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

Class 15: Tu Oct 21, 2008

***EEOS630***

**Slide 1 High Deep-Sea Diversity, Effects of Pollution on Benthic Community Structure: West Falmouth Oilspill & Boston Harbor**

Pearson & Rosenberg vs. Hubbell's neutral model

NOTES:

## Projects

- 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)
  - 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.

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**Slide 2 Projects**

NOTES:

## Background papers

Bell, G. 2001. Neutral macroecology. Science 293: 2413-2418.

Hughes, R. G. 1986. Theories and models of species abundance. Amer. Natur. *128*: 879-899.

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**Slide 3 Background papers**

NOTES:

## Goals of today's class

**Effects of pollution on benthic communities**

- Overall theory: Pearson & Rosenberg vs. Hubbell's neutral model of biodiversity
- How can you determine whether a pollutant has affected community structure?
  - BACI designs: before-after controlled impact experiments
  - Benthic index development
    - EMAP approach
    - Southern California Bight Index
    - Borjas European index

**Slide 4 Goals of today's class**

NOTES:

## Pearson & Rosenberg vs. Hubbell

**Hubbell & Bell's neutral models: not successional**

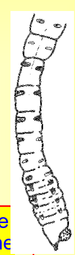
| Pearson & Rosenberg, Rhoads et al. (1978) | Hubbell's Neutral model |
|---|---|
| • Unidirectional Succession | • Ecological drift; stochastic equilibrium |
| • Opportunistic species replaced by equilibrium species | • All individuals & all species equivalent |
| • No metacommunity dynamics | • Emphasis on metacommunity dynamics |
| • Relatively silent on species diversity, except for SAB curves | • A theory for species abundance curves |

**Slide 5 Pearson & Rosenberg vs. Hubbell**

NOTES:

## West Falmouth Oilspill

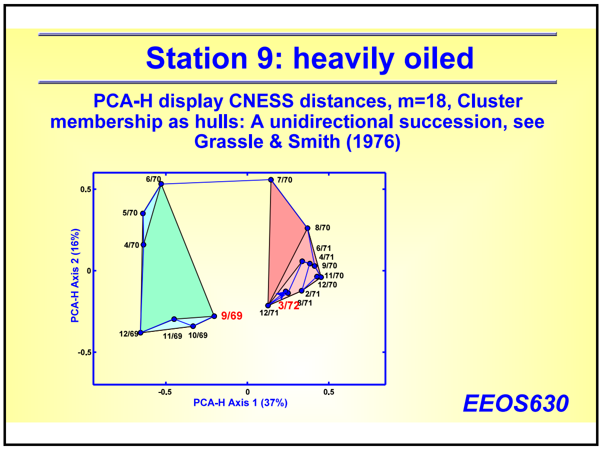
**St. 9: Capitella → Mediomastus**



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)

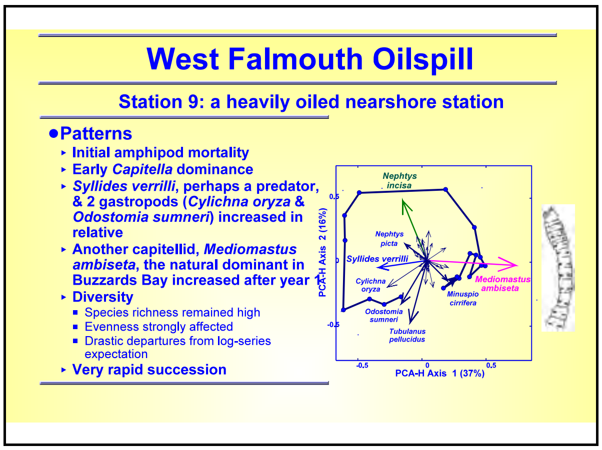
**Slide 6 West Falmouth Oilspill**

NOTES:



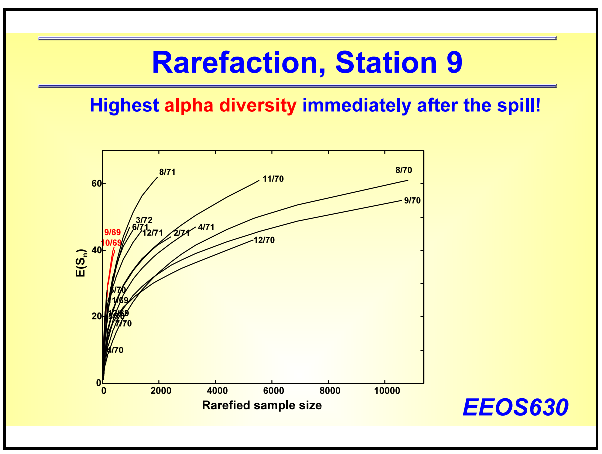

## Slide 7 Station 9: heavily oiled

NOTES:



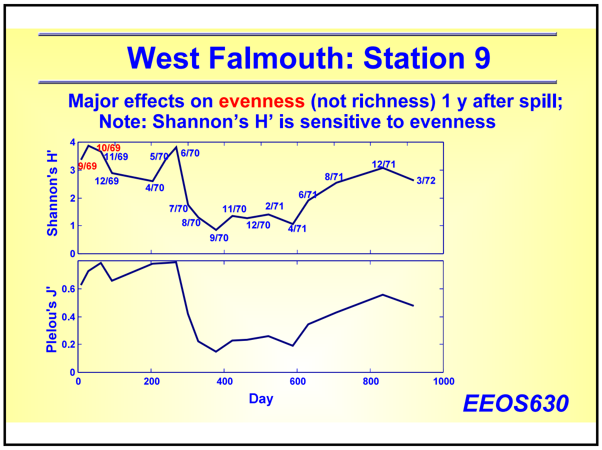

## Slide 8 West Falmouth Oilspill

NOTES:



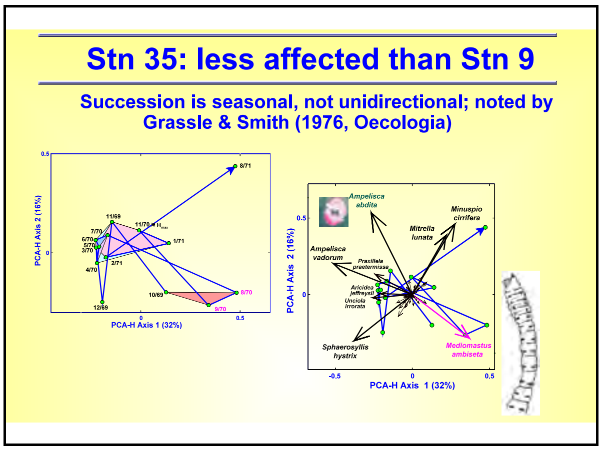

## Slide 9 Rarefaction, Station 9

NOTES:



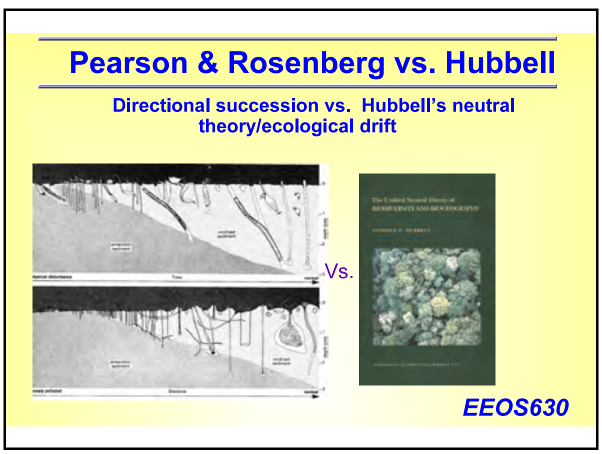

**Slide 10 West Falmouth: Station 9**

NOTES:



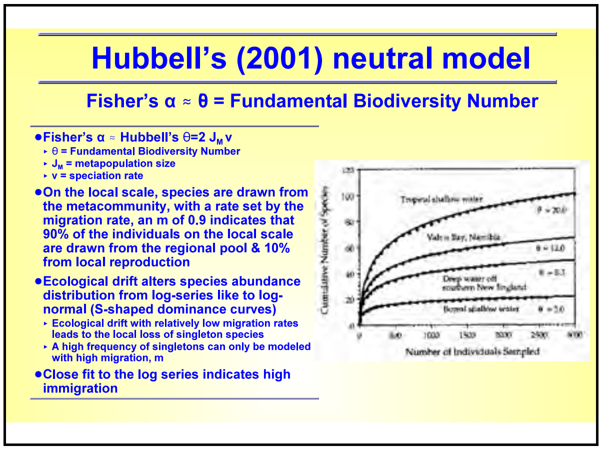

**Slide 11 Stn 35: less affected than Stn 9**

NOTES:



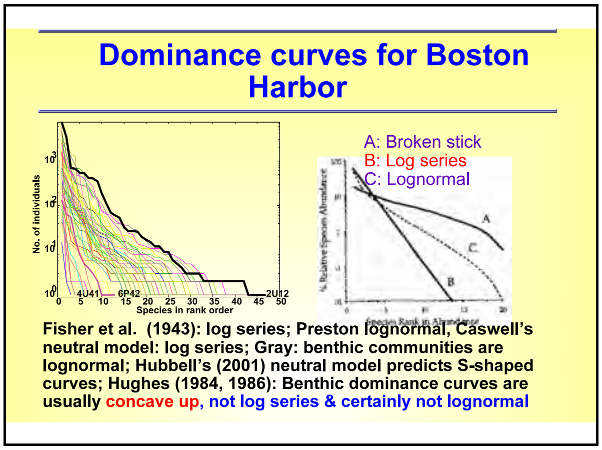

**Slide 12 Pearson & Rosenberg vs. Hubbell**

NOTES:



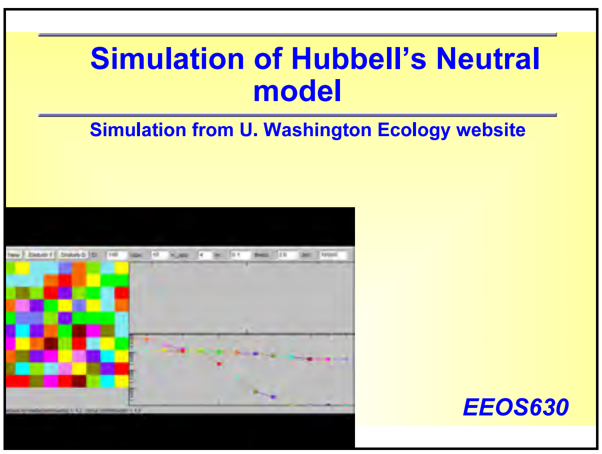

## Slide 13 Hubbell's (2001) neutral model

NOTES:



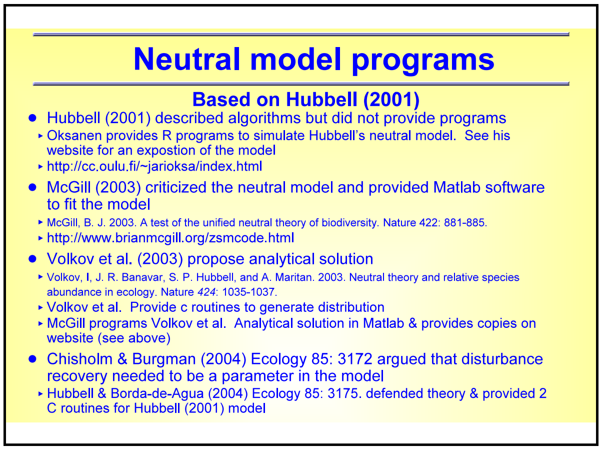

## Slide 14 Dominance curves for Boston Harbor

NOTES:



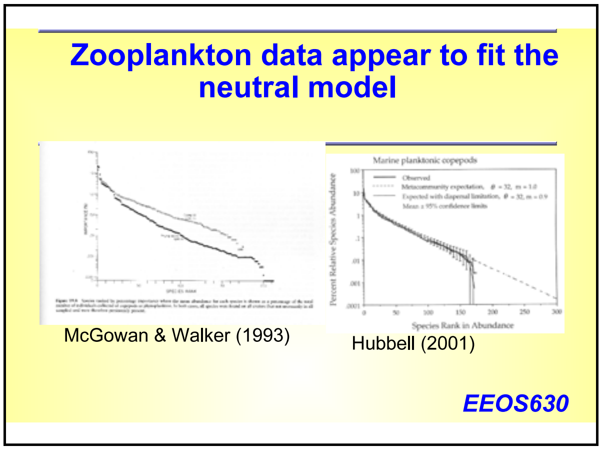

## Slide 15 Simulation of Hubbell's Neutral model

NOTES:



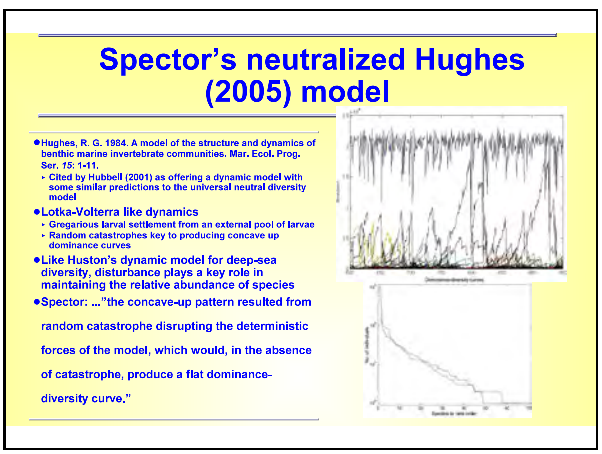

## Slide 16 Neutral model programs

NOTES:



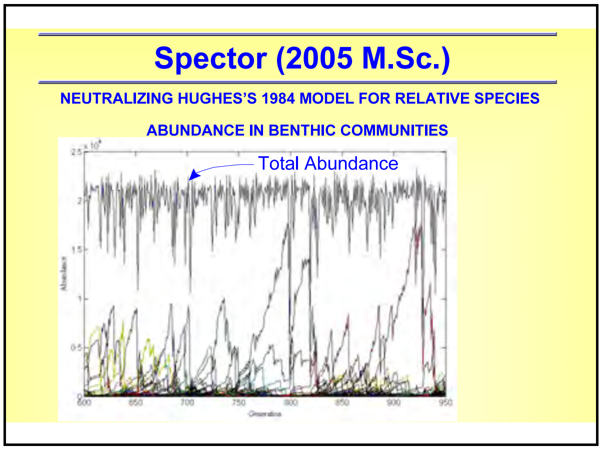

## Slide 17 Zooplankton data appear to fit the neutral model

NOTES:



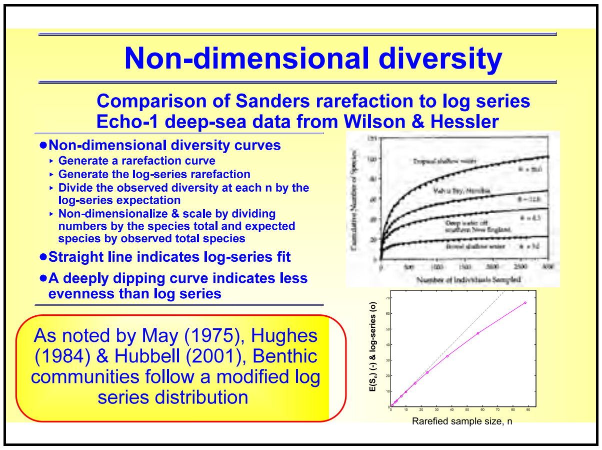

## Slide 18 Spector's neutralized Hughes (2005) model

NOTES:



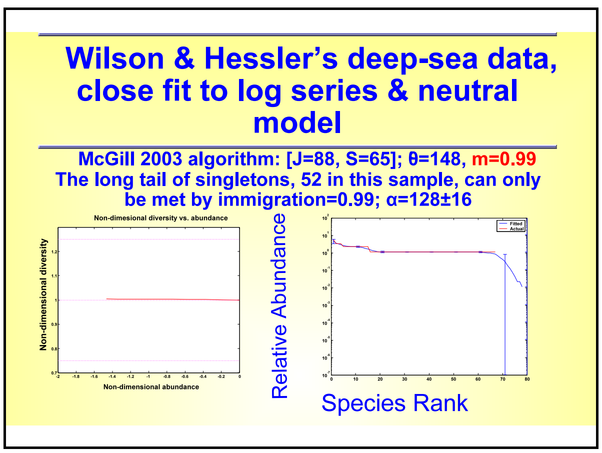

**Slide 19 Spector (2005 M.Sc.)**

NOTES:



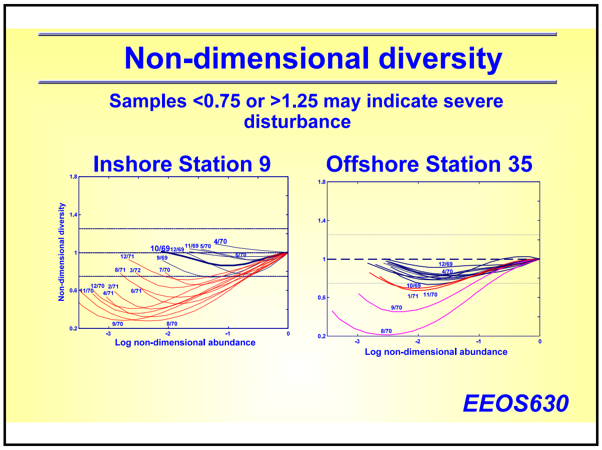

**Slide 20 Non-dimensional diversity**

NOTES:



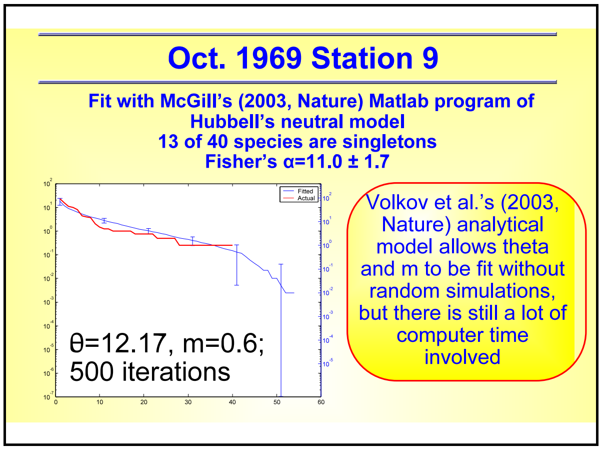

**Slide 21 Wilson & Hessler's deep-sea data, close fit to log series & neutral model**

NOTES:



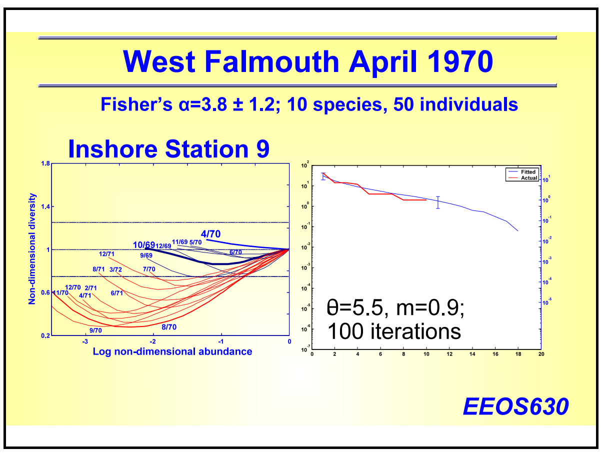

## Slide 22 Non-dimensional diversity

NOTES:



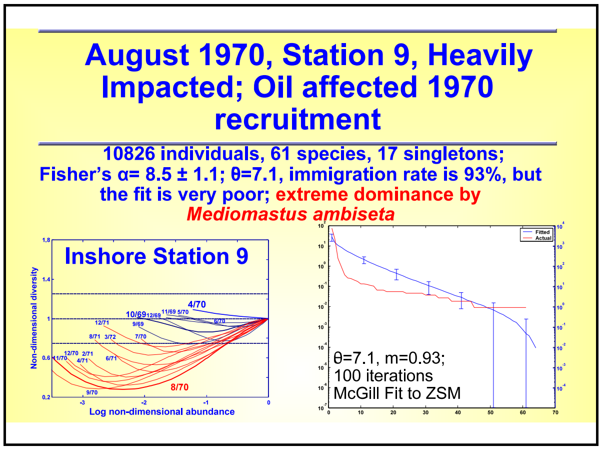

## Slide 23 Oct. 1969 Station 9

NOTES:



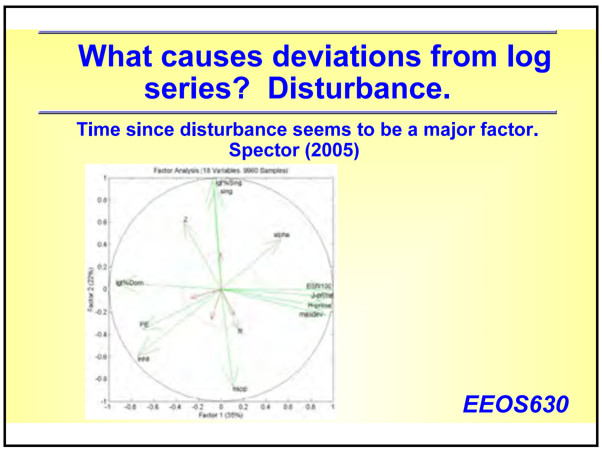

## Slide 24 West Falmouth April 1970

NOTES:



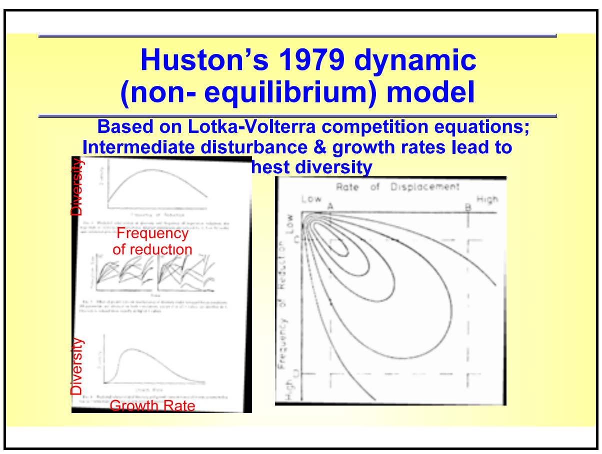

**Slide 25 August 1970, Station 9, Heavily Impacted; Oil affected 1970 recruitment**

NOTES:




**Slide 26 What causes deviations from log series? Disturbance.**

NOTES:




**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 ≈ Hubbell's theta**

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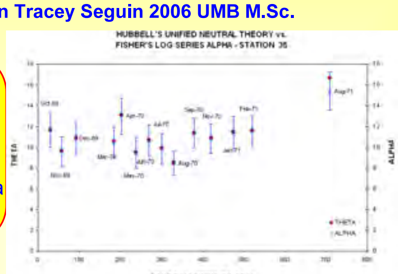
**Slide 29 Station 35 fit to the neutral model**

NOTES:

## Hubbell netural 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 (●)

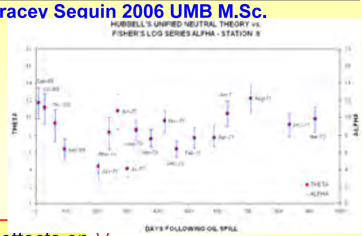



**Slide 30 Hubbell netural theory: Fisher's alpha vs. Hubbell's theta, Stn 35**

NOTES:

## Hubbell netural theory: Fisher's alpha vs. Hubbell's theta

**Joan Tracey Sequin 2006 UMB M.Sc.**




Heavily impacted Station 9: Fisher's alpha (x) and Hubbell's theta (●)

Note that largest effects on species richness were 7-10 months after spill

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**Slide 31 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 32 Conclusions on West Falmouth**

NOTES:

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

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

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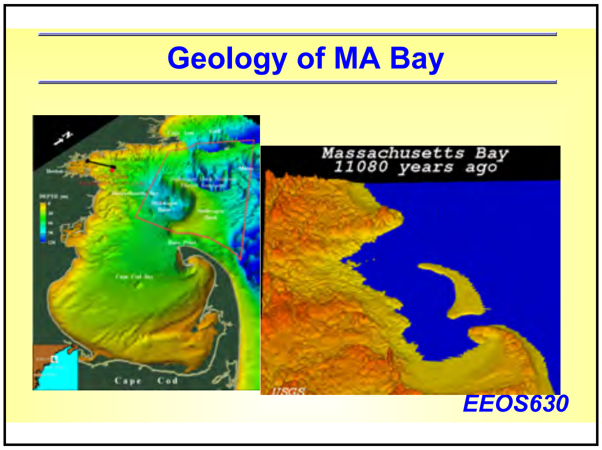
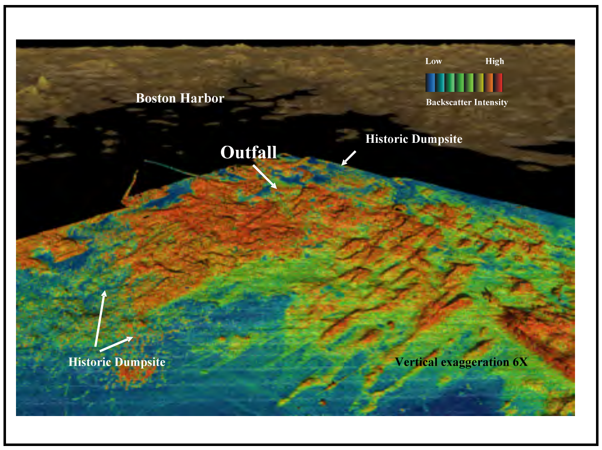
**Slide 33 Case Study: the recovery of Boston Harbor benthic communities in the 1990s**

NOTES:



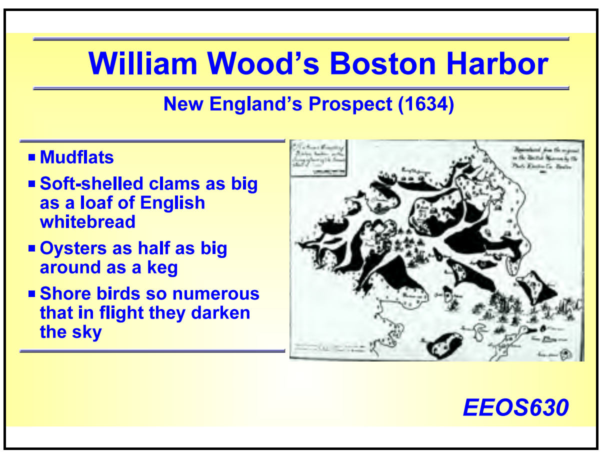

**Slide 34 Geology of MA Bay**

NOTES:



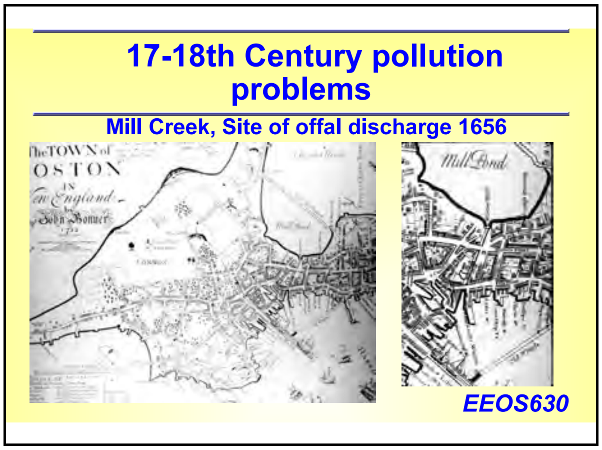

**Slide 35**

NOTES:



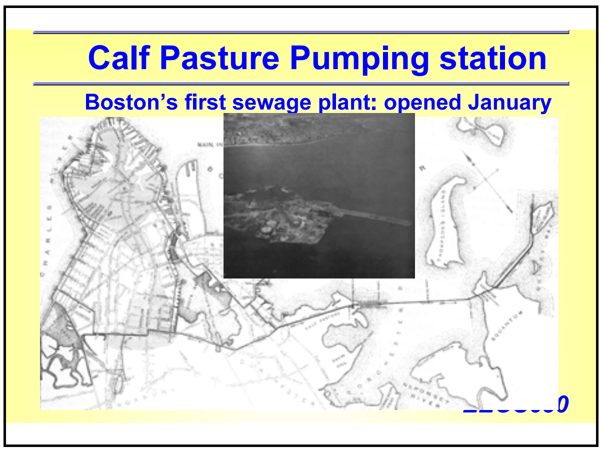

**Slide 36 William Wood's Boston Harbor**

NOTES:




**Slide 37 17-18th Century pollution problems**

NOTES:

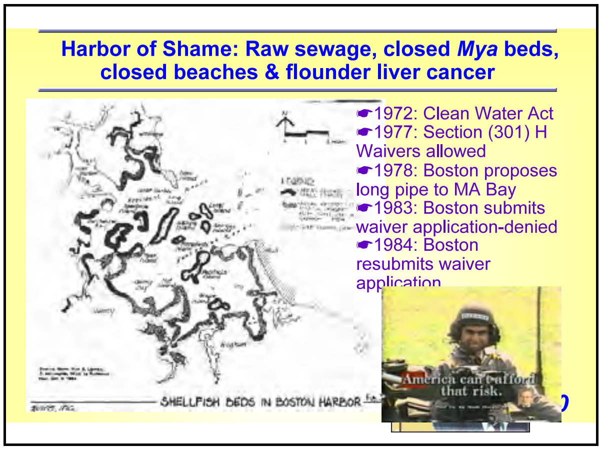



**Slide 38 Calf Pasture Pumping station**

NOTES:

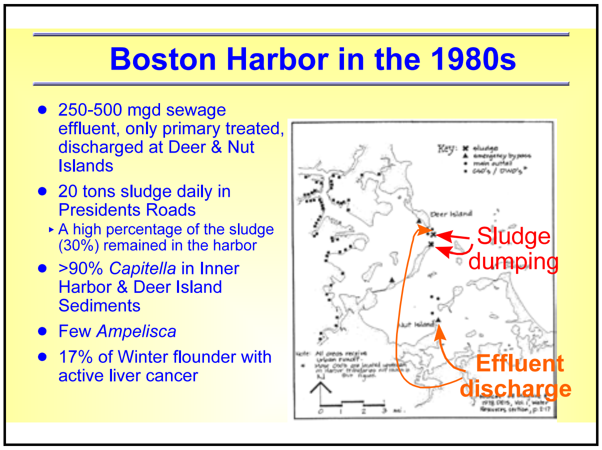

**Slide 39 Boston Harbor 1630 to present**

NOTES:



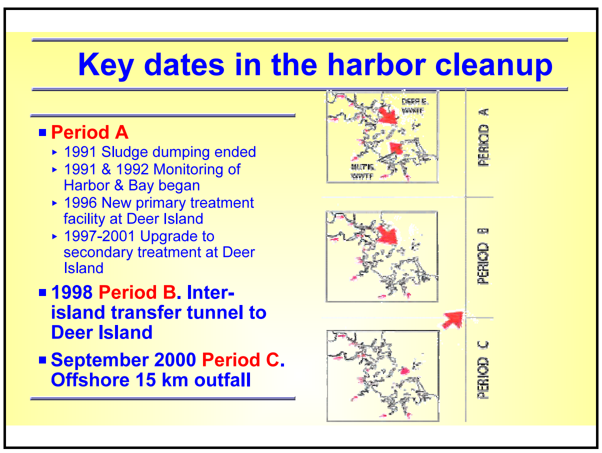

**Slide 40 Harbor of Shame: Raw sewage, closed Mya beds, closed beaches & flounder liver cancer**

NOTES:



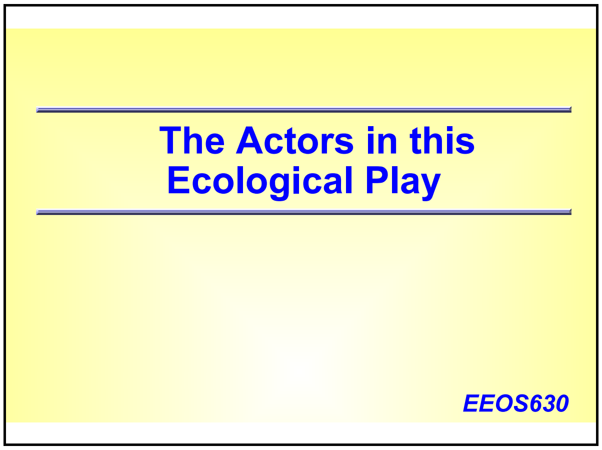

**Slide 41 Boston Harbor in the 1980s**

NOTES:



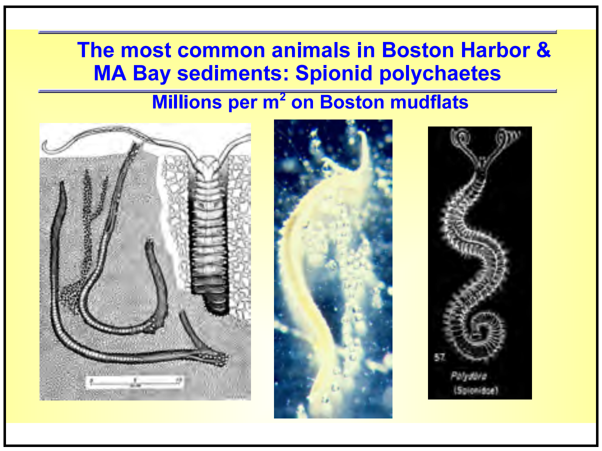

**Slide 42 Key dates in the harbor cleanup**

NOTES:



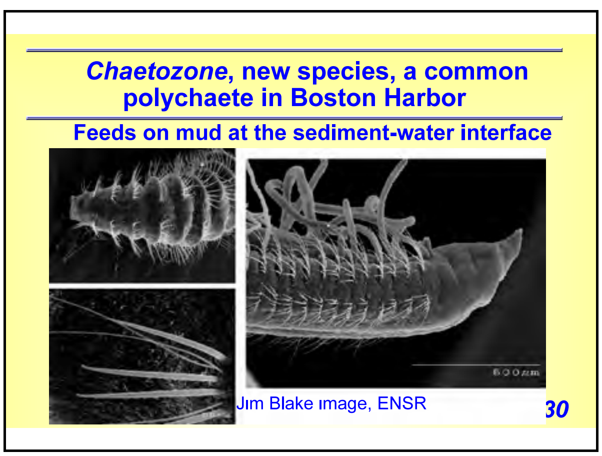

**Slide 43 The Actors in this Ecological Play**

NOTES:




**Slide 44 The most common animals in Boston Harbor & MA Bay sediments: Spionid polychaetes**

NOTES:




**Slide 45 Chaetozone, new species, a common polychaete in Boston Harbor**

NOTES:

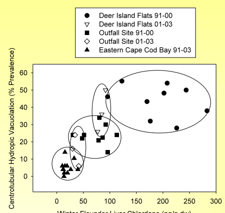
## *Capitella* sp. Ia, flounder food

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

## Slide 46 Capitella sp. Ia, flounder food

NOTES:

*Capitella* sp. Ia


**Moore, M.**, Lefkovitz, 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

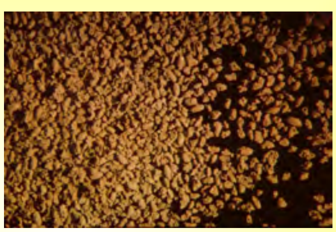
## Slide 47

NOTES:

## *Capitella* fecal pellets

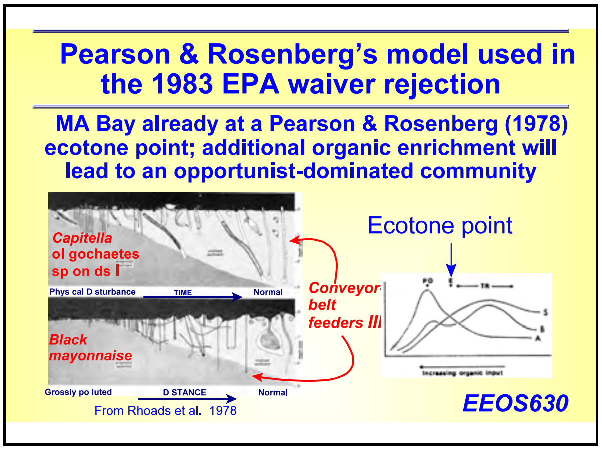
**30-70% of the mass of some harbor sediments**

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



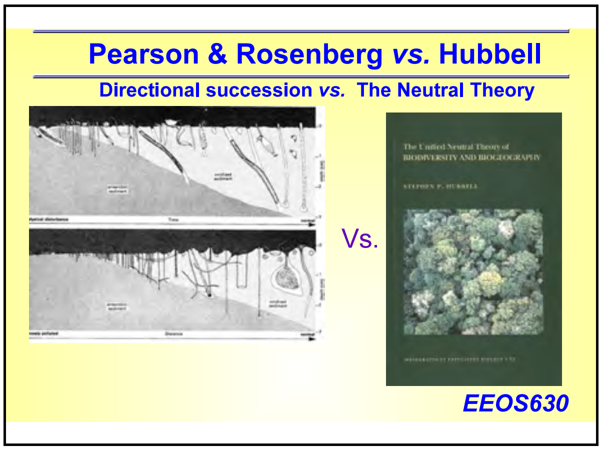
## Slide 48 Capitella fecal pellets

NOTES:



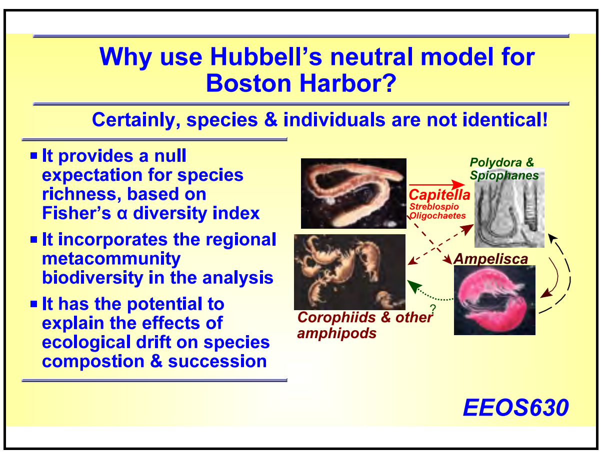

**Slide 49 Pearson & Rosenberg's model used in the 1983 EPA waiver rejection**

NOTES:



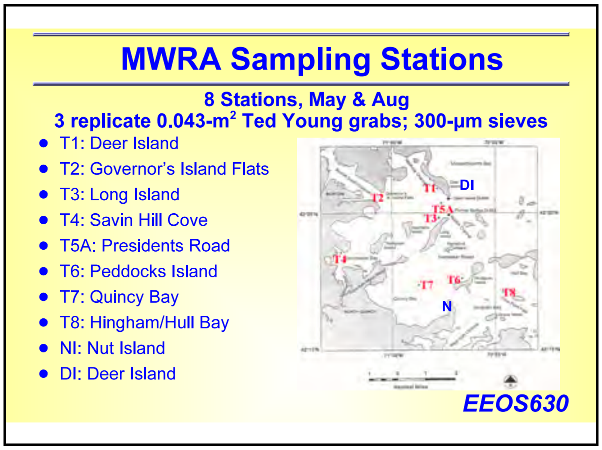

**Slide 50 Pearson & Rosenberg vs. Hubbell**

NOTES:




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

NOTES:




| Slide 52 MWRA Sampling Stations |
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| NOTES: |
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| Slide 53 Inner Harbor: Still degraded |
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| NOTES: |
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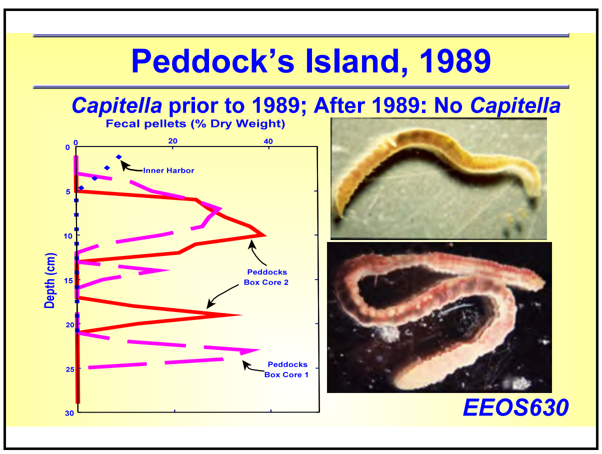


| Slide 54 Peddock's Island, 1989 |
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| NOTES: |
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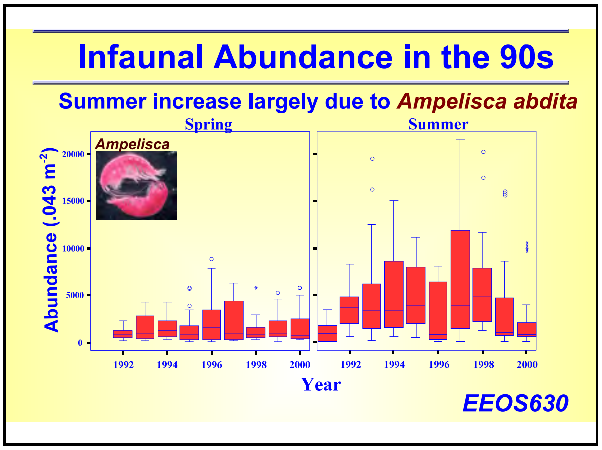
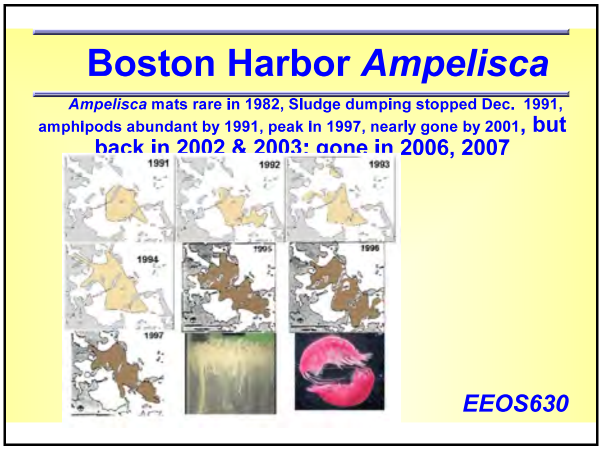


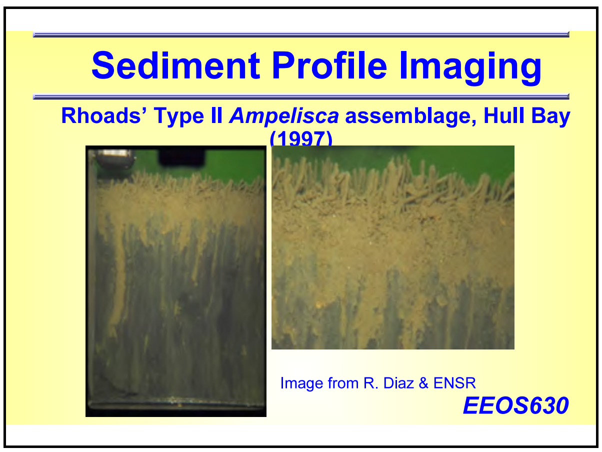

**Slide 55 Infaunal Abundance in the 90s**

NOTES:




**Slide 56 Boston Harbor Ampelisca**

NOTES:




**Slide 57 Sediment Profile Imaging**

NOTES:

## *Ampelisca* mats

Near Peddocks Island in Quincy Bay


**Slide 58 Ampelisca mats**

NOTES:

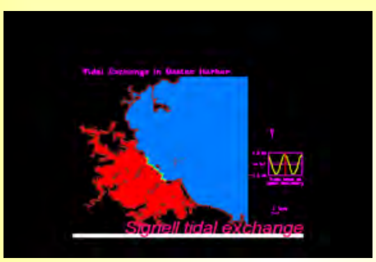
## Peddocks Island, affected by Nut Island sewage

From *Capitella* to amphipods in late 1980s

**Slide 59 Peddocks Island, affected by Nut Island sewage**

NOTES:

## Boston Harbor tidal currents

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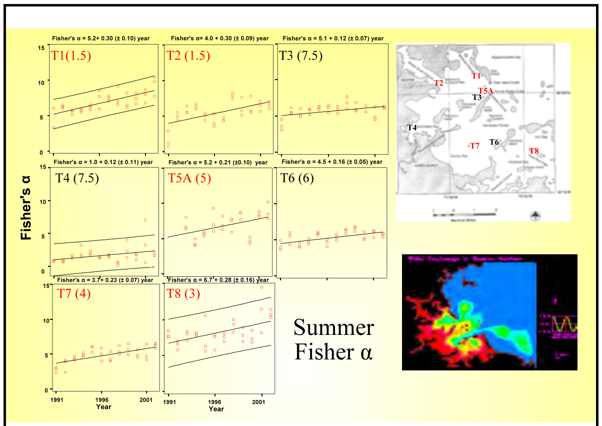
**Slide 60 Boston Harbor tidal currents**

NOTES:




**Slide 61**

NOTES:

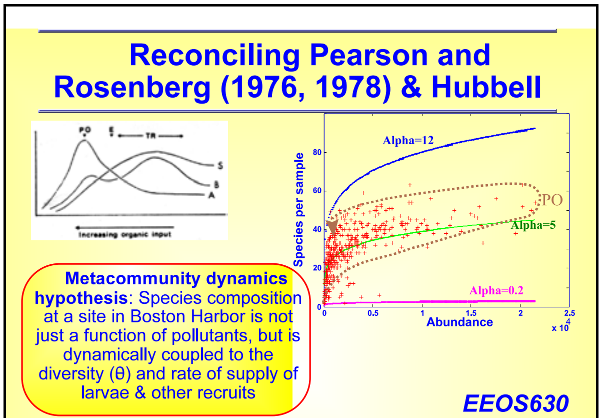
## Metacommunity terms

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

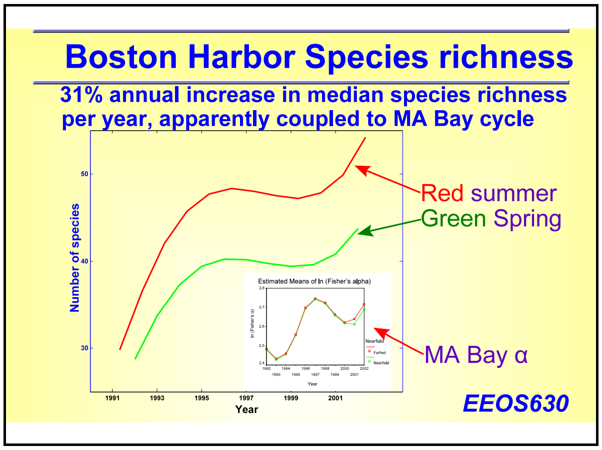
**Slide 62 Metacommunity terms**

NOTES:



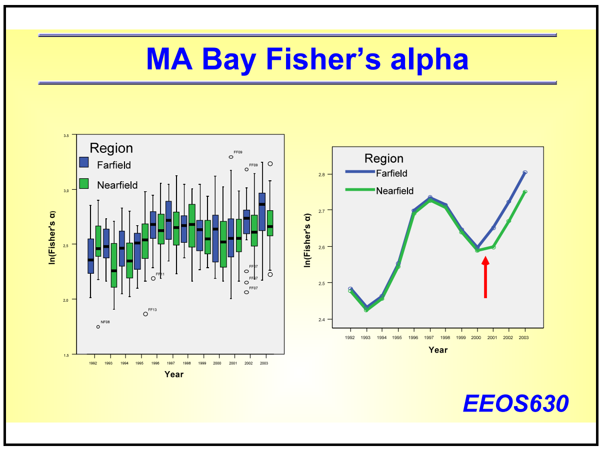

**Slide 63 Reconciling Pearson and Rosenberg (1976, 1978) & Hubbell**

NOTES:



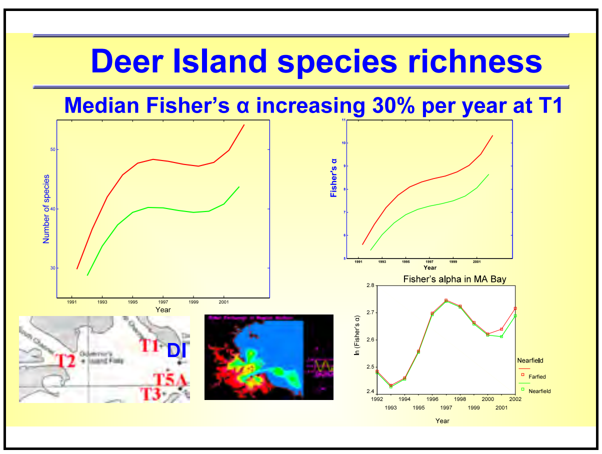

**Slide 64 Boston Harbor Species richness**

NOTES:



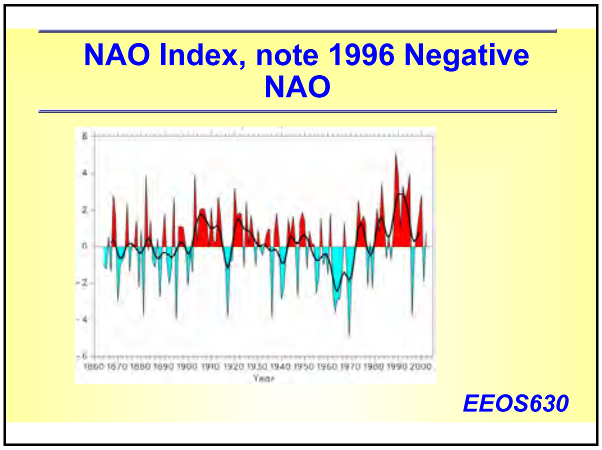

**Slide 65 MA Bay Fisher's alpha**

NOTES:



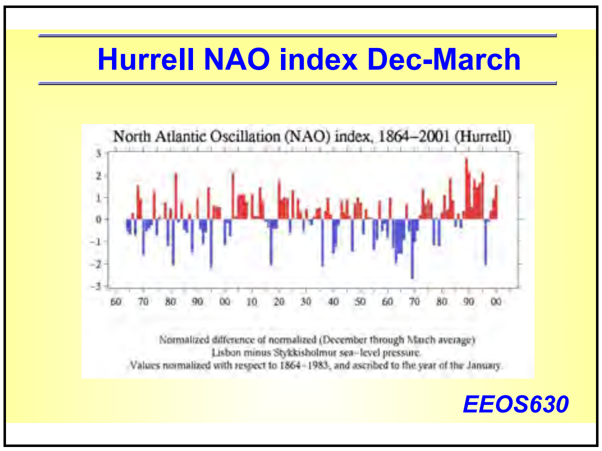

**Slide 66 Deer Island species richness**

NOTES:



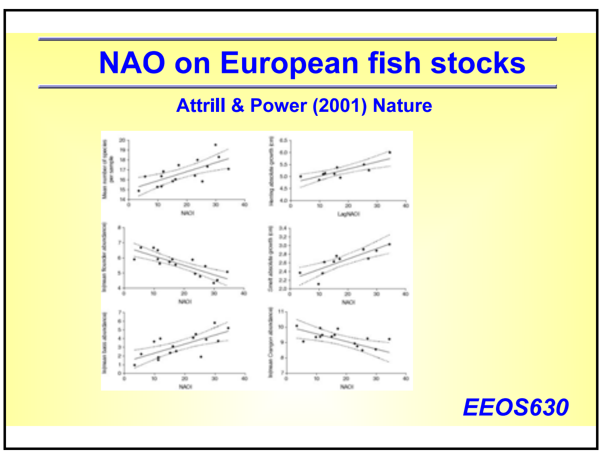

**Slide 67 NAO Index, note 1996 Negative NAO**

NOTES:



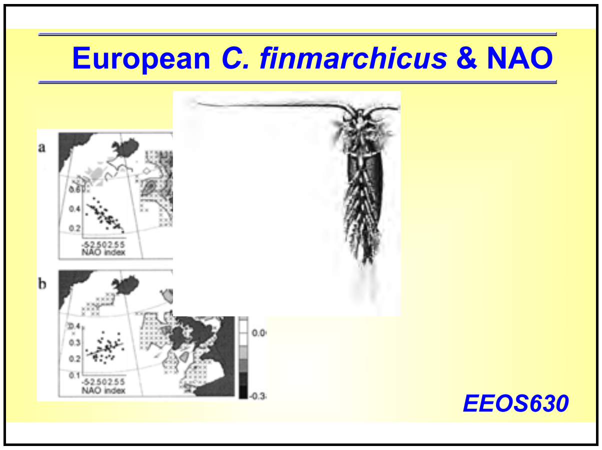

**Slide 68 Hurrell NAO index Dec-March**

NOTES:



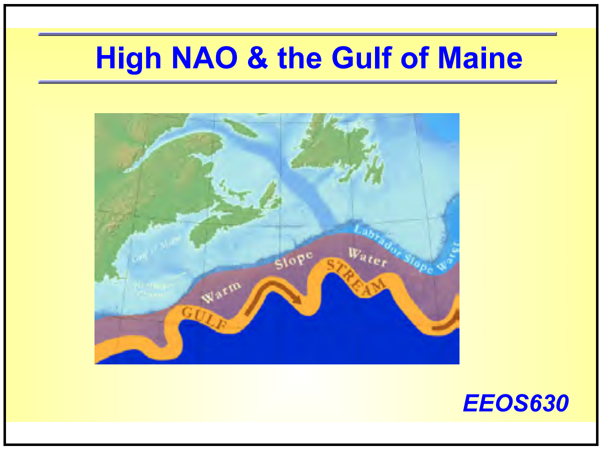

**Slide 69 NAO on European fish stocks**

NOTES:



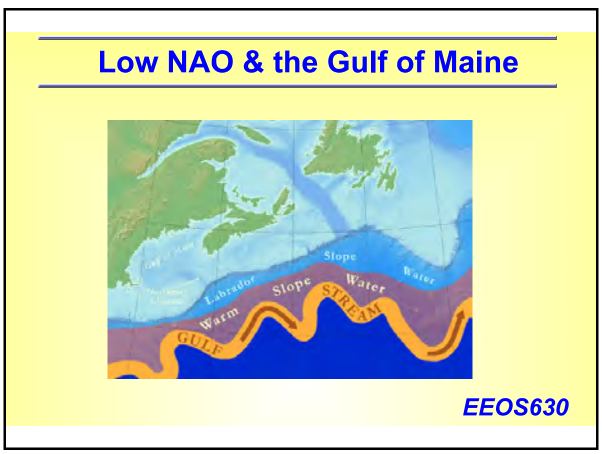

**Slide 70 European C. Finmarchicus & NAO**

NOTES:



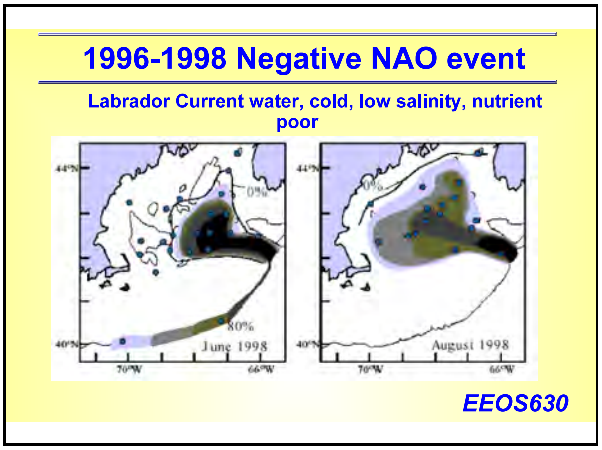

**Slide 71 High NAO & the Gulf of Maine**

NOTES:



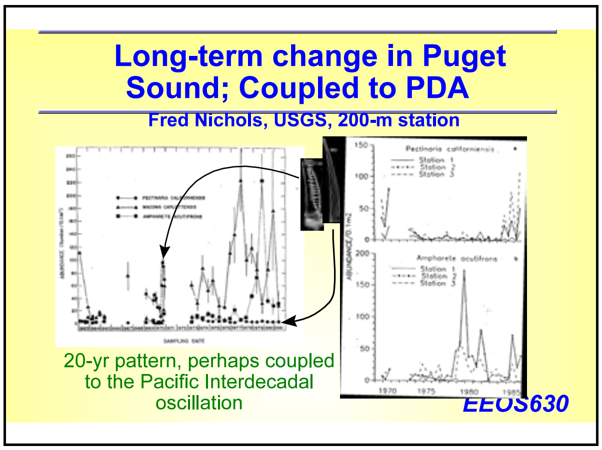

**Slide 72 Low NAO & the Gulf of Maine**

NOTES:



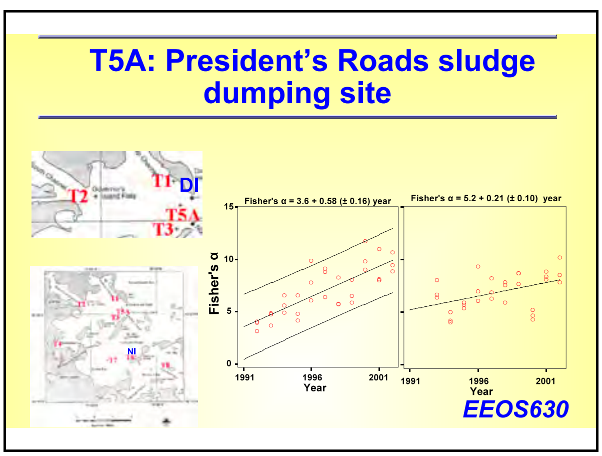

**Slide 73 1996-1998 Negative NAO event**

NOTES:



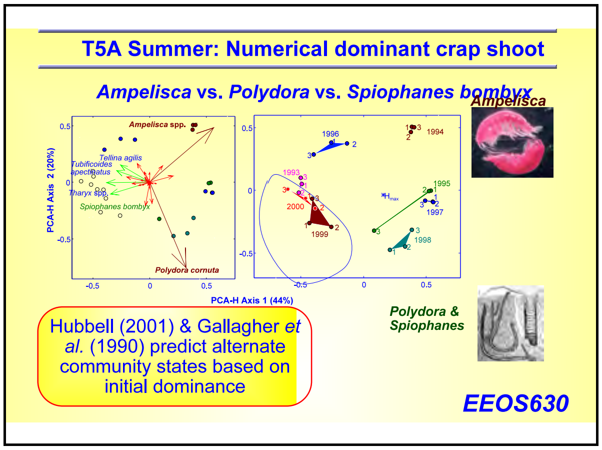

**Slide 74 Long-term change in Puget Sound; Coupled to PDA**

NOTES:



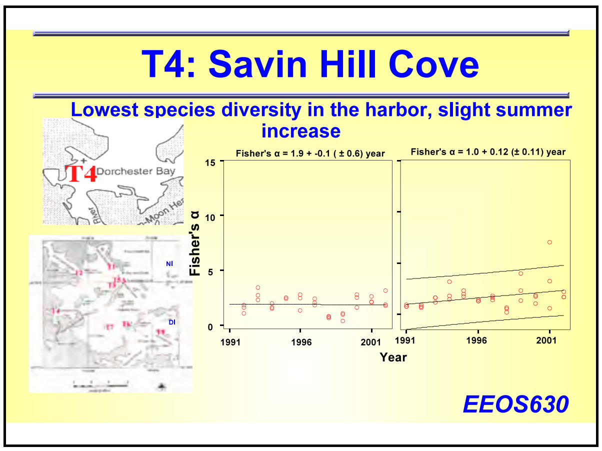

**Slide 75 T5A: President's Roads sludge dumping site**

NOTES:




**Slide 76 T5A Summer: Numerical dominant crap shoot**

NOTES:




**Slide 77 T4: Savin Hill Cove**

NOTES:

## Pearson & Rosenberg vs. Hubbell

Hubbell & Bell's neutral models: not successional

**Pearson & Rosenberg, Rhoads et al. (1978)**

- Unidirectional Succession
- Opportunistic species replaced by equilibrium species
- No metacommunity dynamics
- Relatively silent on species diversity, except for SAB curves

**Hubbell's Neutral model**

- Ecological drift; stochastic equilibrium
- All individuals & all species equivalent
- Emphasis on metacommunity dynamics
- A theory for species abundance curves

**Slide 78 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 79 Conclusions**

NOTES: