High Deep-Sea Diversity, Effects of Pollution on Benthic Community Structure: West Falmouth Oilspill & Boston Harbor Pearson & Rosenberg *vs.* Hubbell's neutral model

Class 13: Th Oct 14, 2009

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Slide 1 Goals of today's class

NOTES:

Required reading, community structure

Chapter 5: Global Patterns of Benthic Community Structure Especially Deep-Sea Diversity

Etter, R.J. and L. S. Mullineaux. 2001. Deep-sea communities. Pp. 367-393 in M. D. Bertness, S. D. Gaines, and M. Hay ,Eds., Marine Community Ecology. Sinauer Associates, Sunderland, Massachusetts. 550 pp

Gallagher, E. D. & K. E. Keay. 1998. Organism-sediment-contaminant interactions in Boston Harbor. Pp. 89-132 in K. D. Stolzenbach and E. E. Adams, eds., Contaminated Sediments in Boston Harbor. MIT Sea Grant College Program, Cambridge MA. 170 p. [There is a slightly expanded version of this document available as a pdf at http://www.es.umb.edu/edg/ECOS630/GallagherKeay98.pdf]

Jumars, P. A. and E. D. Gallagher. 1982. Deep-sea community structure: three plays on the benthic proscenium. Pages 217-255 *in* W. G. Ernst and J. G. Morin, *eds.*, The environment of the deep sea; Rubey Volume II. Prentice-Hall, Englewood Cliffs, N.J.

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Slide 2 Required reading, community structure

NOTES:

Benthic Pollution Biology

Chapter 6

Gallagher, E. D. & K. E. Keay. 1998. Organism-sediment-contaminant interactions in Boston Harbor. Pp. 89-132 in K. D. Stolzenbach and E. E. Adams, eds., Contaminated Sediments in Boston Harbor. MIT Sea Grant College Program, Cambridge MA. 170 p. [There is a slightly expanded version of this document available as a pdf at http://www.es.umb.edu/edg/ECOS630/GallagherKeay98.pdf]

Grassle, J. F. and J. P. Grassle. 1974. Opportunistic life histories and genetic systems in marine benthic polychaetes. J. Marine Research 32: 253-284.

Grassle, J. F. and W. K. Smith. 1976. A similarity measure sensitive to rare species and its use in investigation of marine benthic communities. Oecologia *25*: 13-22. also used for Project 1

Rosenberg, R. 2001. Marine benthic faunal successional stages and related

Slide 3 Benthic Pollution Biology

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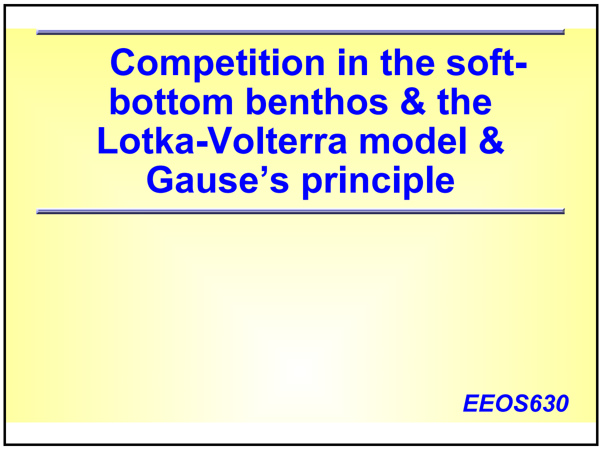

Slide 4 Competition in the soft-bottom benthos & the Lotka-Volterra model & Gause's principle

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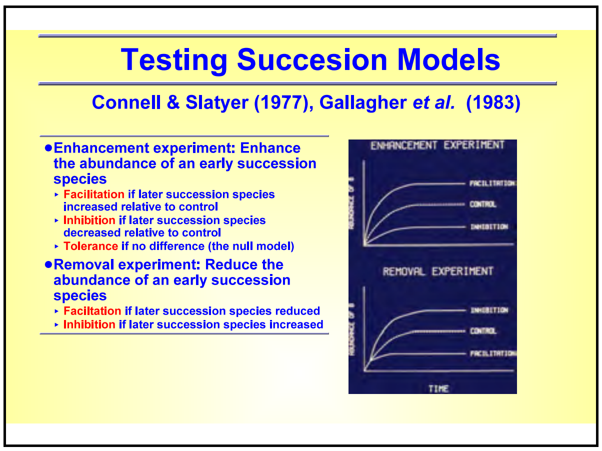

Slide 5 Testing Succesion Models

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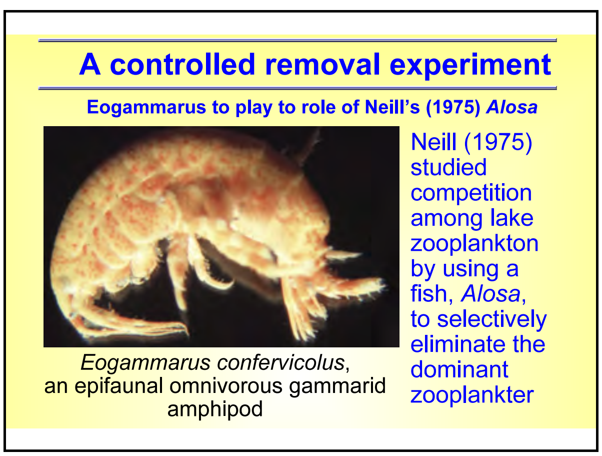
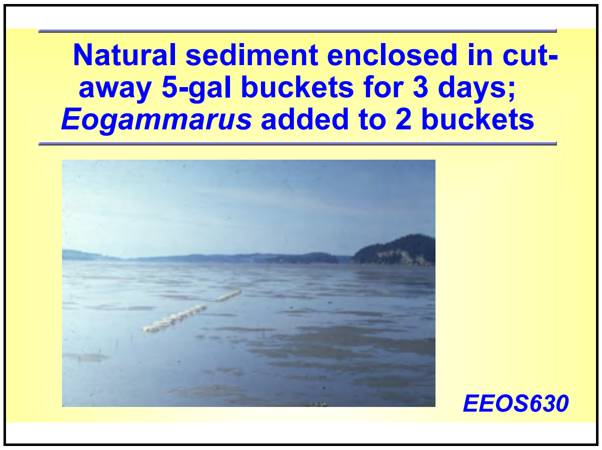


Slide 6 A controlled removal experiment

NOTES:

Slide 7 Eogammarus is an omnivore

NOTES:



Slide 8 Natural sediment enclosed in cut-away 5-gal buckets for 3 days; Eogammarus added to 2 buckets

NOTES:

Slide 9 Buckets enclosed with 1-mm mesh to retain Eogammarus

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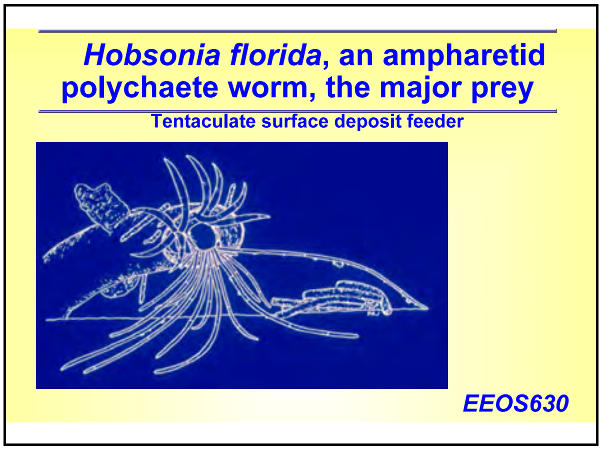

Slide 10 Hobsonia florida, an ampharetid polychaete worm, the major prey

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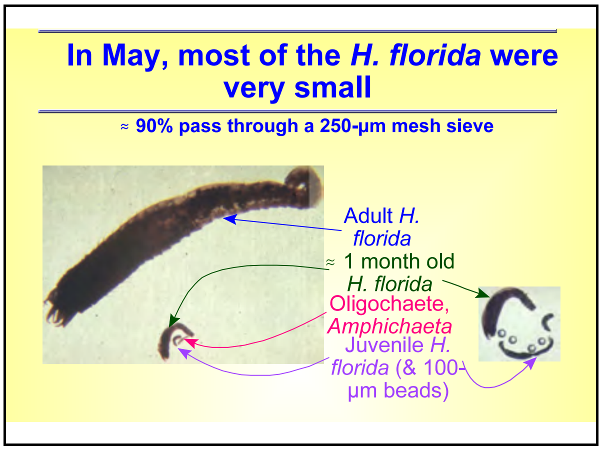

Slide 11 In May, most of the H. Florida were very small

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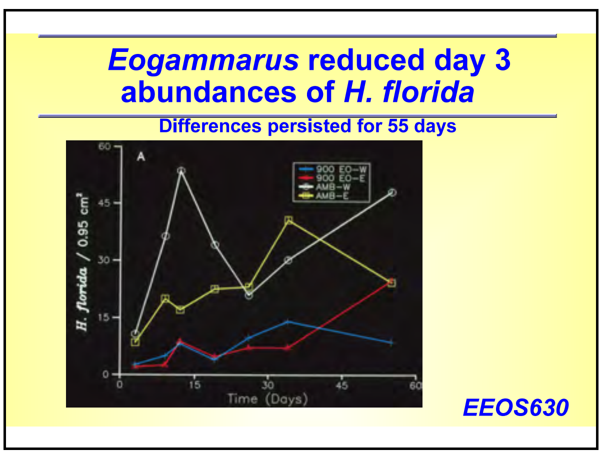

Slide 12 Eogammarus reduced day 3 abundances of H. Florida

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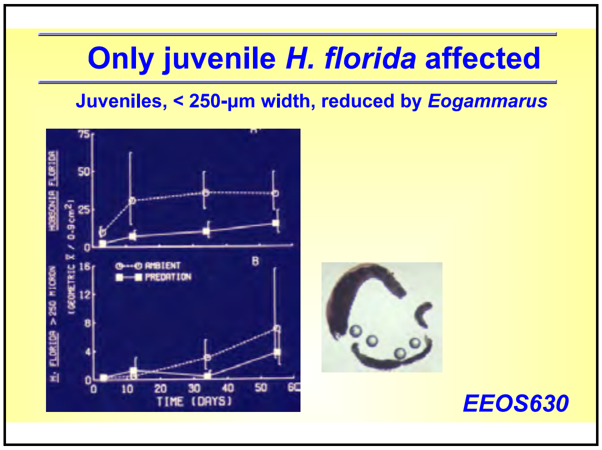

Slide 13 Only juvenile H. Florida affected

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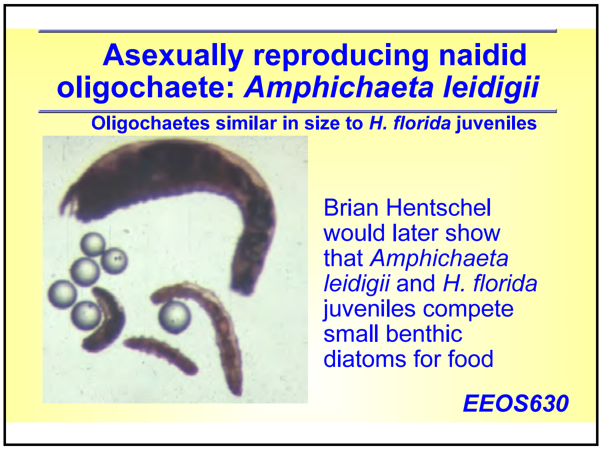
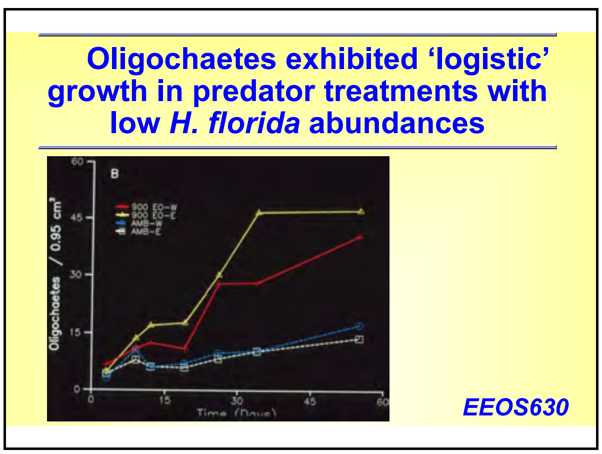


Slide 14 Asexually reproducing naidid oligochaete: Amphichaeta leidigii

NOTES:

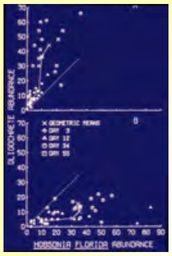


Slide 15 Oligochaetes exhibited 'logistic' growth in predator treatments with low H. Florida abundances

NOTES:

Two distinct population growth trajectories

In predator treatment, oligochaetes > *H. florida*
In natural community, *H. florida* > Oligochaetes



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Slide 16 Two distinct population growth trajectories

NOTES:

What is competition?

- Competition: ‘the shared utilization of a resource that is demonstrably in short supply.’
- “competition is occurring if the increase in the growth rate of one population leads to the decline in the growth rate of another.”
  - *“intraspecific competition occurs if increasing density of one population leads to a decrease in the per capita growth rate* or density
- Density-dependent limits on abundance or growth is the key element

Slide 17 What is competition?

NOTES:

Types of competition

Exploitative (’scramble’) vs. Interference

In **exploitative**, **or scramble competition**, the effects of competition are caused by the consumption of the shared resource.

In **interference competition**, one individual or group of individuals prevents another individual or group of individuals from gaining access to the resource.

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Slide 18 Types of competition

NOTES:

Competition vs. Predation vs. Density-independent control

- Competition for resources is the key factor limiting population growth:
  - Lack's & Darwin's finches
  - A. J. Lotka's logistic growth
  - Volterra-Lotka competition models (1926, 1928) & Gause's (1930) competitive exclusion principle
  - Connell's barnacles crushing each other in the Scottish intertidal
- Predation is the key limiting factor
- Andrewartha & Birch (1954): Neither factor controls populations. It is climate & the environment

Slide 19 Competition vs. Predation vs. Density-independent control

NOTES:

Lotka-Volterra competition

An extension of the logistic equation: invoked to explain high-deep sea diversity in both equilibrium and non-equilibrium explanations

$$\frac{dN_1}{dt} = r_1 N_1 \left(1 - \frac{N_1 - \alpha_{12} N_2}{K_1}\right).$$

$$\frac{dN_2}{dt} = r_2 N_2 \left(1 - \frac{N_2 - \alpha_{21} N_1}{K_2}\right).$$

where, α = Interspecific competition coefficient.
K = Carrying capacity.
r = maximum per capita growth rate.

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Slide 20 Lotka-Volterra competition

NOTES:

Model Estimates

Interspecific competiton coefficients ≈ 1
See Gallagher *et al.* (1990) for fitting methods

Taxon	Doubling Time	Carrying Capacity	Competition Coefficient (α_{ij})
Oligochaetes	5.8 Days	57	1.005
Hobsonia florida	2.8 Days	45	0.857

Note that the interspecific competition coefficients make these two taxa competitively equivalent species

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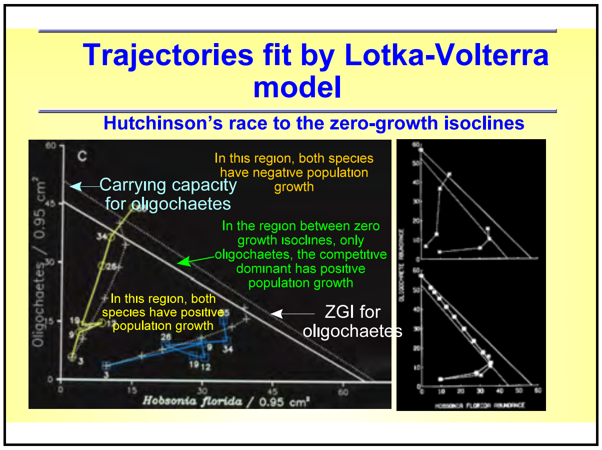
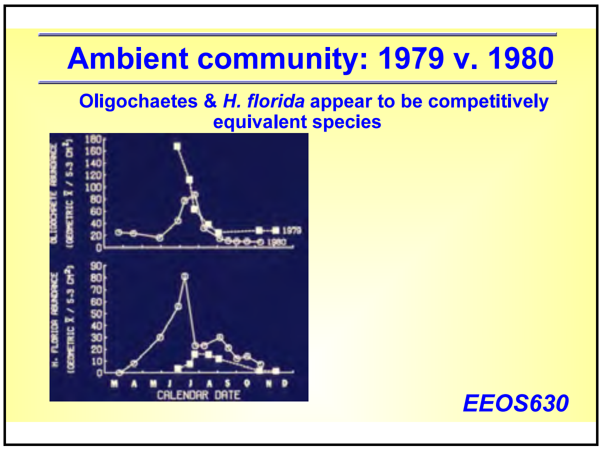
Slide 21 Model Estimates

NOTES:



Slide 22 Trajectories fit by Lotka-Volterra model

NOTES:

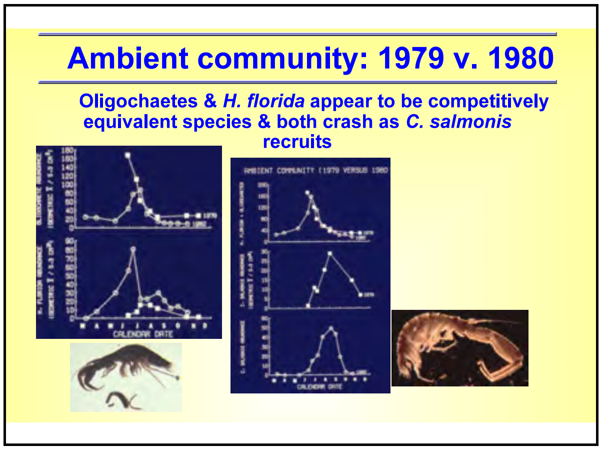


Slide 23 Ambient community: 1979 v. 1980

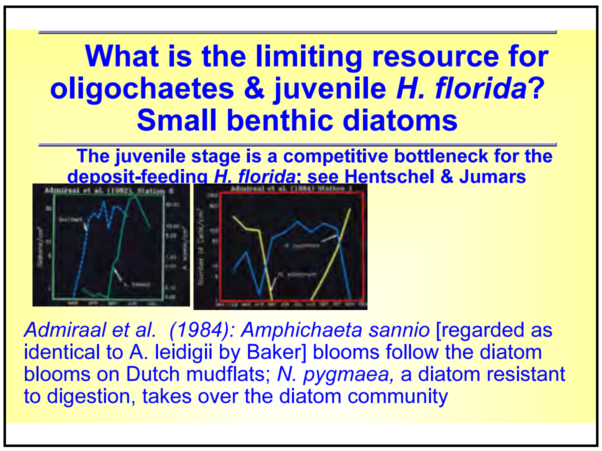
NOTES:

Slide 24 Corophium salmonis, a large interface feeder, recruits to the sandflat each July AS ADULTS

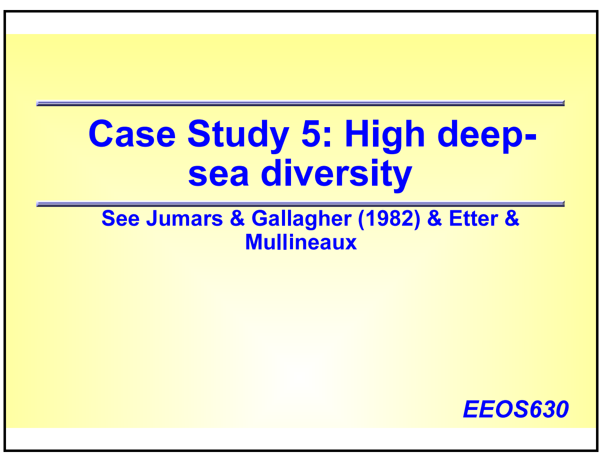
NOTES:



Slide 25 Ambient community: 1979 v. 1980	
NOTES:	



Slide 26 What is the limiting resource for oligochaetes & juvenile H. Florida? Small benthic diatoms	
NOTES:	



Slide 27 Case Study 5: High deep-sea diversity	
NOTES:	

Milestones in deep-sea diversity

Documenting High Deep-Sea diversity

- 1846 Forbes dredged shells from the abyss, indicating that there is life in the deep sea.
- 1873-1876 Challenger expedition
  - Dredged animals from 5500 m1880
  - Thomas: The deep sea fauna is stable and ancient, containing the ancestral forms of many shallow water taxa.
- 1967 Hessler and Sanders
  - First quantitative demonstration of high deep-sea diversity.
  - Gayhead MA to Bermuda transect.

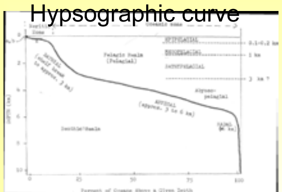
Slide 28 Milestones in deep-sea diversity

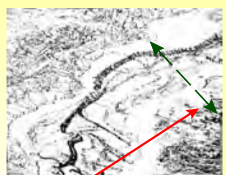
NOTES:

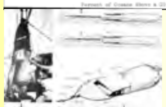
High deep-sea diversity

Gayhead to Bermuda transect: Sanders & Hessler 1967

Hypsographic curve







Abyssal plains: largest habitat on earth by far (about 75% of ocean area)

Slide 29 High deep-sea diversity

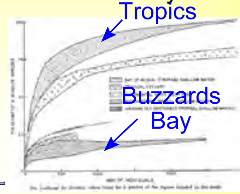
NOTES:

Sanders-Hurlbert rarefaction

Sanders (1968) & Hurlbert (1971)

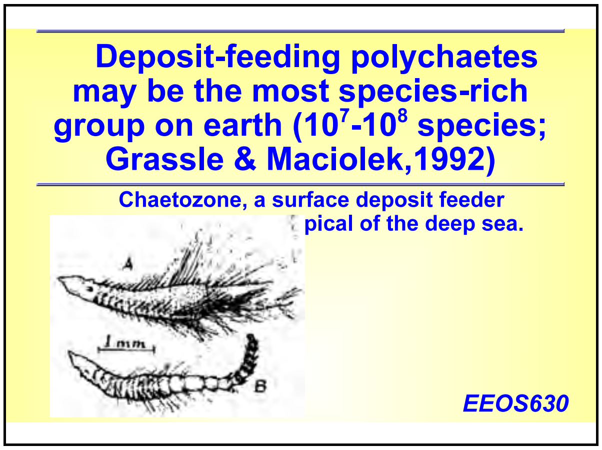
- **Each sample is plotted as a rarefaction curve, with the end being the observed number of species and individuals**
- **The expected number of species at a smaller, or 'rarefied' sample size is noted E(S_n), with n being the rarefied sample size**
- **Hurlbert corrected Sanders' algorithm using the hypergeometric distribution**

Soft-bottom benthic diversity



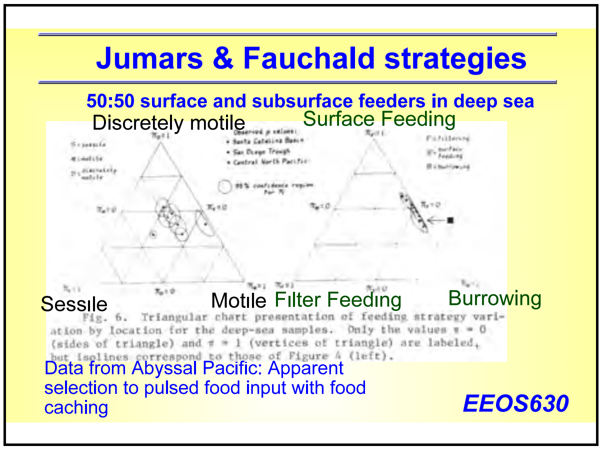
Slide 30 Sanders-Hurlbert rarefaction

NOTES:



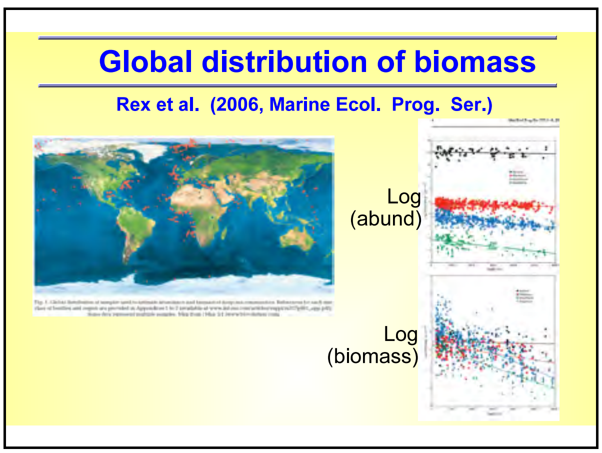
Slide 31 Deposit-feeding polychaetes may be the most species-rich group on earth (107-108 species; Grassle & Maciolek,1992)

NOTES:



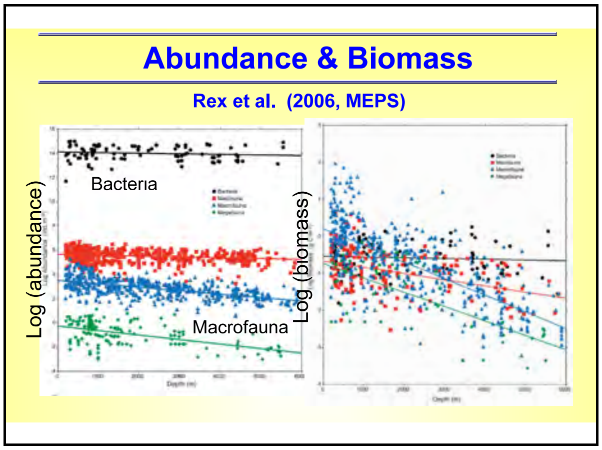
Slide 32 Jumars & Fauchald strategies

NOTES:



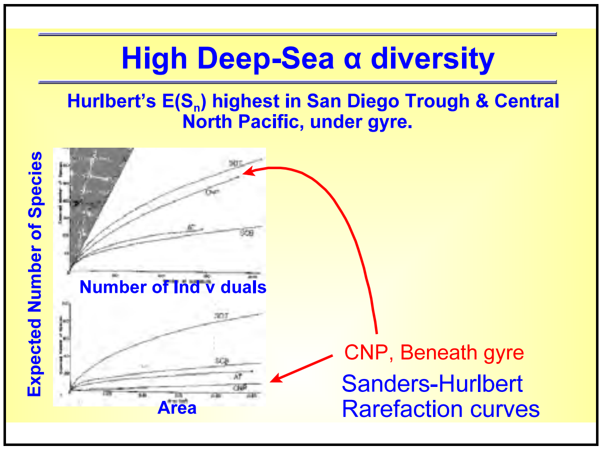
Slide 33 Global distribution of biomass

NOTES:



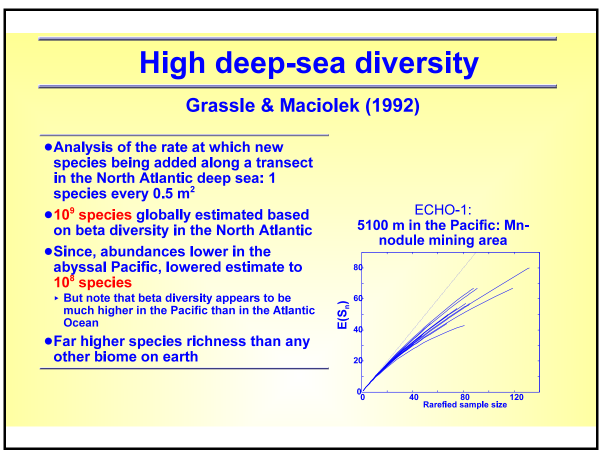
Slide 34 Abundance & Biomass

NOTES:



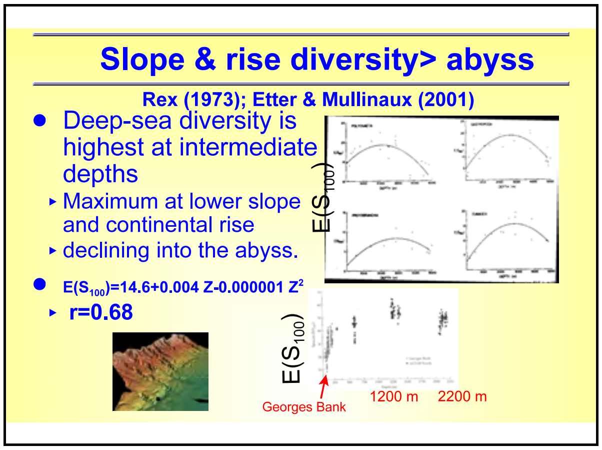
Slide 35 High Deep-Sea α diversity

NOTES:

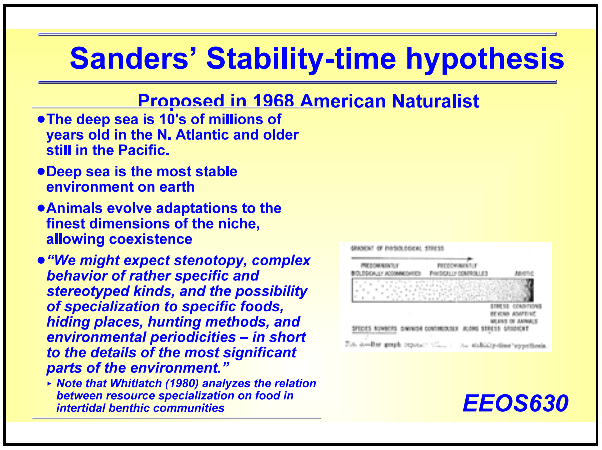


Slide 36 High deep-sea diversity

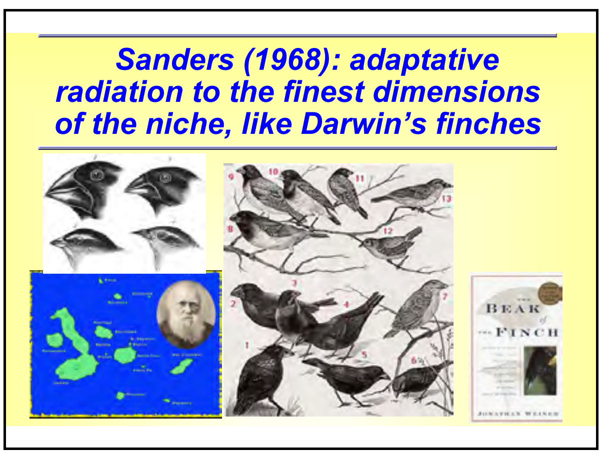
NOTES:



Slide 37 Slope & rise diversity> abyss	
NOTES:	



Slide 38 Sanders' Stability-time hypothesis	
NOTES:	



Slide 39 Sanders (1968): adaptative radiation to the finest dimensions of the niche, like Darwin's finches	
NOTES:	

Sanders (1968): adaptative radiation to the finest dimensions of the niche, like Darwin's finches

Slide 40 The cropper hypothesis

NOTES:

Spatial heterogeneity

Grassle & Sanders (1973), Jumars (1975 a & b, 1976)

- Written as a rebuttal to Dayton & Hessler's (1972) cropper hypothesis based on predation and disturbance
- Grassle & Sanders (1973): little evidence for 'cropping' in the deep-sea
- **Habitat specialization, aided by deep-sea spatial heterogeneity** may be the key to maintaining high deep-sea diversity
- Jumars (1975a & b, 1976, Jumars & Eckman 1980): Deep sea may be the most spatially heterogeneous environment on earth.

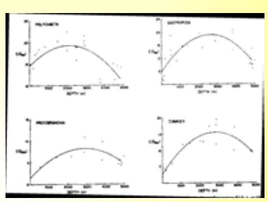
Slide 41 Spatial heterogeneity

NOTES:

Explanations based on competition

Interaction of predation and competition: Increasing predation in the deep sea may keep competitors below their carrying capacity, allowing coexistence.

- **1976 Rex Both predation and competition control the gradient in species richness producing an intermediate peak**
- **1976 Menge and Sutherland: Predation and competition interact to produce high deep-sea diversity**
- **1979 Huston's dynamic equilibrium model**



Slide 42 Explanations based on competition

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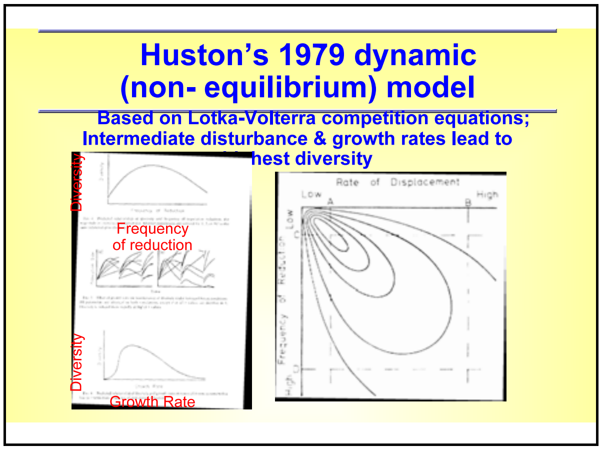

Slide 43 Huston's 1979 dynamic
(non- equilibrium) model

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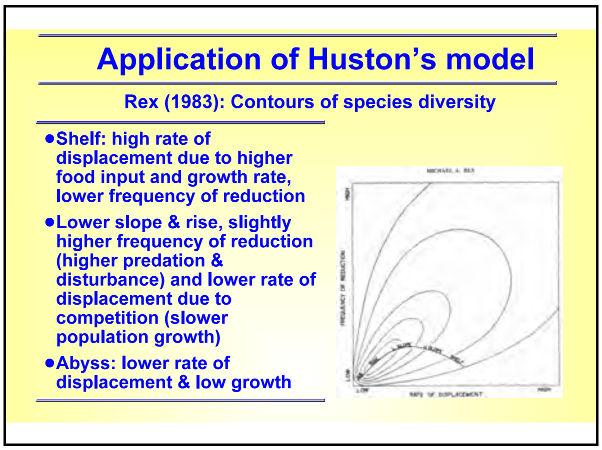

Slide 44 Application of Huston's model

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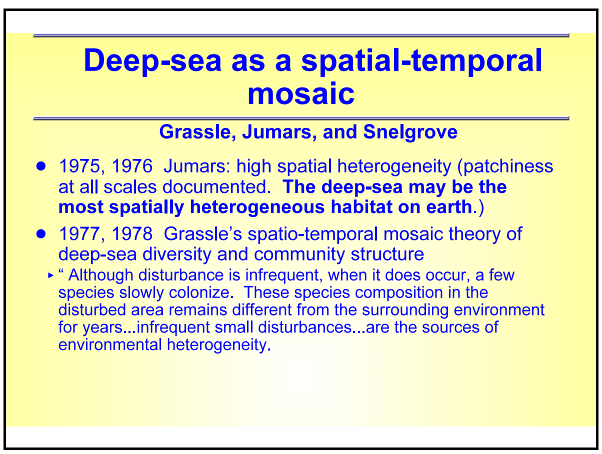
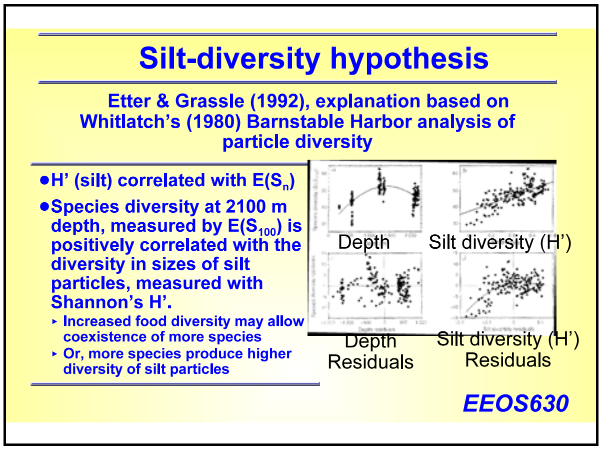


Slide 45 Deep-sea as a spatial-temporal mosaic

NOTES:



Slide 46 Silt-diversity hypothesis

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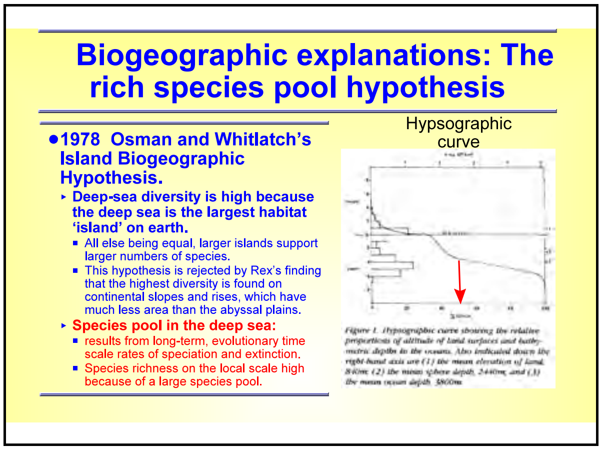
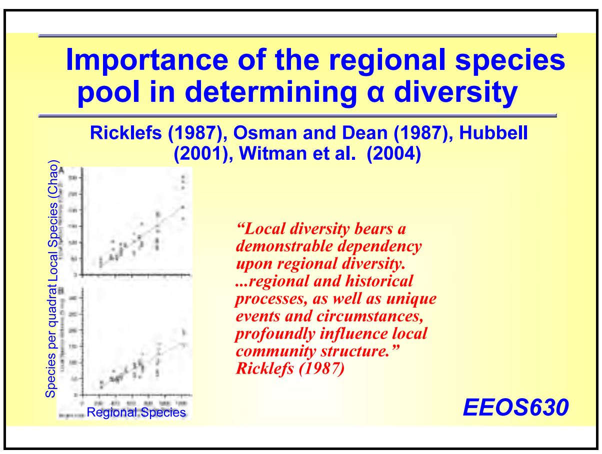


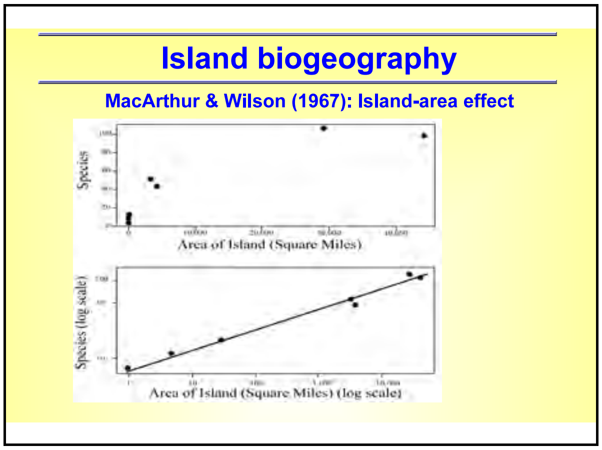
Slide 47 Biogeographic explanations: The rich species pool hypothesis

NOTES:



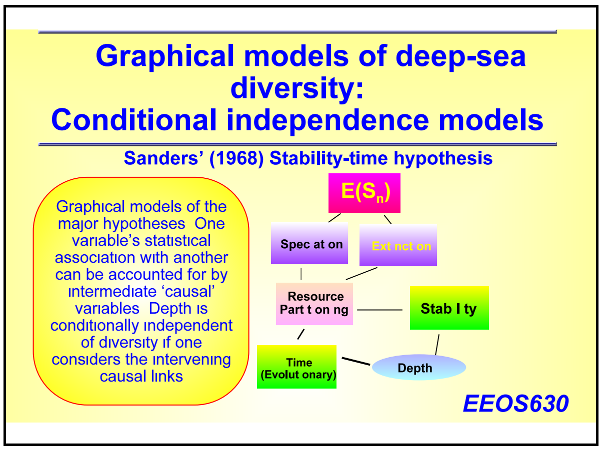
Slide 48 Importance of the regional species pool in determining α diversity

NOTES:



Slide 49 Island biogeography

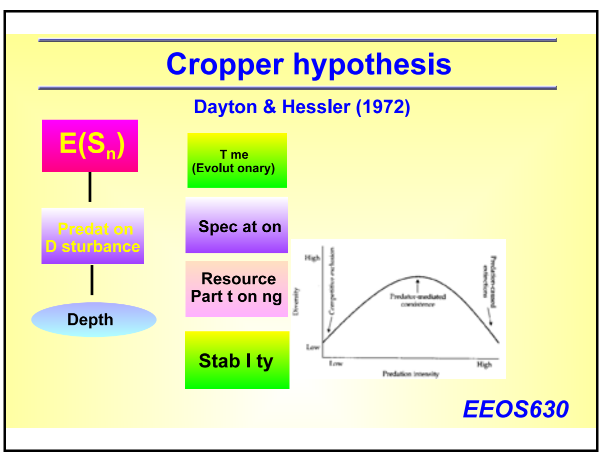
NOTES:



Slide 50 Graphical models of deep-sea diversity:

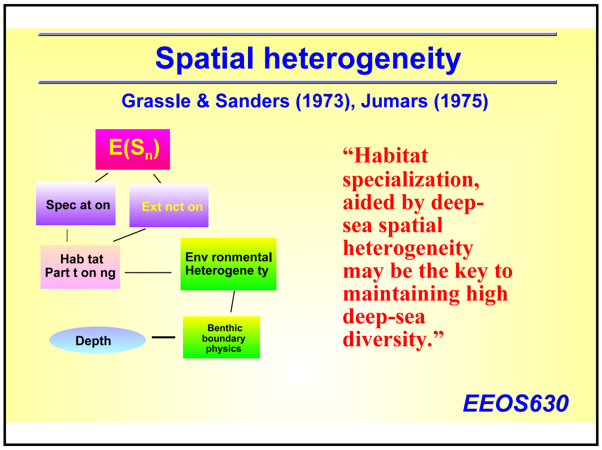
Conditional independence models

NOTES:



Slide 51 Cropper hypothesis

NOTES:



Slide 52 Spatial heterogeneity

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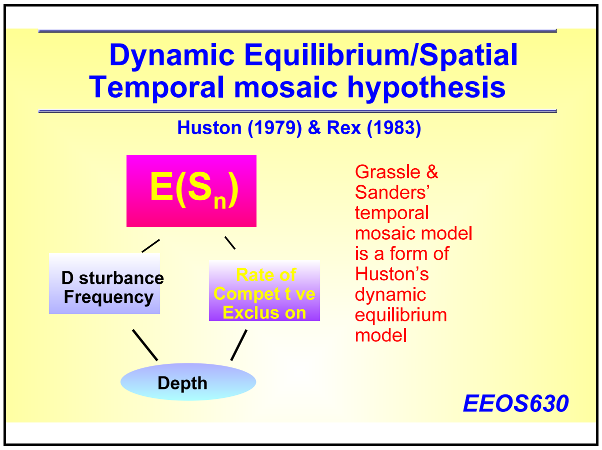

Slide 53 Dynamic Equilibrium/Spatial Temporal mosaic hypothesis

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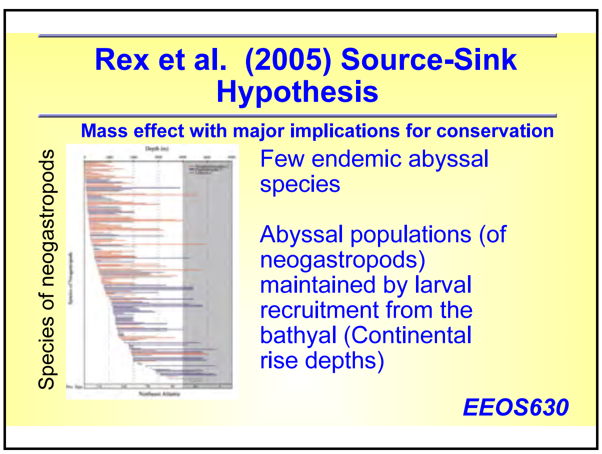
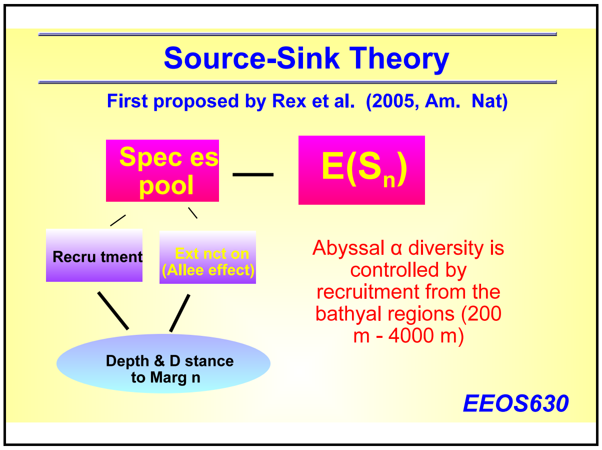


Slide 54 Rex et al. (2005) Source-Sink Hypothesis

NOTES:



Slide 55 Source-Sink Theory

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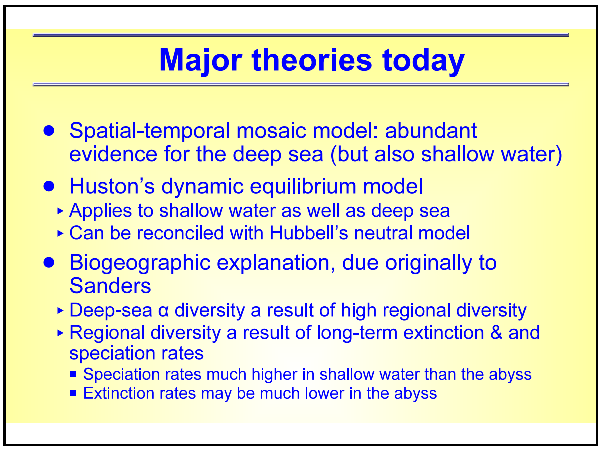
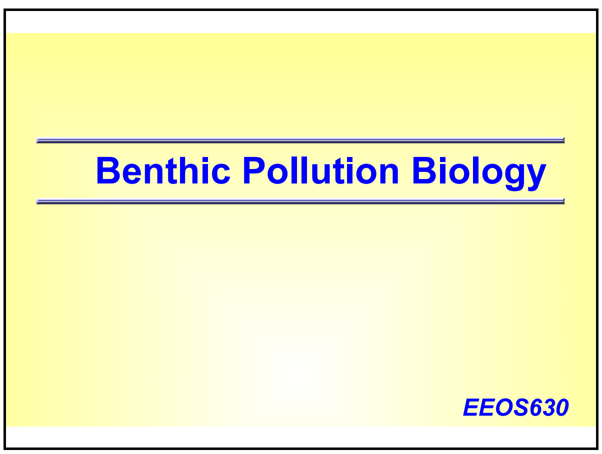


Slide 56 Major theories today

NOTES:



Slide 57 Benthic Pollution Biology

NOTES:

Types of benthic surveys

Green (1979, p. 68)

- **Baseline study**: determine the present state of the system (**EPA's EMAP**)
- **Impact study**: The effects of an impact are assessed **(Oil spill)**
- **Monitoring study**
  - Detect change from the present state
  - BACI, Before-After comparitive impact design
  - **Baseline data** must be available in an impact study to provide a standard against which to detect a change.
  - MWRA monitoring

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Slide 58 Types of benthic surveys

NOTES:

Why monitor the benthos?

A standard part of monitoring world-wide

- Infaunal populations relatively sedentary & don't migrate
- Generation times
  - Short enough to respond numerically
  - Populations adapted to short-term changes in the environment
  - Biodiversity senstive to changes in pollutant load
- Human health links (flounder)

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Slide 59 Why monitor the benthos?

NOTES:

A definition of monitoring

Gallagher's definition

Monitoring is a sampling program designed to detect **ecologically significant** changes in the value of 'response' variables and to account for observed changes in these variables in terms of 'explanatory' or 'predictor' variables.

- There should be a theory or model to account for any changes observed
- There is a difference between ecological significance & statistical significance
- All communities are changing. One should be able to demonstrate whether the changes are due to changes in the physical or chemical environment

Slide 60 A definition of monitoring

NOTES:

Monitoring plans

Monitoring designs should describe:

- The null hypotheses to be tested, usually ‘no change in time’ or ‘no change relative to control areas’
- The statistical model and test statistics to be employed.
- Alternate hypotheses necessary for the calculation of statistical power.
  - Ecologically meaningful effects
  - Another way of specifying the alternate hypothesis is to answer the question, “What level of change should the monitoring program be designed to detect?”

Slide 61 Monitoring plans

NOTES:

Examples of pollution effects

Analyzed with PCA-H, diversity analyses & sediment profiling

- Case Study 1: 1969 West Falmouth oilspill: an impact survey
- Case Study 2: Boston Harbor & MA Bay
  - 1982 Section 301 (h) waiver application: Boston Harbor at its worst
  - Ongoing MWRA Harbor monitoring with profile imaging: Boston Harbor’s recovery
- Case Study 3: EMAP-E Virginian Province

Slide 62 Examples of pollution effects

NOTES:

Case Study 1: West Falmouth Oilspill

12/10/02 Boston Globe; Effects of West Falmouth 33 years later

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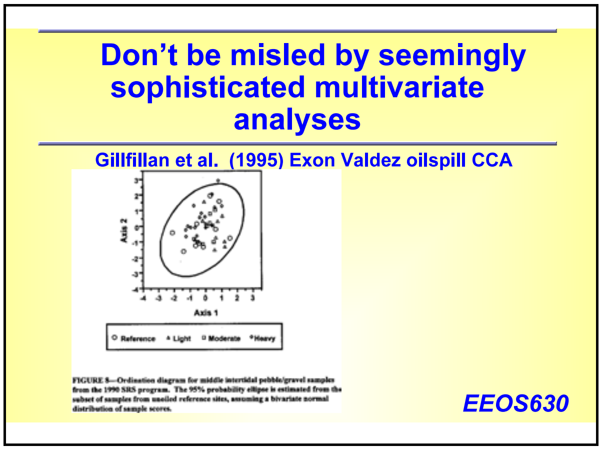
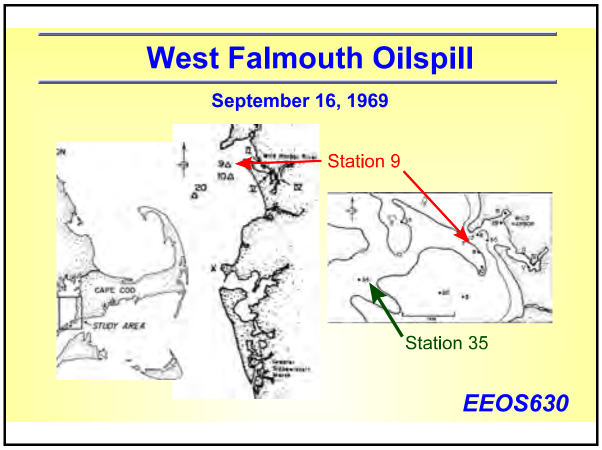
Slide 63 Case Study 1: West Falmouth Oilspill

NOTES:



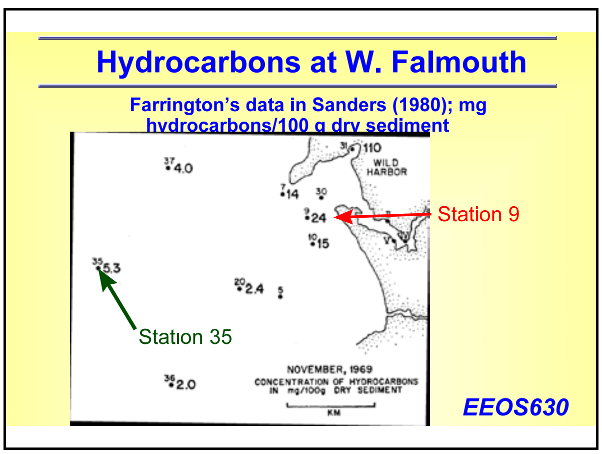
Slide 64 Don't be misled by seemingly sophisticated multivariate analyses

NOTES:



Slide 65 West Falmouth Oilspill

NOTES:

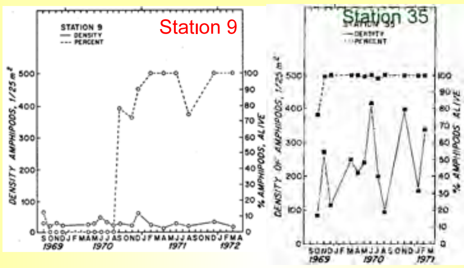


Slide 66 Hydrocarbons at W. Falmouth

NOTES:

Amphipod mortality

Amphipods (Ampelisca) killed at 9, abundant at 35



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Slide 67 Amphipod mortality

NOTES:

Opportunistic vs equilibrium spp.

Grassle & Grassle (1974)

- We propose defining degree of **opportunism** both in terms of ability to respond to unpredictable events and the **mortality rates** sustained by the species.
  - High abundance, high reproductive rate and **high mortality rate** are all part of the life history of the opportunist.
- Two major life history patterns in marine benthic opportunists
  - planktonic larvae or
  - rapidly exploit local resource through direct development or a brief planktonic existence.

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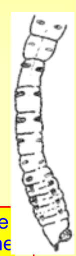
Slide 68 Opportunistic vs equilibrium spp.

NOTES:

West Falmouth Oilspill

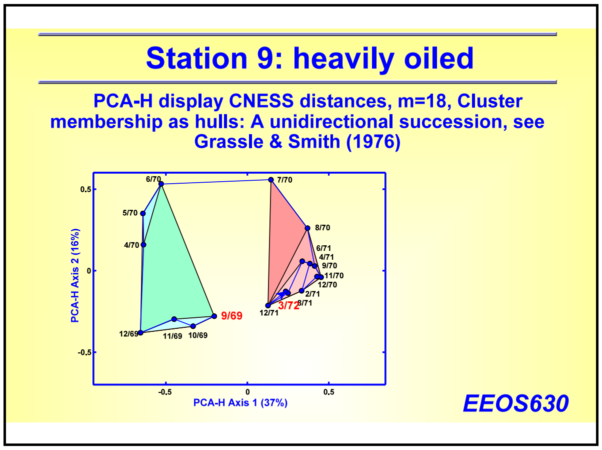
St. 9: Capitella → Mediomastus



Both are capitellids, members of the polychaete family Capitellidae, *Mediomastus ambiseta* is the most abundant macrofaunal species in the EMAP Virginian province (Nantucket to Virginia)

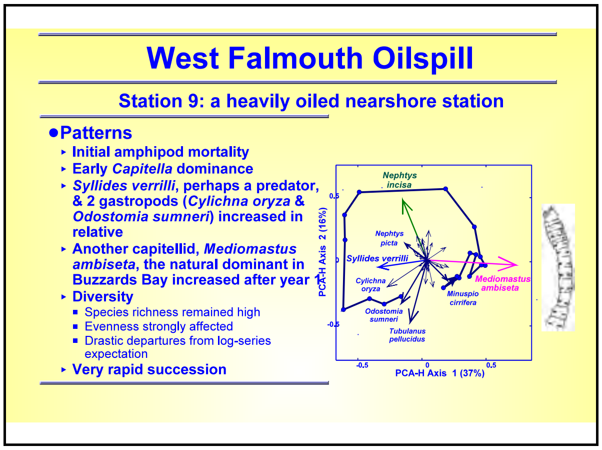
Slide 69 West Falmouth Oilspill

NOTES:



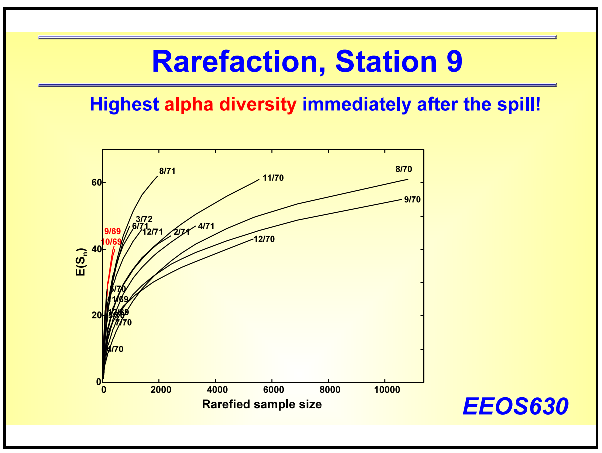
Slide 70 Station 9: heavily oiled

NOTES:



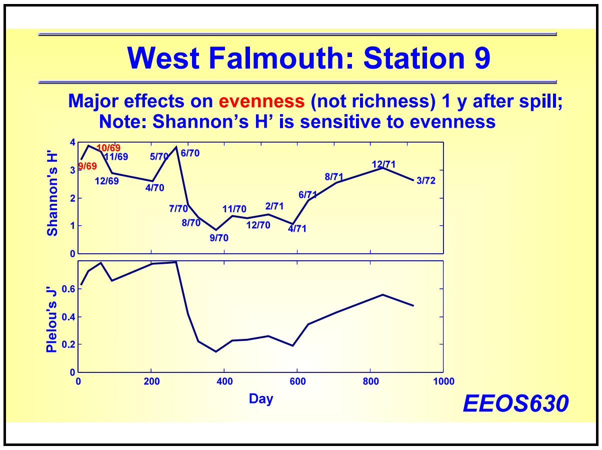
Slide 71 West Falmouth Oilspill

NOTES:



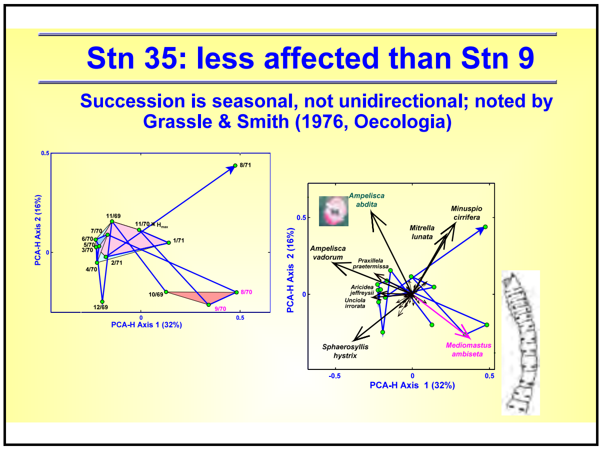
Slide 72 Rarefaction, Station 9

NOTES:



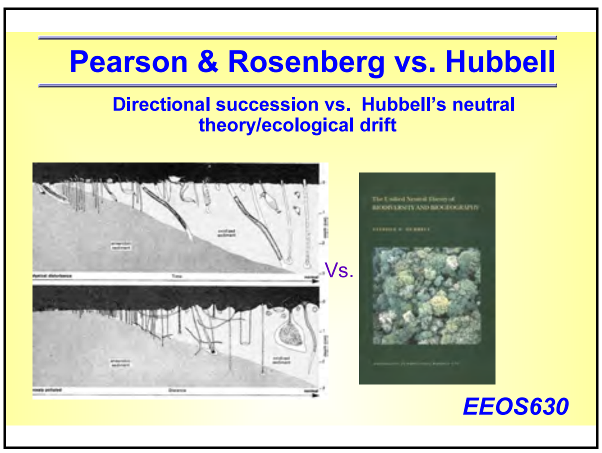
Slide 73 West Falmouth: Station 9

NOTES:



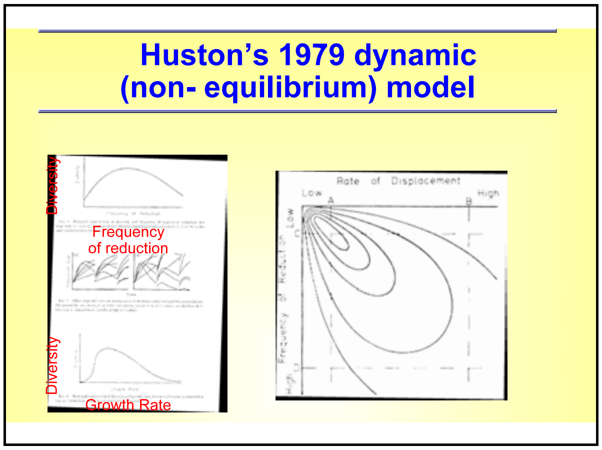
Slide 74 Stn 35: less affected than Stn 9

NOTES:



Slide 75 Pearson & Rosenberg vs. Hubbell

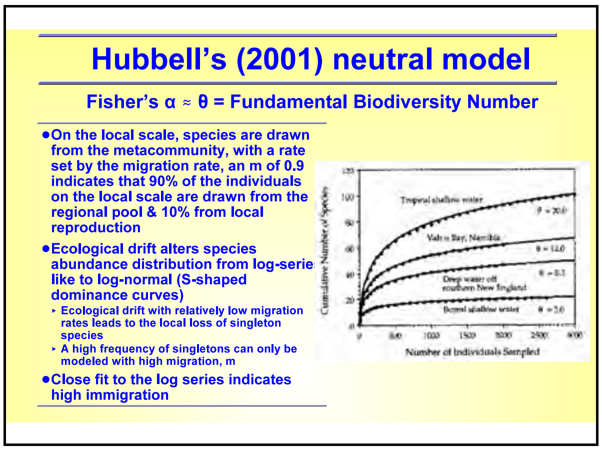
NOTES:



Slide 76 Huston's 1979 dynamic

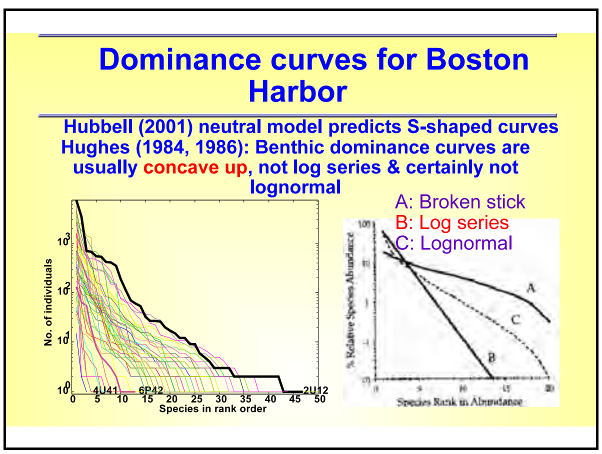
(non- equilibrium) model

NOTES:



Slide 77 Hubbell's (2001) neutral model

NOTES:



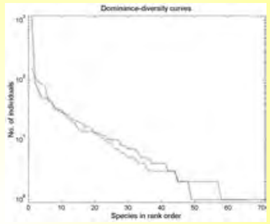
Slide 78 Dominance curves for Boston Harbor

NOTES:

Benthic dominance diversity curves from MA Bay

Spector (2005, UMB M.Sc. Thesis)

- Fisher et al. (1943): insect communities distributed as log series
- Preston: most communities distributed as lognormal
- Caswell's neutral model: log series
- Benthos
  - John Gray: lognormal
  - May, Hughes, Lambshead: log series or modified log series
  - Hubbell (2001): Zero-sum multinomial



Slide 79 Benthic dominance diversity curves from MA Bay

NOTES:

Neutral model programs

Based on Hubbell (2001)

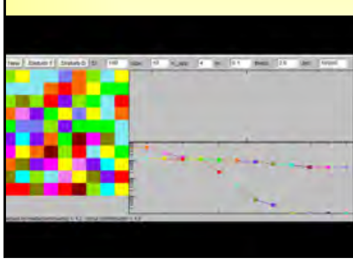
- Hubbell (2001) described algorithms but did not provide programs
  - Oksanen provides R programs to simulate Hubbell's neutral model. See his website for an expostion of the model
  - http://cc.oulu.fi/~jarioksa/index.html
- McGill (2003) criticized the neutral model and provided Matlab software to 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 80 Neutral model programs

NOTES:

Simulation of Hubbell's Neutral model

Simulation from U. Washington Ecology website



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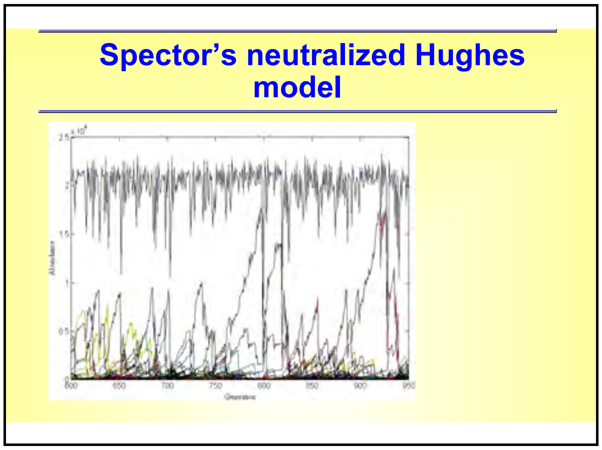
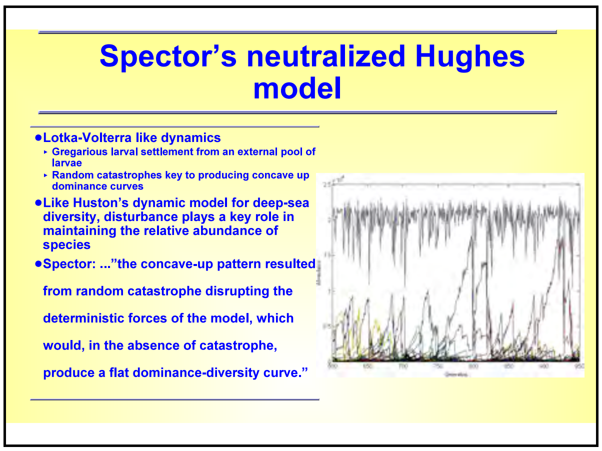
Slide 81 Simulation of Hubbell's Neutral model

NOTES:



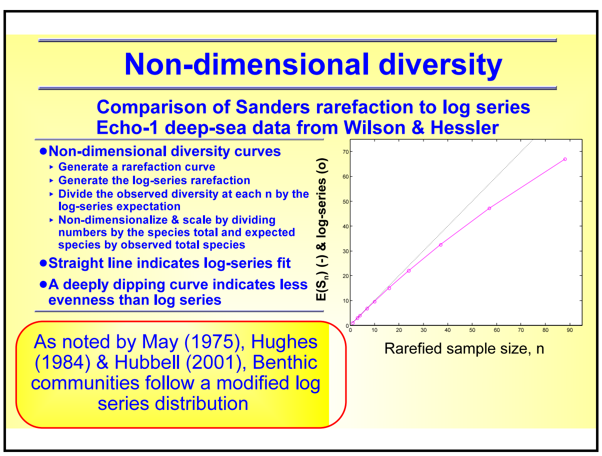
Slide 82 Spector's neutralized Hughes model

NOTES:



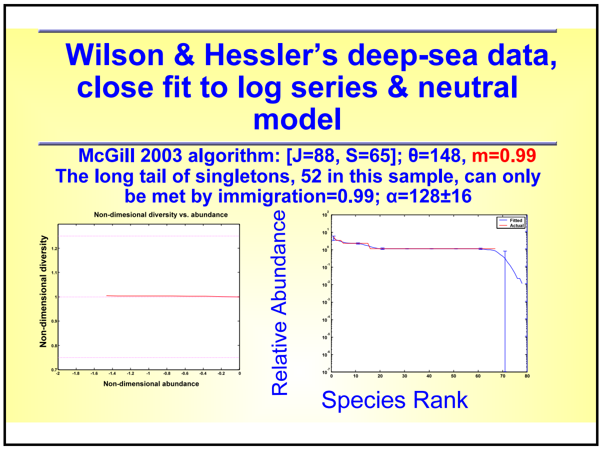
Slide 83 Spector's neutralized Hughes model

NOTES:



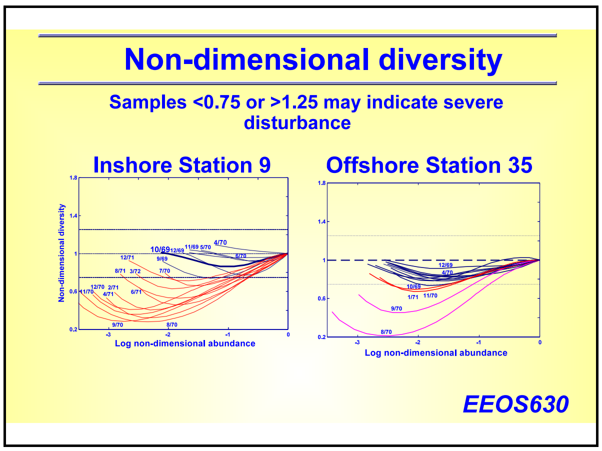
Slide 84 Non-dimensional diversity

NOTES:



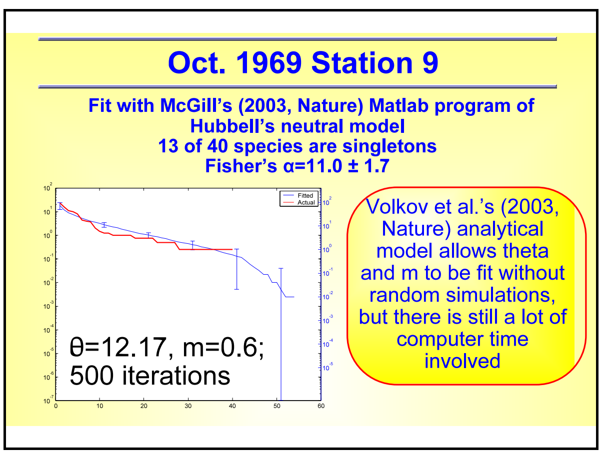
Slide 85 Wilson & Hessler's deep-sea data, close fit to log series & neutral model

NOTES:



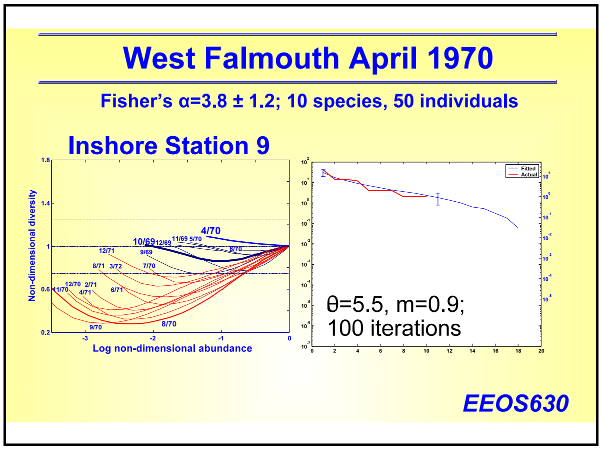
Slide 86 Non-dimensional diversity

NOTES:



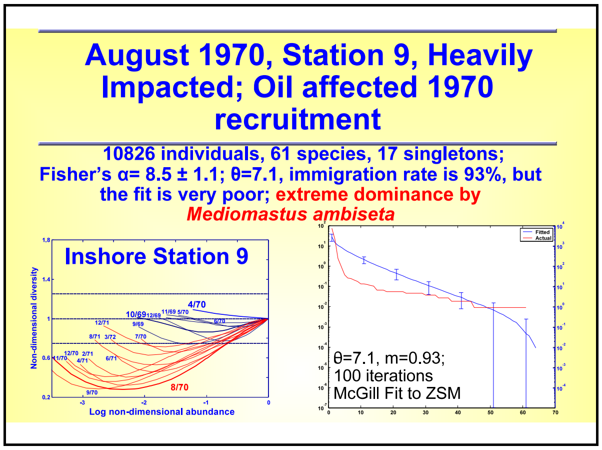
Slide 87 Oct. 1969 Station 9

NOTES:



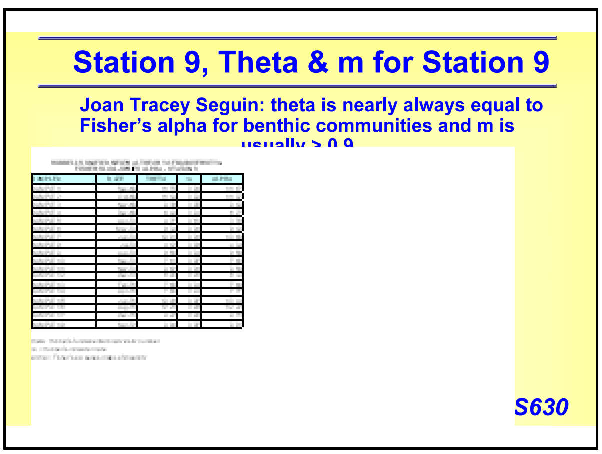
Slide 88 West Falmouth April 1970

NOTES:



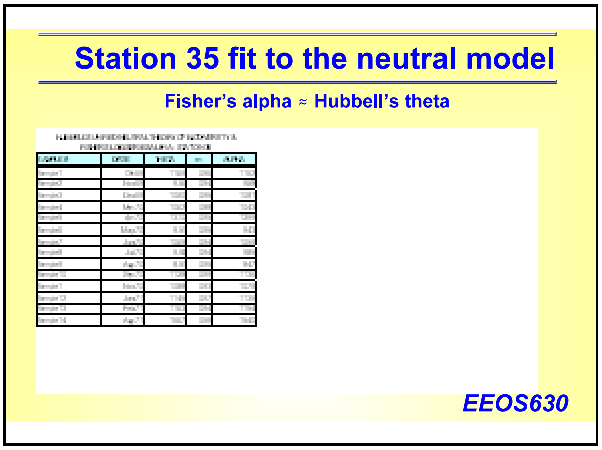
Slide 89 August 1970, Station 9, Heavily Impacted; Oil affected 1970 recruitment

NOTES:



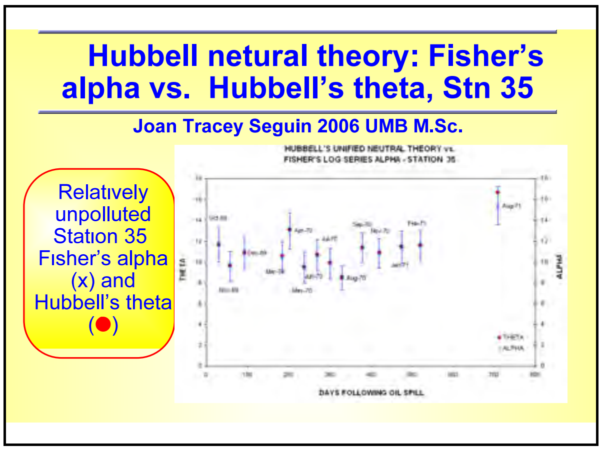
Slide 90 Station 9, Theta & m for Station 9

NOTES:



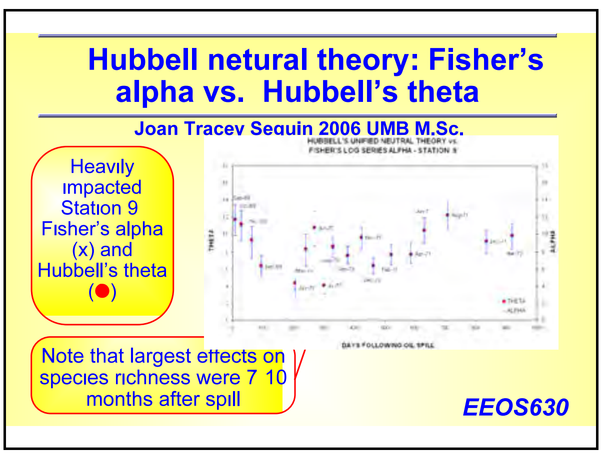
Slide 91 Station 35 fit to the neutral model

NOTES:



Slide 92 Hubbell netural theory: Fisher's alpha vs. Hubbell's theta, Stn 35

NOTES:



Slide 93 Hubbell netural theory: Fisher's alpha vs. Hubbell's theta

NOTES:

Conclusions on West Falmouth

The September 1969 spill had long-lasting effects

- Species richness remained relatively high throughout the Sanders & Grassle's monitoring
  - 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 *Mediomastus ambiseta* & *Nephtys incisa*, normal numerical dominance of the Buzzards Bay benthos (dominants in Sanders' Station R surveys)
- Major effects on species evenness

Slide 94 Conclusions on West Falmouth

NOTES:

Case Study 2: the recovery of Boston Harbor benthic communities in the 1990s

Pearson & Rosenberg vs. Hubbell's (2001) unified neutral model

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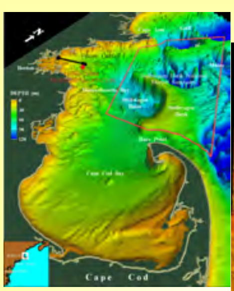
Slide 95 Case Study 2: the recovery of Boston Harbor benthic communities in the 1990s

NOTES:

Geology of MA Bay



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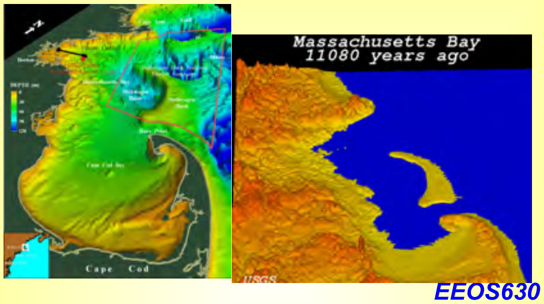
Slide 96 Geology of MA Bay

NOTES:

Geology of MA Bay



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Slide 97

NOTES:

William Wood's Boston Harbor

New England's Prospect (1634)

- 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

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Slide 98 William Wood's Boston Harbor

NOTES:

17-18th Century pollution problems

Mill Creek, Site of offal discharge 1656

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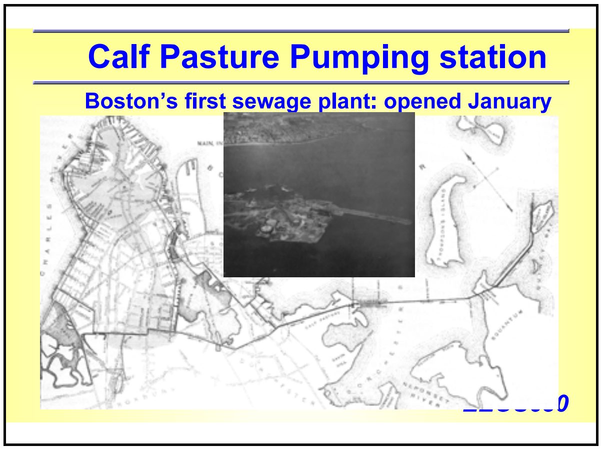
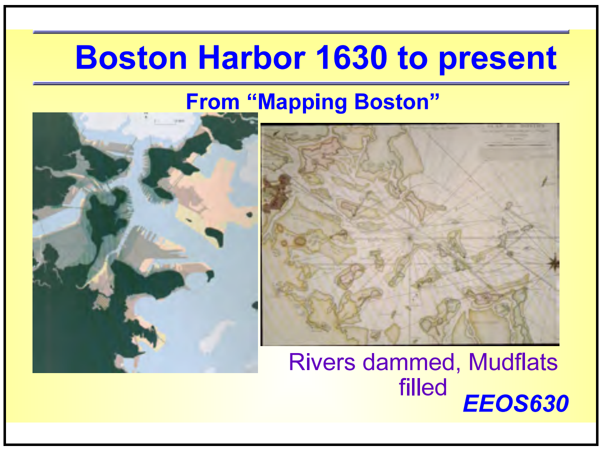
Slide 99 17-18th Century pollution problems

NOTES:



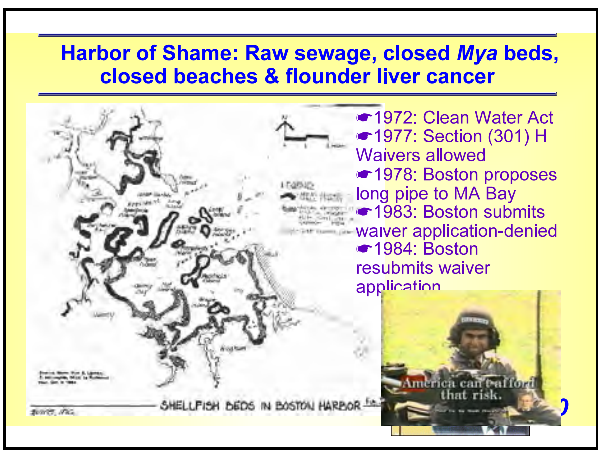
Slide 100 Calf Pasture Pumping station

NOTES:



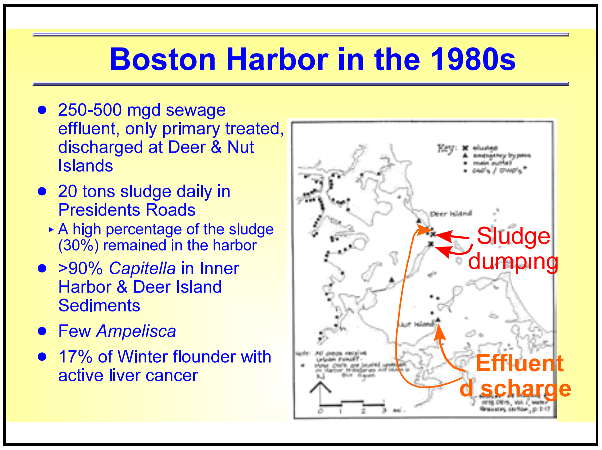
Slide 101 Boston Harbor 1630 to present

NOTES:



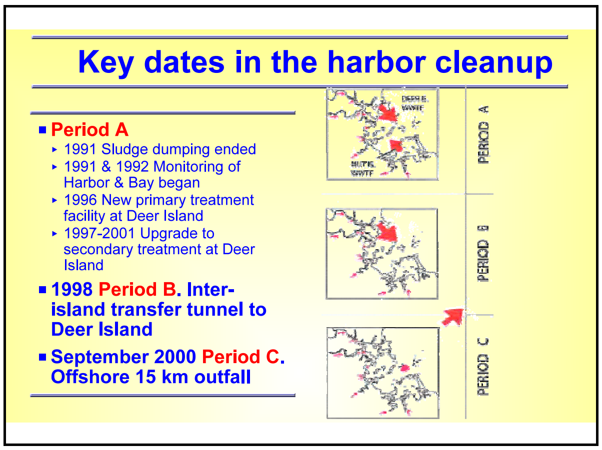
Slide 102 Harbor of Shame: Raw sewage, closed Mya beds, closed beaches & flounder liver cancer

NOTES:



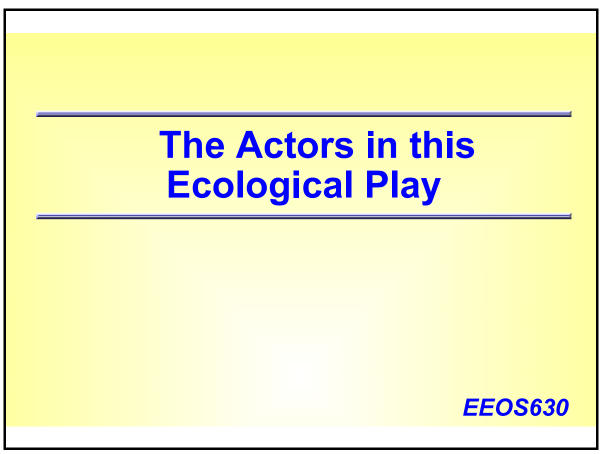
Slide 103 Boston Harbor in the 1980s

NOTES:



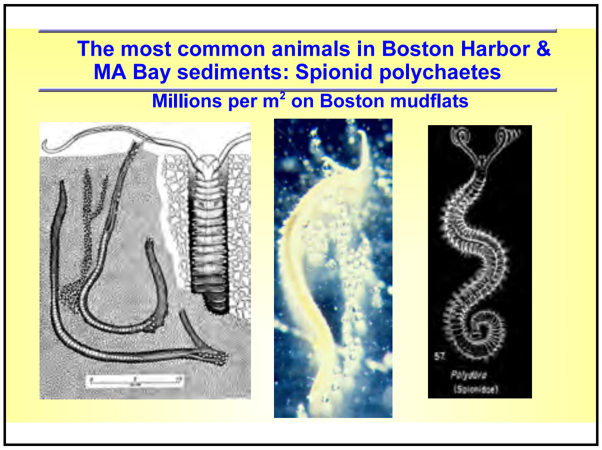
Slide 104 Key dates in the harbor cleanup

NOTES:



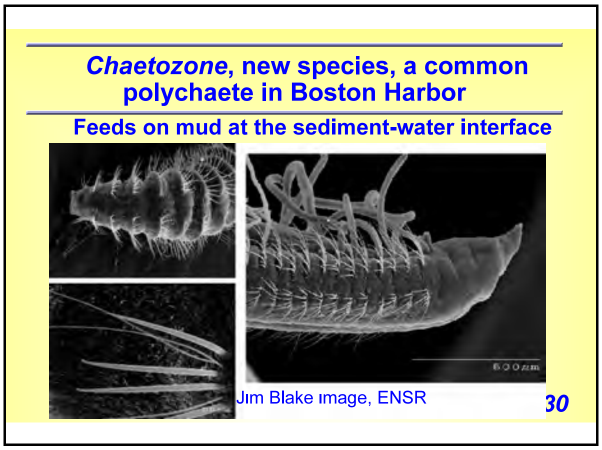
Slide 105 The Actors in this Ecological Play

NOTES:



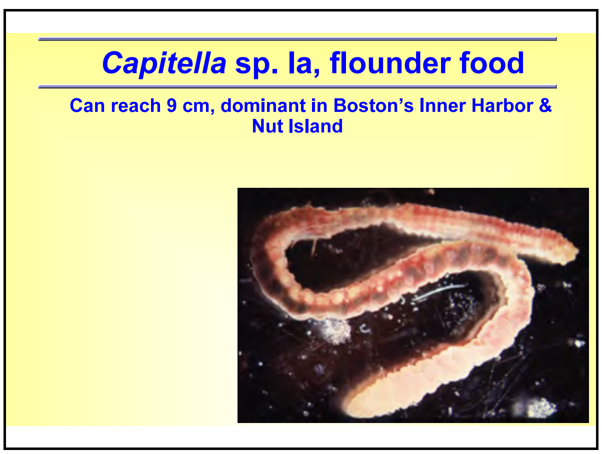
Slide 106 The most common animals in Boston Harbor & MA Bay sediments: Spionid polychaetes

NOTES:



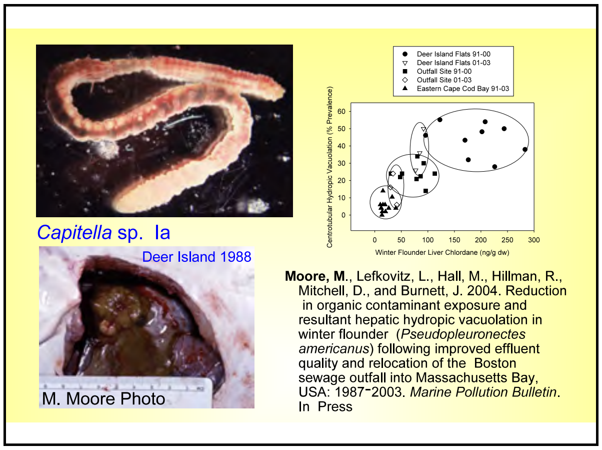
Slide 107 Chaetozone, new species, a common polychaete in Boston Harbor

NOTES:



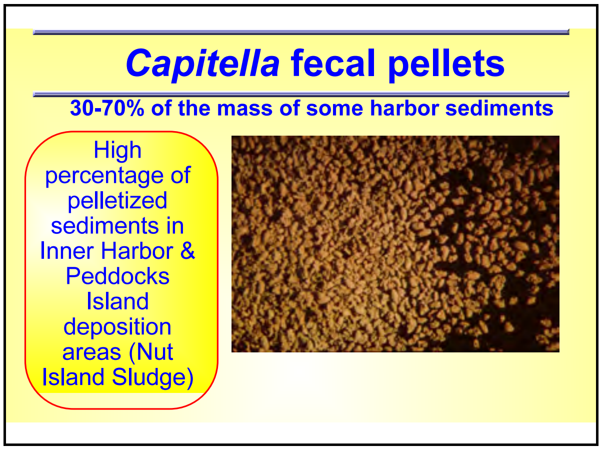
Slide 108 Capitella sp. Ia, flounder food

NOTES:



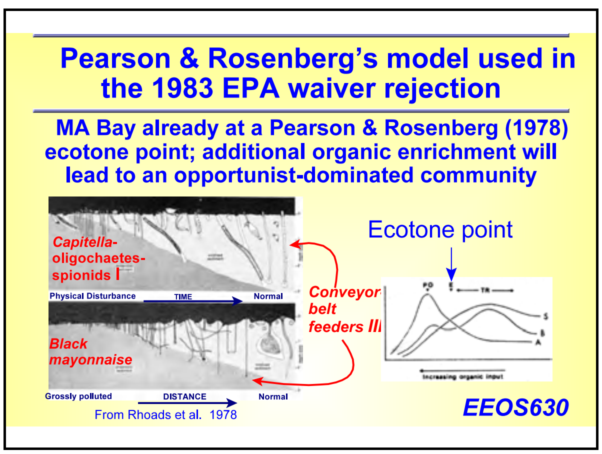
Slide 109

NOTES:



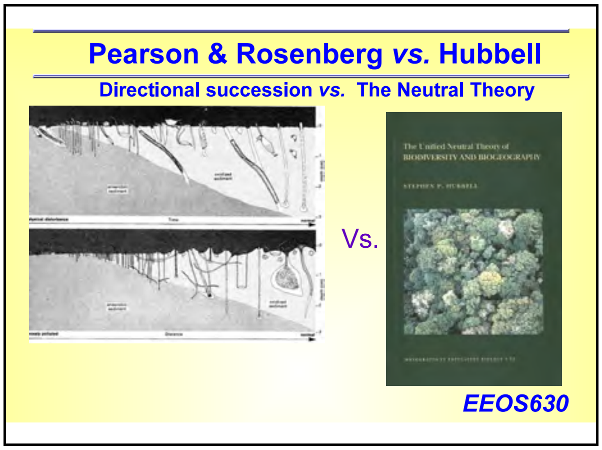
Slide 110 Capitella fecal pellets

NOTES:



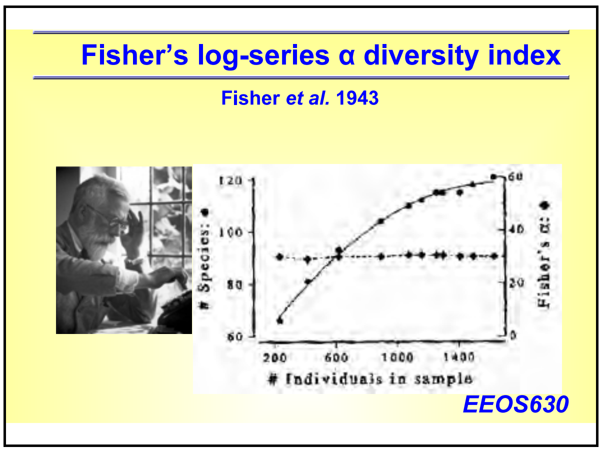
Slide 111 Pearson & Rosenberg's model used in the 1983 EPA waiver rejection

NOTES:



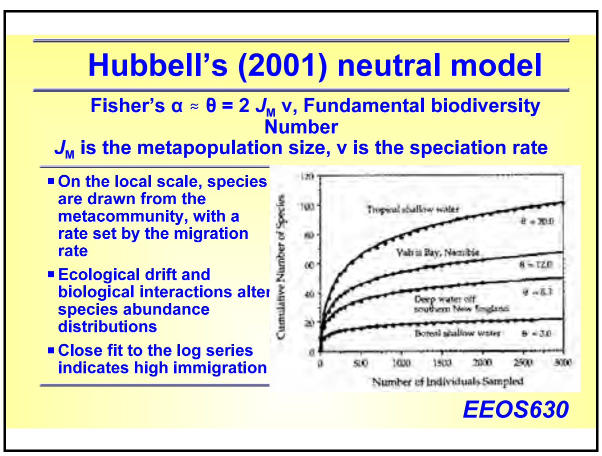
Slide 112 Pearson & Rosenberg vs. Hubbell

NOTES:



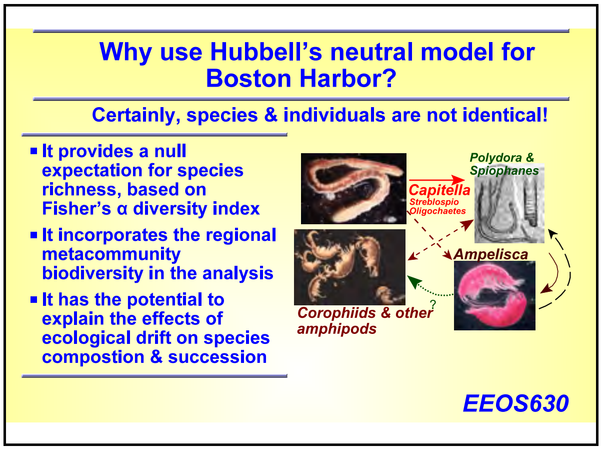
Slide 113 Fisher's log-series α diversity index

NOTES:



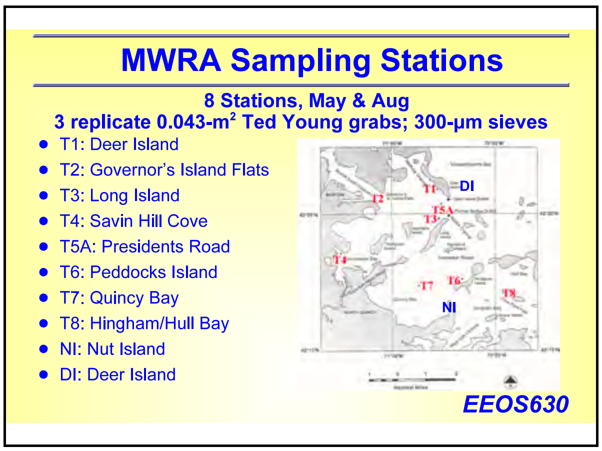
Slide 114 Hubbell's (2001) neutral model

NOTES:



Slide 115 Why use Hubbell's neutral model for Boston Harbor?

NOTES:

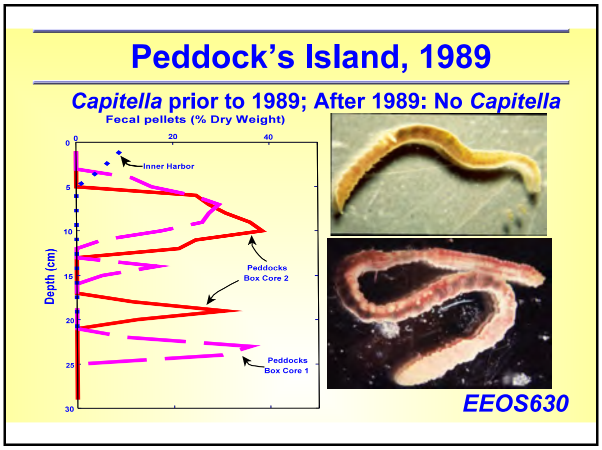


Slide 116 MWRA Sampling Stations

NOTES:

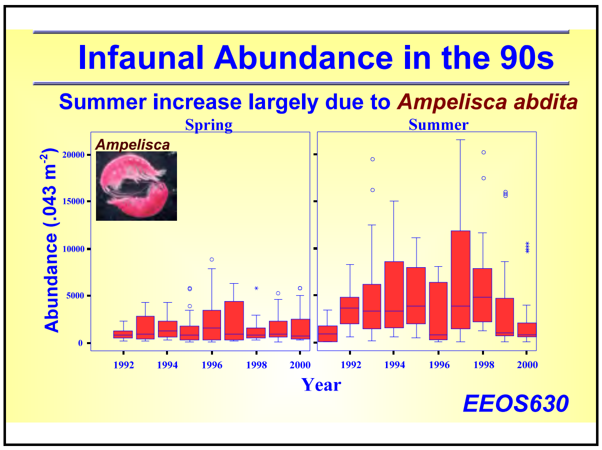
Slide 117 Inner Harbor: Still degraded

NOTES:



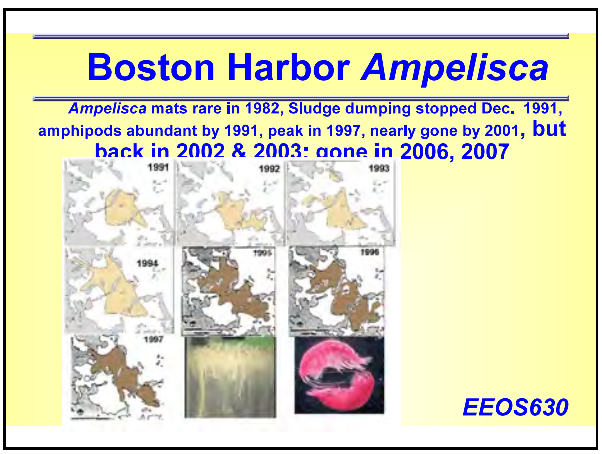
Slide 118 Peddock's Island, 1989

NOTES:



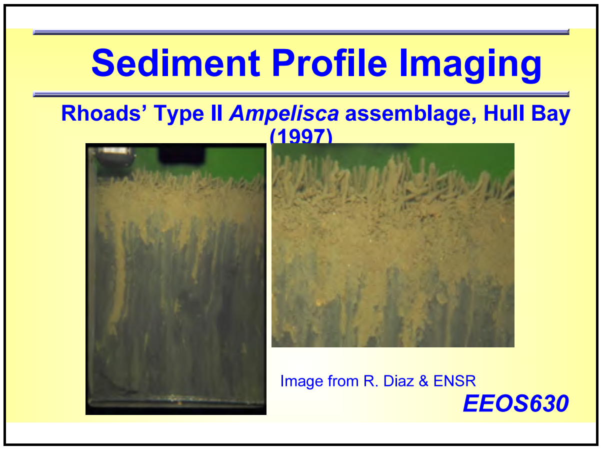
Slide 119 Infaunal Abundance in the 90s

NOTES:



Slide 120 Boston Harbor Ampelisca

NOTES:

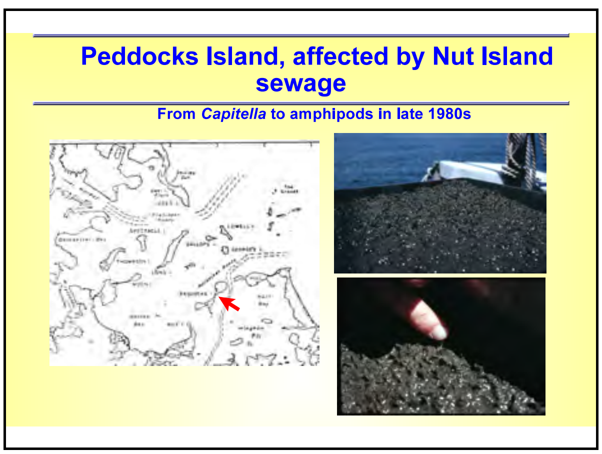


Slide 121 Sediment Profile Imaging

NOTES:

Slide 122 Ampelisca mats

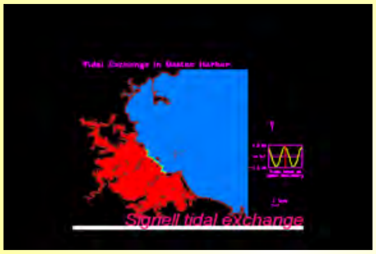
NOTES:



Slide 123 Peddocks Island, affected by Nut Island sewage

NOTES:

Boston Harbor tidal currents



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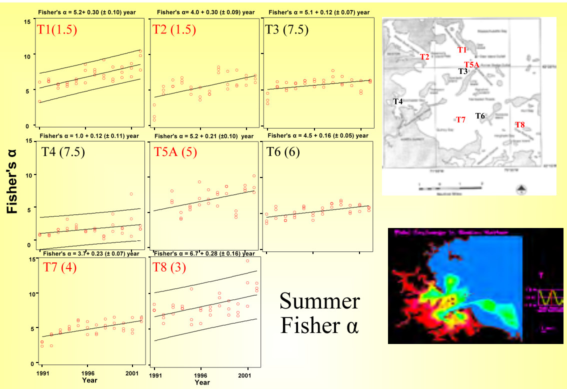
Slide 124 Boston Harbor tidal currents

NOTES:



Slide 125

NOTES:

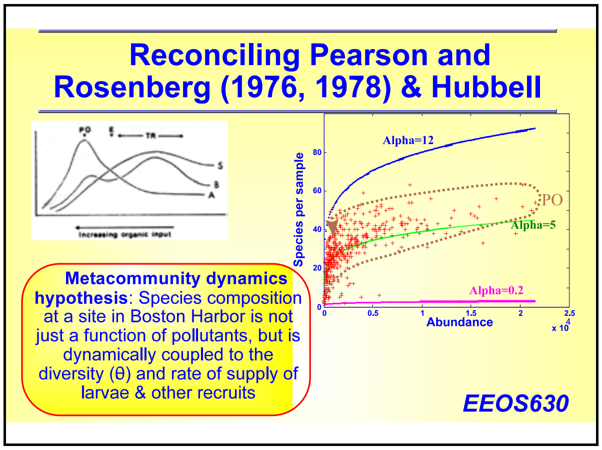
Metacommunity terms

Holyoak et al. 2005. Metacommunities.

- 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

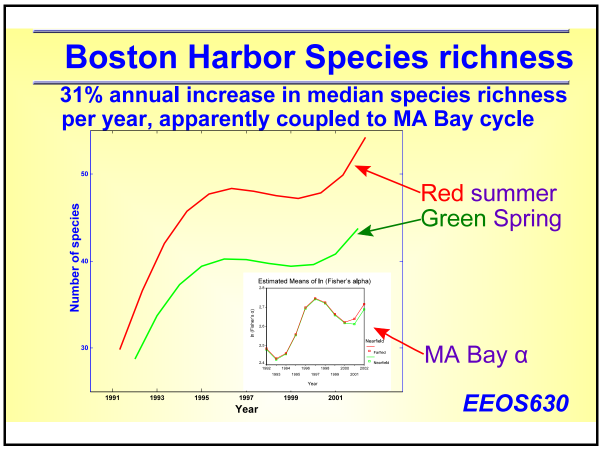
Slide 126 Metacommunity terms

NOTES:



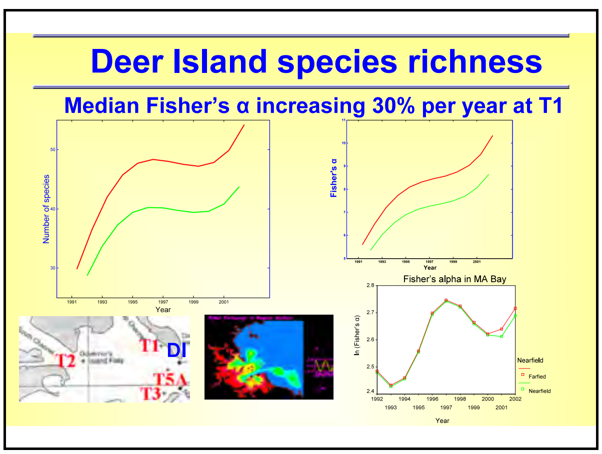
Slide 127 Reconciling Pearson and Rosenberg (1976, 1978) & Hubbell

NOTES:



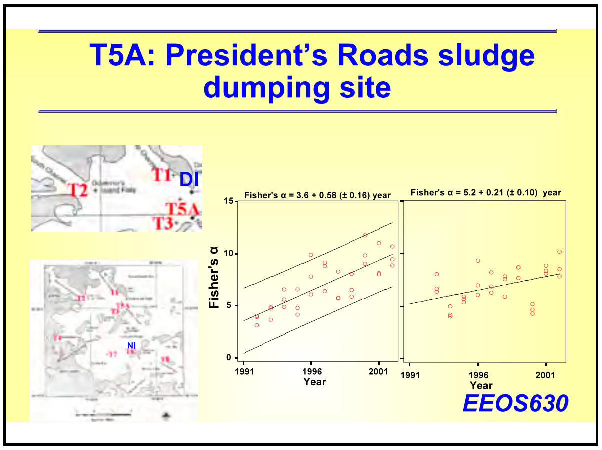
Slide 128 Boston Harbor Species richness

NOTES:



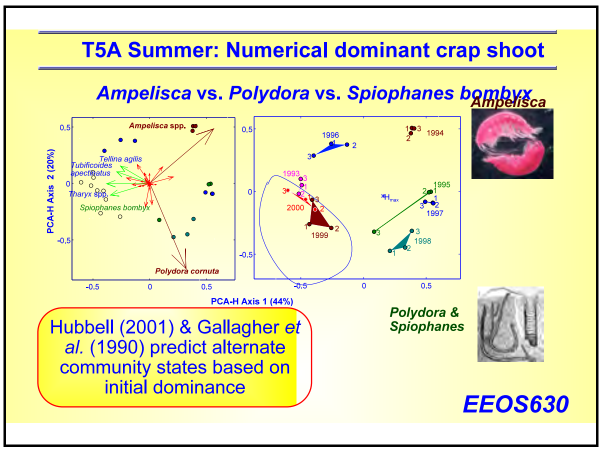
Slide 129 Deer Island species richness

NOTES:



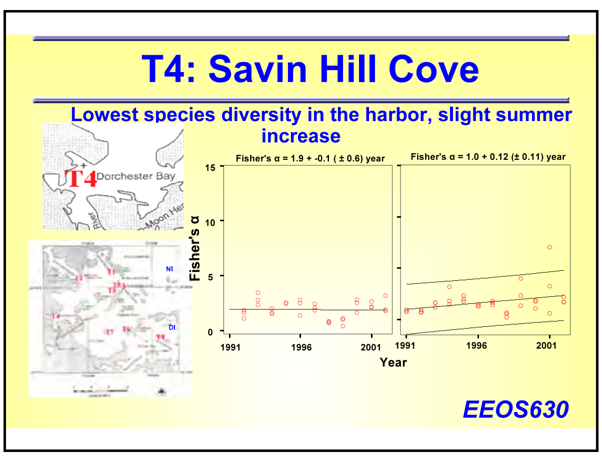
Slide 130 T5A: President's Roads sludge dumping site

NOTES:



Slide 131 T5A Summer: Numerical dominant crap shoot

NOTES:



Slide 132 T4: Savin Hill Cove

NOTES:

Pearson & Rosenberg vs. Hubbell

Hubbell & Bell's neutral models: not successional

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

Slide 133 Pearson & Rosenberg vs. Hubbell

NOTES:

Conclusions

- 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 *Capitella* being replaced by spionids & amphipod crustaceans
- Hubbell's neutral model appears to apply now
  - A theory for assessing biodiversity
  - Boston Harbor is coupled to MA Bay metacommunities
  - Ecological drift produces interannual shifts in dominants: spionids one year, ampelisciids on other years

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Slide 134 Conclusions

NOTES:

High Deep-Sea Diversity, Effects of Pollution on Benthic Community Structure: West Falmouth Oilspill & Boston Harbor
Pearson & Rosenberg *vs.* Hubbell's neutral model

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Slide 135 High Deep-Sea Diversity, Effects of Pollution on Benthic Community Structure: West Falmouth Oilspill & Boston Harbor

Pearson & Rosenberg vs. Hubbell's neutral model

NOTES: