Biological Oceanographic Processes

Introduction to EEOS 630
Fall 2008

EEOS630

Send me an email

Eugene.Gallagher@umb.edu

- Name
- Email address (if available)
- Home address and phone number
  - Needed for mailing papers
  - Snow cancellations
- Program (campus mailbox)
- Availability for Wimba (Is M 7 to 7:45, Th 9 to 9:45 ok?)
- Why are you taking the course?
  - Requirement
  - Interest in Boston Harbor, Plankton, Benthos, Microbial Processes, Modeling
  - Which best describes your interest in biological oceanography?
    - **A** I like the quantitative aspects: numerical modeling, growth modeling, Matlab-based applications, coupling physical and biological oceanographic processes
    - **B** I like the history and sociology of biological oceanography and the applications of biological oceanography to problems of society
    - **C** I'm interested in the biodiversity of marine species and testing ecological theories in the marine environment
    - **D** I'm primarily interested in biogeochemical rate processes
    - **E** Other: specify

Course handouts

All handouts in pdf, some in html too

- Gallagher's web page: http://alpha.es.umb.edu/faculty/edg/files/edgwebp.htm
- Course handout page
  - All handouts will be posted on WebCT
  - **http://www.lms.umb.edu**
  - **http://boston.umassonline.net**
  - **You will be registered by the Wiser registration system.**
  - **A handout of slides for that day's class will be on the web by 5 am on the day of class.**
  - **Try to print out a copy of the slide handout before class.**
  - **Movies will be available for every class.**

Textbooks

None required, and some recommended

- Required: None
- Recommended
  - Miller (2004) Biological Oceanography
  - Mann & Lazier (1996)
  - Falkowski & Raven (2007): Aquatic photosynthesis, 2nd edition
  - Parsons *et al.* (1984)
  - Jumars (1996)
  - Valiella (1984)
  - Kirchman (2000) Microbial ecology of the oceans

EEOS630 Grading

Discussion based on Wimba & Class discussions

- Class projects (Using the concepts of differentiated instruction or universal design framework)
  - Oral presentation (can be a team project) and essay (individual)
  - Project 1: 25%
  - Project 2: 25%
  - No midterm examination
- Discussion 25%
- Final examination 25%

Class preparation

TABLE 2. ASSIGNMENTS FOR EACH CLASS		
ITEM	**BEFORE CLASS**	**LOCATION**
Gallagher's chapter	Read the Comments & Outlines	Available as pdf files
Assigned readings (Usually 2)	Read and outline main ideas (See Discussion Format below)	Textbook or available as pdfs on E-Reserve
Supplemental Readings	Scan the Outline in Handout Read if you are interested.	JSTOR or electronically from Gallagher

Indicates a clickable link

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For Thursday class

- Chapter 1 Benthic Feeding Guilds and Functional Groups
- Two papers & Gallagher's Chapter 1
  - These readings will be posted on WebCT (or my personal web page http://alpha.es.umb.edu/faculty/edg/files/edgwebp.htm
  - Cammen, L. M. 1980. Ingestion rate: an empirical model for aquatic deposit feeders and detritivores. Oecologia (Berlin) *44*: 303-310.
  - Jumars, P. A. and K. Fauchald. 1977. Between-community contrasts in successful polychaete feeding strategies. Pp. 1-20 *in* B. C. Coull, *ed.*, Ecology of marine benthos. University of South Carolina Press, Columbia. *[This paper introduced the guild classification scheme used later in the comprehensive Fauchald & Jumars Diet of Worms.]*

Jumars on e-reserve, *fathom*

Learning through discussion

Group cognitive map: Won't be used if more than 7 students

- Step 1: Definitions of terms and concepts
- Step 2: Statement of the author's message
- Step 3: Major themes
- Step 4: Allocation of time
- Step 5: Discussion of major themes
- Step 6: Integration of material
- Step 7: Application of the material
- Step 8: Evaluation of the author's presentation
- Step 9: Evaluation of group performance

Background on Boston Harbor & MA Bay, a theme of the course

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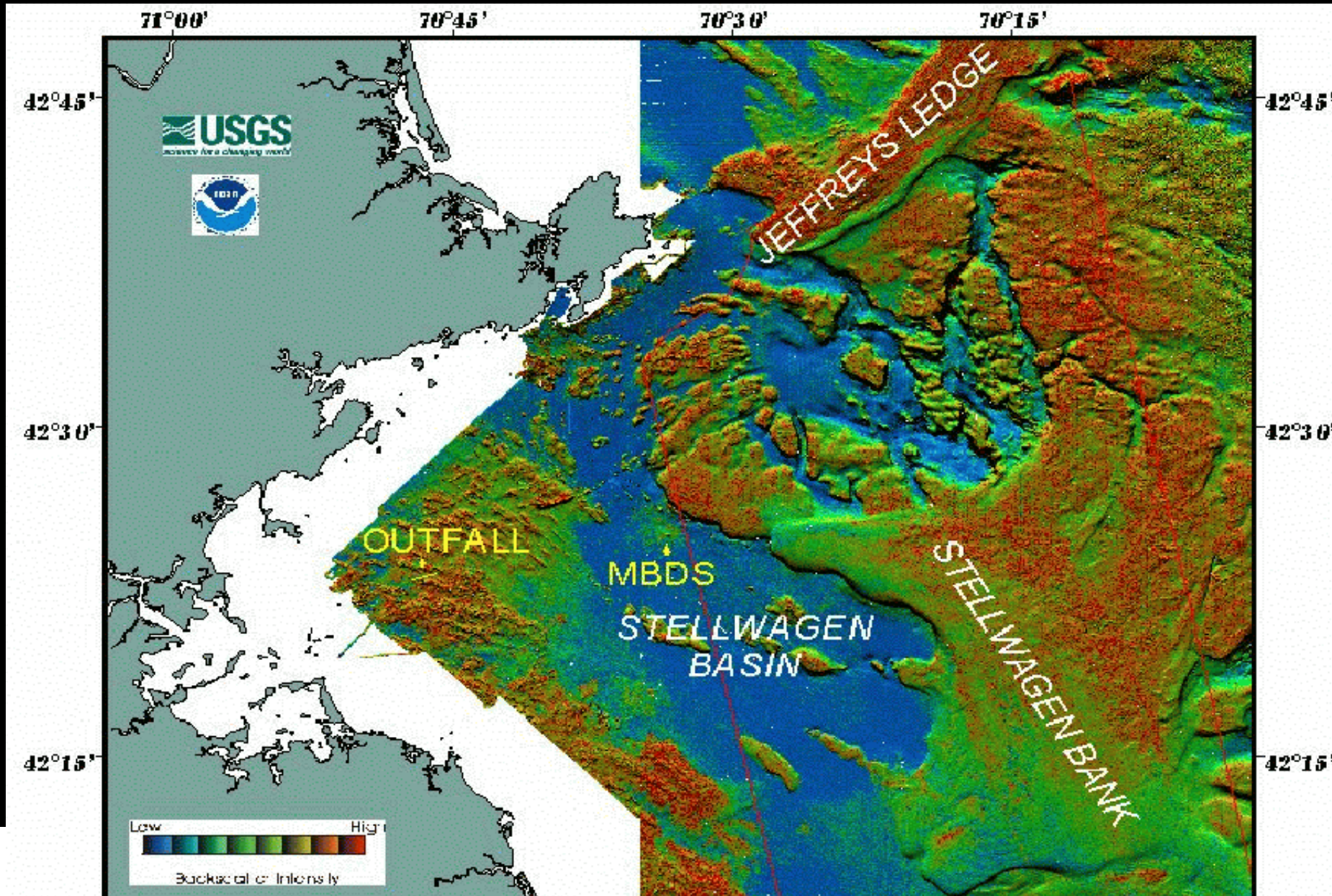
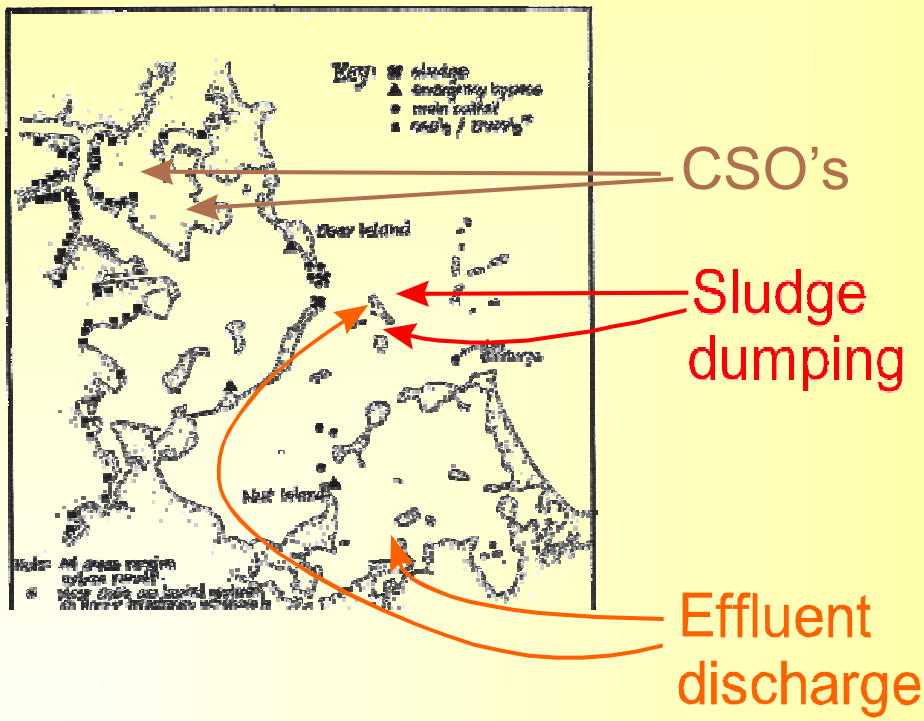


Boston Harbor in the 1980s

- 250-500 mgd sewage effluent, only primary treated, discharged at Deer & Nut Islands
- 20 tons sludge daily released in Presidents Roads
- >90% *Capitella* in Inner Harbor & Deer Island Sediments
- Few *Ampelisca*
- 17% of winter flounder with liver cancer
- Cleanup began under court order in 1984



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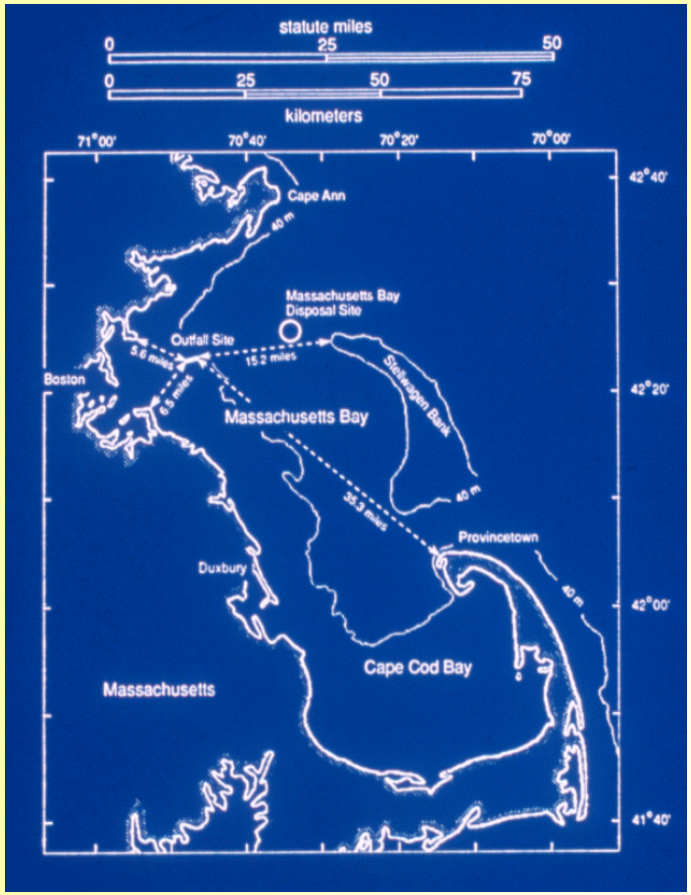
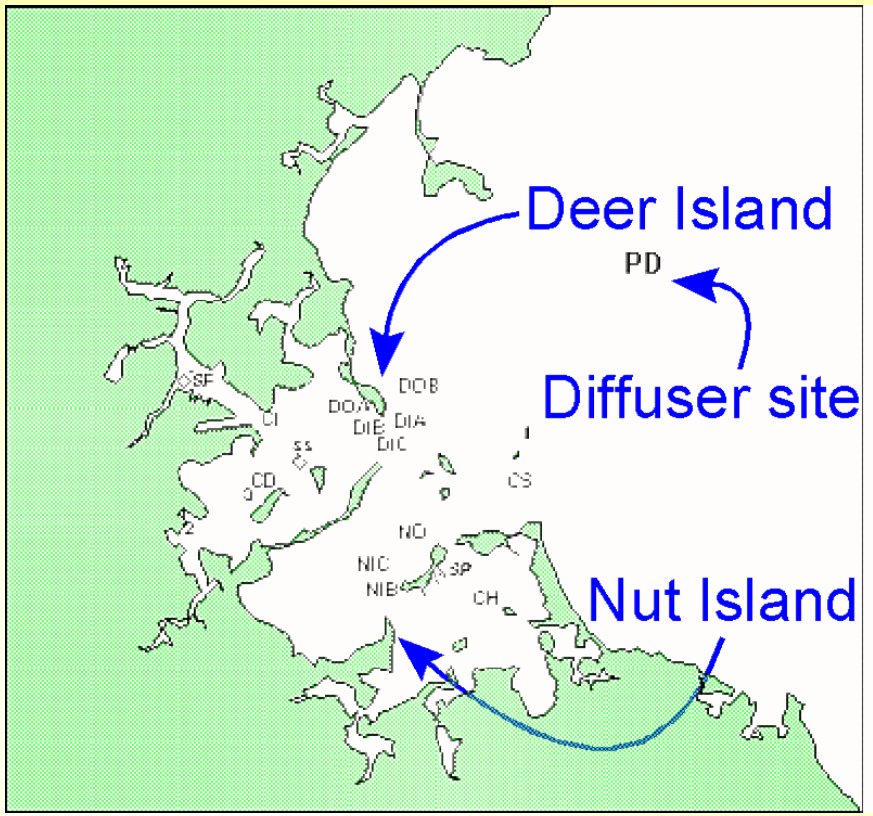
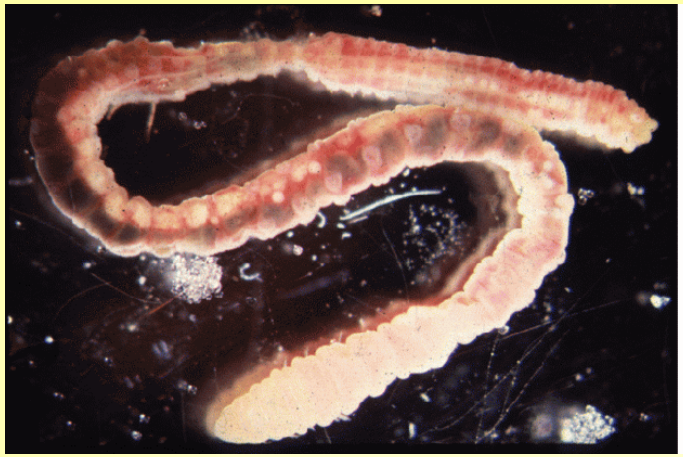
The 1972 Clean Water Act

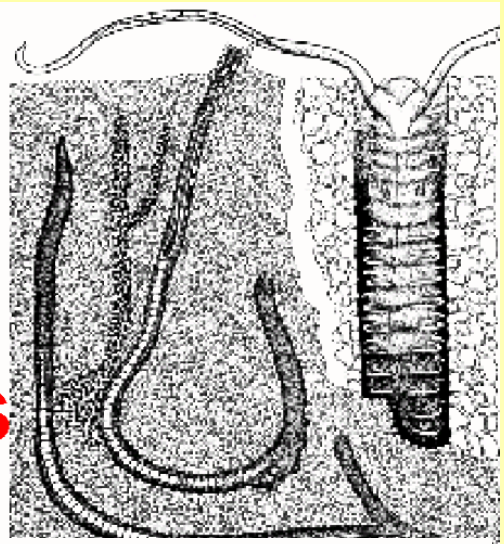
Federal lawsuit led to the MWRA and the harbor cleanup





Boston Harbor succession

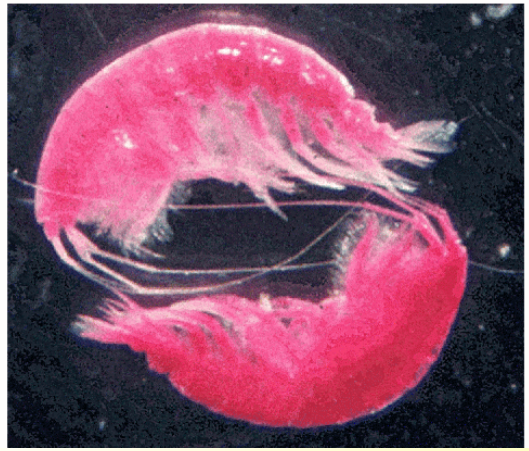




Spionids

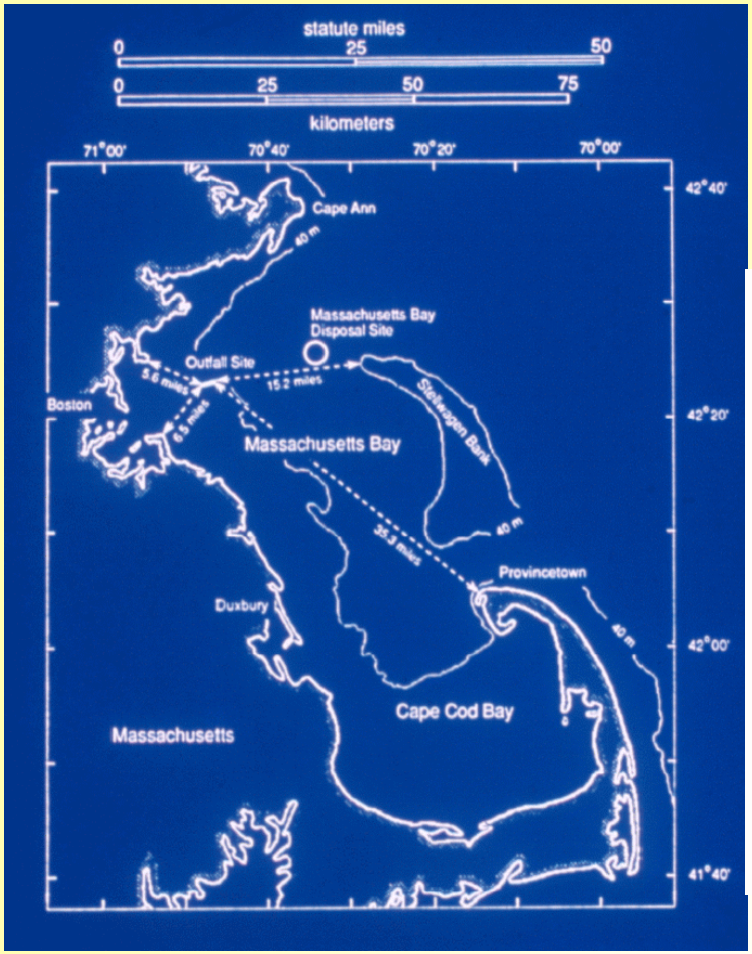
Ampelisca

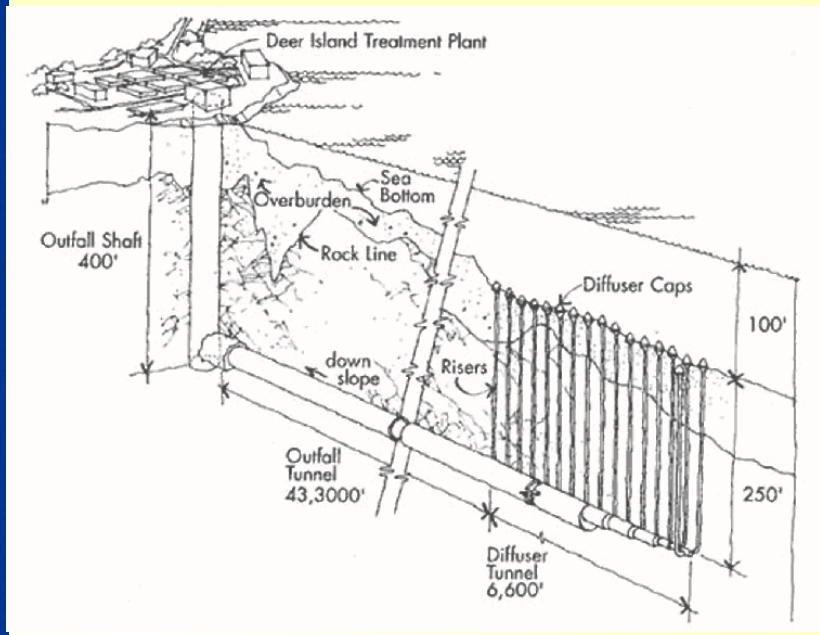
Crassocorophiun



MA Bay: a major theme of course

The outfall went online September 2000





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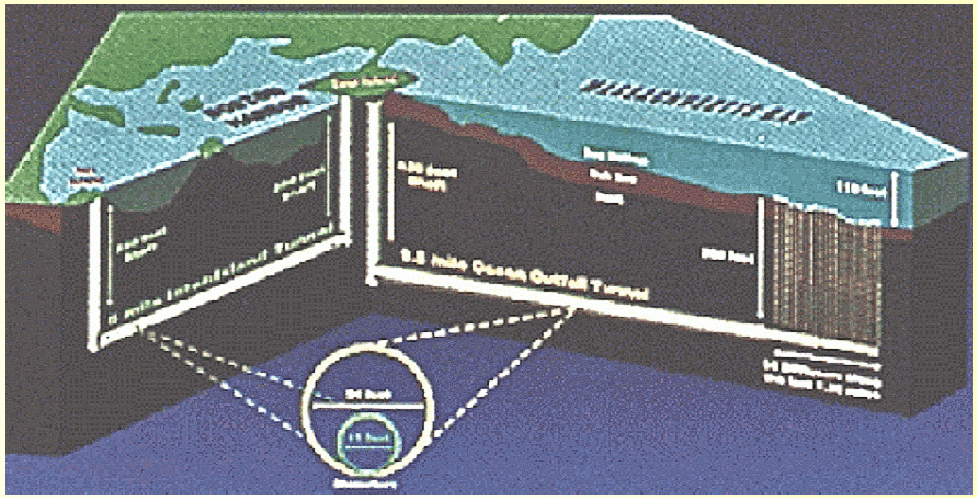
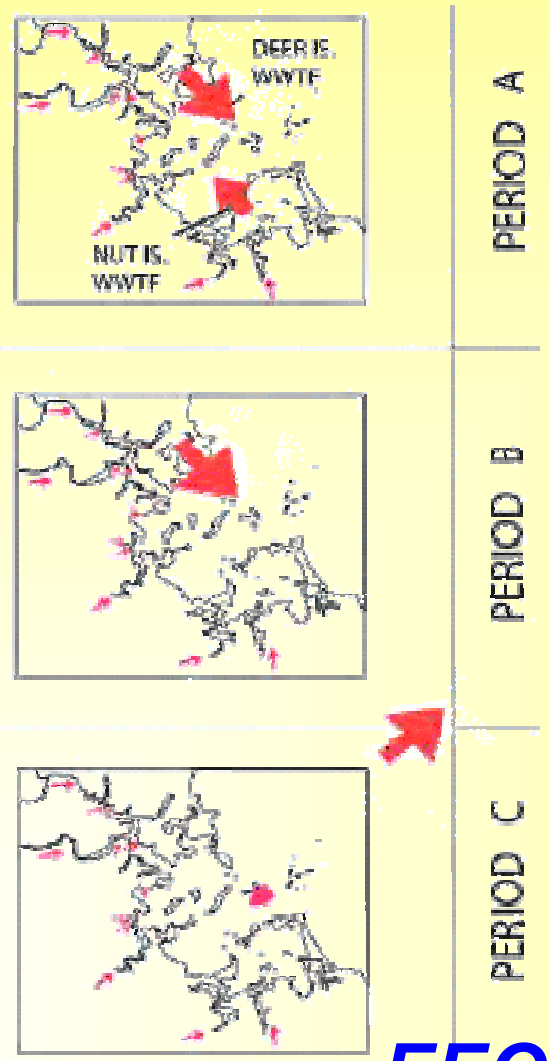
Discharge at 35 meters depth



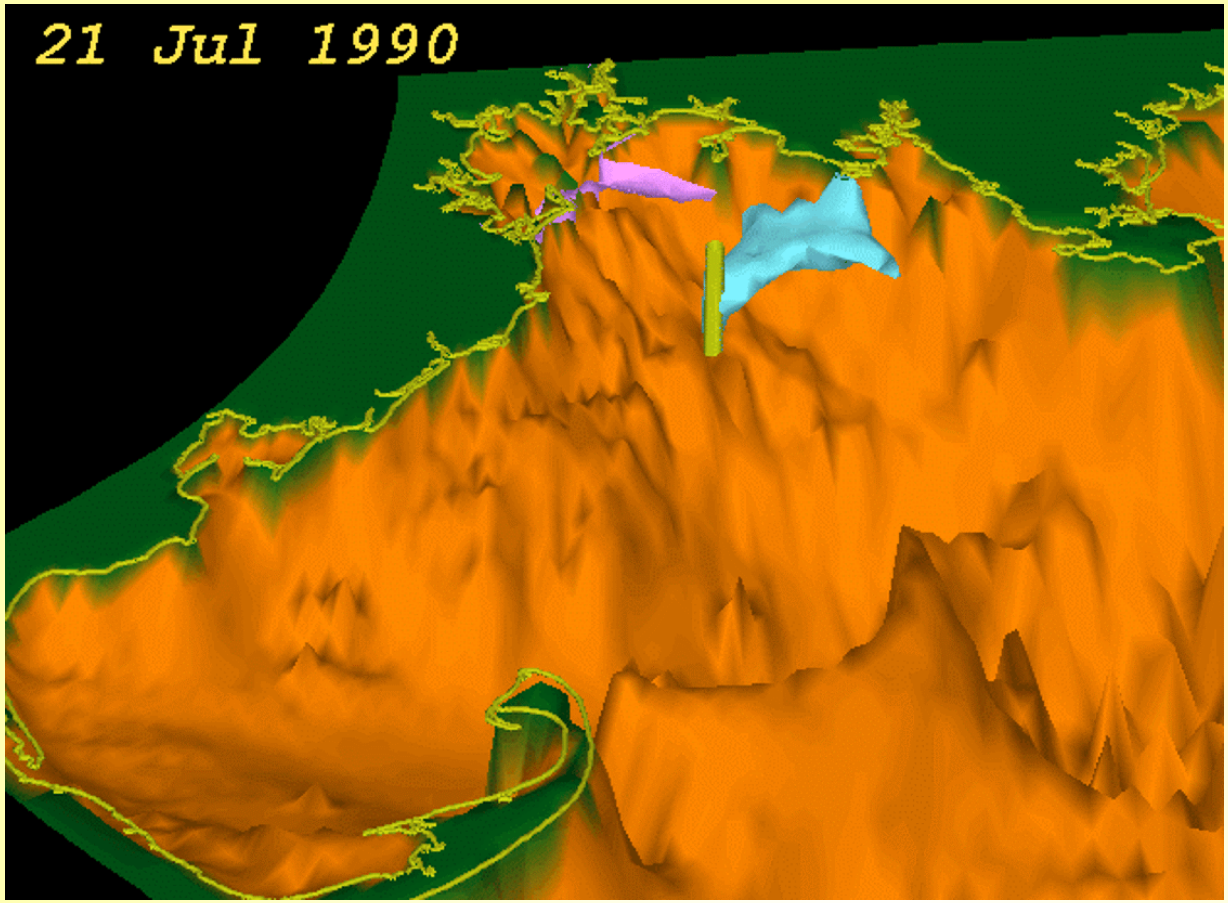
The $4 billion MWRA cleanup of Boston Harbor

- **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



Signell's 3-d circulation model

Shows the nutrient plume from the 35-m deep outfall



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Course Outline

See p. 13 in syllabus

- Introduction to the course (today)
- Part I: Benthos
  - Introduction to benthic organisms & feeding guilds (Class 2)
    - Classification of benthic organisms
    - Feeding Guilds & Functional groups
    - Distribution of feeding guilds with depth and along environmental gradients

Course Outline

Part I. Benthos (cont)

- Microphytobenthos & benthic primary production (Class 3)
  - Benthic diatom production
  - Biodiversity of benthic diatoms
  - Methods for estimating benthic diatom production, standing stock and specific growth rate
  - Gould & Gallagher (1990)
  - Experimental evidence for factors controlling benthic diatom production
  - Importance of benthic diatom production to estuarine production and secondary producers

Course Outline

Part I. Benthos (cont)

- Bioturbation and the effects of benthos on sediment chemistry and stratigraphy (Class 4)
  - Bioturbation
  - What is it?
  - Why is it important?
  - How is it measured?
  - Bioirrigation
  - Pelletization

Course Outline

Part I. Benthos (cont)

- Competition & Predation in the soft-bottom benthos (Class 5)
  - Effects of predation on soft-bottom enthic communities
  - Problems with Caging studies
  - Models of soft-bottom benthic competition
    - Lotka-Volterra competition models
    - Fitting competition models to field data
  - Relative importance of predation, competition, density-independent factors

Course Outline

Part I. Benthos (cont)

- General patterns of community structure (Class 6)
  - Methods for assessing benthic biodiversity
  - Deep-sea community structure and patterns of marine biodiversity (Class 7)
    - Sanders' stability-time hypothesis
    - Grassle-Sanders-Jumars spatial temporal mosaic
    - Huston's dynamic-equilibrium
    - Other hypotheses for patterns of deep-sea diversity.

Part I. Benthos, Part II. Plankton

Classes 7-9

- Effects of pollution on marine benthic communities: Boston Harbor, MA Bay & New Bedford Harbor (Class 8)
- Part II: Plankton
  - P, B, and μ: the fundamental units of phytoplankton ecology (Class 9)
    - C:Chl ratios
    - Effects of temperature

Course Outline (cont.)

Class 10

- Part II Plankton (continued)
  - Environmental factors controlling primary production: Light
  - Readings
    - Harrison et al. (1985)
    - Falkowski & Raven (1997)
  - What is photosynthesis?
  - P *vs.* I curves
    - simulated *in situ* incubations.
    - Jassby-Platt equation
    - Estimating primary production using the P *vs.* I approach in MA Bay.
  - Diel and vertical patterns of production.
  - Photoadaptation & photoinhibition
  - Importance of light quality

Class Outline (cont)

Class 11

- Part II Plankton (cont)
  - Liebig's Law of the minimum and Brandt's denitrification hypothesis
    - Phytoplankton growth
    - nitrification & the nitrogen cycle
  - Chemostats in oceanography
    - Michaelis-Menten growth equations
      - uptake kinetics
      - the cell quota
      - growth kinetics
- Other nutrients: P, Si, Fe, Zn

Temporal and spatial patterns of primary production

Class 12

- The spring and fall blooms
  - Sverdrup's critical depth concept
  - The vernal bloom in the North Pacific and North Atlantic.
  - Spring bloom in MA Bay
  - The Fall bloom in MA Bay
- Dimensional analysis of spring-bloom timing

Upwelling & El Niño

Class 13

- Physics
  - Coriolis effect
  - Ekman mass transport
  - Barotropic & baroclinic pressure gradients
  - Geostrophic currents
- Biology
  - Upwelling and fish production
  - Primary production at equatorial divergences
- El Niño Southern Oscillation & Pacific decadal oscillation

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Production on shelves

Class 14

- Case Studies
  - Riley on the New England Shelf
  - Eppley et al. Southern CA
- Nitrogen as the key limiting nutrient in the sea
  - The advection-diffusion equation, and the importance of horizontal and vertical eddy diffusive fluxes of NO_3^-
  - The role of vertical stability and fronts.
- Modeling with Matlab

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Presentation of Project 1

Class 15-16

- Three topics will be chosen based on benthos and phytoplankton
  - Quantitative/modeling topic
  - Autecological topic (focusing on individual species)
  - Policy/management topic
- First topic: effect of OCS drilling on biological oceanographic processes, with an emphasis on Georges Bank
- You must make a 12-minute presentation & submit a 5-10 page paper.
- No midterm exam

MA Bay Production

Class 17

- Effects of light and nutrients and the Cole-Cloern/ Platt relationship.
- The seasonal cycle of production
- The vertical distribution of phytoplankton & the subsurface chlorophyll maximum
- Eutrophication

Oceanic gyres

Class 18

- Primary production in the oceanic gyres
  - Rates of production in gyres.
    - Problems with the ^{14}C method.
    - Indirect measures of primary production
  - Models of gyre production.
    - Are the gyres analogous to a chemostat?
    - The micro-nutrient patch hypothesis
    - The role of mesoscale phenomena
  - Pacific decadal oscillation and gyre production, Karl's regime change hypothesis

Satellite Remote Sensing

Class 19

- Satellite remote sensing of Chl *a* and primary production
  - Theory
  - Limitations
- Estimating Chl *a* from space
- Estimating primary production from space
  - Platt & Sathyendranath
  - Behrenfeld & Falkowski

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Part III. Secondary Production

Zooplankton Grazing, Class 20

- Grazing mechanisms
  - Life at Low Reynolds number
  - Frost's empirical relationships between grazing and phytoplankton concentration
  - Interaction between phytoplankton size and grazing
  - How to measure zooplankton grazing rates.

Zooplankton Predation& population biology

Class 21

- Predation on zooplankton
  - Brooks and Dodson's (1965) `Size-efficiency hypothesis'
  - The role of invertebrate predation
  - The trophic-cascade hypothesis

Vertical Migration

Class 22

- Vertical migration of zooplankton
  - Zooplankton life histories
  - Demography
  - Demographic analysis of the adaptive value of vertical migration
- The vertical migration game
  - Game theory
  - *Pseudocalanus-Euchaeta*

The Microbial Loop

Class 23

- Methods for determining microbial standing stocks & production
- The microbial loop hypothesis
  - sources of dissolved organic matter (DOM)
  - Control of bacterial standing stock and production
  - Nutrient regeneration
  - transfer of DOM to macrozooplankton and fish

Effects of Body Size

Class 24

- Allometric scaling
  - Growth rate versus body size
  - Respiration rate
  - Predation rate
  - P:B ratios
  - Size-Spectra in plankton and benthos
- Food for Right Whales
- Size spectra of planktonic and benthic communities
  - Loch Ness monsters and mermaids

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Production in HNLC areas

Class 25

- The N. Pacific
  - The *Neocalanus* major grazer paradigm
  - Refutation/Revolution: the role of microzooplankton
  - New paradigm: Ecumenical iron hypothesis
- The marine biological pump
- The Geritol Solution to global warming

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Ecosystem modeling

Classes 26-28

- Introduction to Ecosystem Models
  - Riley's Georges Bank Model
  - Steele's North Sea Ecosystem Model
    - the standard run
    - Model stability: the role of refuges and predation
  - **Mulitcohort and other models**
    - Frost's modifications of the Landry model
    - Evans and Parslow: a model of grazing effects on the vernal phytoplankton bloom

Narragansett & MA Bay models

Class 28, last class

- Simulation of a coastal marine ecosystem: Kremer and Nixon's Narragansett Bay Model
  - Physical model
  - Phytoplankton growth
  - Zooplankton growth
  - Predation
  - Benthic-pelagic coupling
- Predicting the effects of nutrient addition on MA Bay: the Hydroqual model

FINAL EXAMINATION

- In-class 3-hour, closed-book examination
- All questions will be handed out about 2 weeks in advance
- Date for final will be set in mid-semester by the University