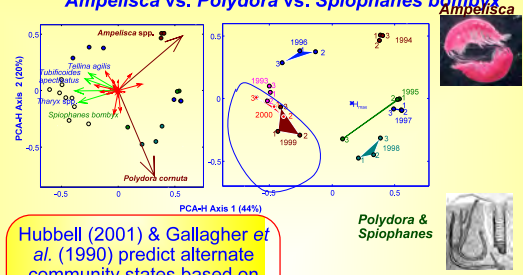
T5A: President's Roads sludge dumping site



EEOS630

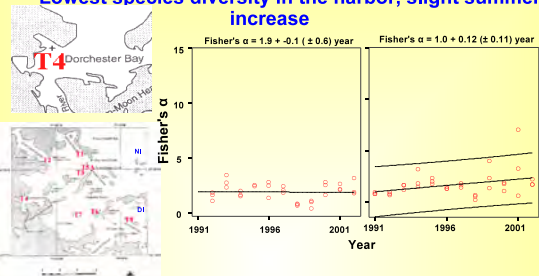
Slide 75 T5A: President's Roads sludge dumping site

NOTES:

<p>T5A Summer: Numerical dominant crap shoot</p> <p><i>Ampelisca</i> vs. <i>Polydora</i> vs. <i>Spiophanes bombyx</i></p>  <p>Hubbell (2001) & Gallagher <i>et al.</i> (1990) predict alternate community states based on initial dominance</p> <p><i>Polydora & Spiophanes</i></p> <p>EEOS630</p>	<p>Slide 76 T5A Summer: Numerical dominant crap shoot</p>
	<p>NOTES:</p>

T4: Savin Hill Cove

Lowest species diversity in the harbor, slight summer increase



EEOS630

Pearson & Rosenberg vs. Hubbell

Hubbell & Bell's neutral models: not successional

Pearson & Rosenberg, Rhoads et al. (1978)	Hubbell's Neutral model
<ul style="list-style-type: none"> • Unidirectional Succession • Opportunistic species replaced by equilibrium species • No metacommunity dynamics • Relatively silent on species diversity, except for SAB curves 	<ul style="list-style-type: none"> • Ecological drift; stochastic equilibrium • All individuals & all species equivalent • Emphasis on metacommunity dynamics • A theory for species abundance curves

Slide 77 T4: Savin Hill Cove

Conclusions	Slide 79 Conclusions
<ul style="list-style-type: none"> • The biodiversity of Boston Harbor's benthic infauna has undergone a tremendous change since the mid 1980s • The early succession fit the Pearson-Rosenberg/Rhoads model with <i>Capitella</i> being replaced by spionids & amphipod crustaceans • Hubbell's neutral model appears to apply now <ul style="list-style-type: none"> ▸ A theory for assessing biodiversity ▸ Boston Harbor is coupled to MA Bay metacommunities ▸ Ecological drift produces interannual shifts in dominants: spionids one year, ampeliscids on other years <p style="text-align: right;"><i>EEOS630</i></p>	
	NOTES: