Modelling Ocean Ecology

Oceanography 6324 and Physics 4340

Lectures will be twice per week, for a total of 3 hours. The instructor will be
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General Description

This course is about models of ecological processes that control animal populations with planktonic stages. We will begin with some fundamental ideas about simple biological models focusing on age and stage structure. Simple physical models will be limited to one-dimensional models of vertical mixing, horizontal advection-diffusion models, shallow-water models of horizontal circulation and simplified spatial models that include wind forcing but with greatly simplified stratification. Numerical techniques are fundamental to such modelling, both for the treatment and inclusion of data and the numerical scheme of the model itself. Accordingly we will draw upon elements of numerical modelling techniques and data analysis to illuminate the mechanics of the models employed.

The biological focus will be on three different groups: holozooplankton, meroplankton and icthyoplankton. A life history approach will be developed, focussing on development from eggs and larvae to juvenile stages. Coupling between biological and physical models will be emphasized. Our material stands at a cross roads between several different disciplines and approaches. The interesting and exciting challenge is the integration between disciplines in the move towards the development of realistic bio-physical models.

Text – Modelling of Marine Ecosystems – W. Fennel and T. Fennell, 2004, Elsevier, 297 pp.

Marking

Assignments	Roughly 10% each		50%	100%
Term Project	Written Paper - 35%	50		
	Presentation - 15%			

There will be five assignments. You will normally be given about ten days to complete each assignment, which will be worth roughly 10%. Each assignment will include several problems following the material that we discuss in class. Where computer coding is required, the code should be handed in with the assignment. You are expected to include some interpretation with your assignments; thus although this is a numerical analysis course, we will consider interpretation to be a fundamental component of producing results. Each assignment will have a theme:

Assignment #1 - Graphical techniques and numerical analysis in Matlab
Assignment #2 - Solving simple ordinary differential equations relevant to biology
Assignment #3 - Tracking particles in space, applications in the ocean
Assignment #4 - Building a simple NPZ model and including age structure
Assignment #5 - Solving an advection-diffusion problem

The assignments are designed to give you practice in building and exploring tools relevant to solving real-world problems. In the term project, you will tackle a simplified real world problem. We can suggest a project for you, or you can come up with your own. Possible projects are (1) Including vertical migratory behaviour for an organism in a one-dimensional mixing model (e.g. PWP model), (2) Explore Lagrangian particle tracking in a simplified circulation model (e.g. shallow water model or reduced gravity model), (3) Including predation in a spatially explicit model, (4) Exploring horizontal behaviour of organisms (biological particles) in an advection-diffusion model and (5) Exploring stability and non-linearity in a population model and (6) Including environmental factors in a virtual fish population model. Since the project will take a substantial amount of time and effort, we suggest that you keep it in mind as we go through the material. Selection of the project should be made by early October so that you can begin to prepare. We have intentionally tapered the assignment workload toward the end of the term so that you will have time to work on the project in November and early December. The written paper should be substantial, like a <u>small</u> research paper. Likewise the presentation should follow the form of a research talk.

A sample lecture outline is provided below. This is the old schedule from the last time the course was offered. It will be updated later in December. This gives an idea of the content covered but will change as the course will be different this time.

Course

Date	Topic(s)	Reading
	Introduction. Topics, goals, assignments, readings, computers	Denman & Gargett 1995 Mann 1992
	The idea of models. Biological formulations. Age- stage-structured models. NPZ models	Hastings 1997 (Chap. 2) Steele and Frost 1977
	The idea of models. Biological formulations. Age- stage-structured models. NPZ models	Steele 1974 Fasham et al. 1990 Hofmann 1997
	Practice of modelling. Numerical techniques. Use of Matlab. Data, analysis, plotting.	Etter 1997 (Chaps. 1,2,3,7) Matlab Manuals
	Practice of modelling. Forms of equations, analytical solutions, numerical solutions. Using Matlab.	Garcia 1994 (Chaps. 1-3) Nakamura 1996
	Practice of modelling. Collection of data and incorporation into model.	
	Simple dynamical models. Examples. A three-level food chain.	Hastings and Powell, 1991
	Simple dynamical models. Examples. Two stages, two patches, with dispersion between patches	Hastings, 1992

	Forcing in the ocean. Wind forcing in the ocean, Ekman dynamics, spatial structure.	Pond and Pickard 1991 (Chap. 9) Gill 1982 (Chap. 9)
	Forcing in the oceans – Winds and currents, Ekman dynamics and upwelling, simple models and representation.	Pond and Pickard 1991 (Chap. 9) Gill 1982 (Chap. 9) Krauss 1977
	Physical circulation modelling. Representation of processes in physical models, strengths and limitations.	Dyke 1996 (Chap. 3) Pond & Pickard 1991
	Physical circulation modelling . Coupling physical and biological models. Particle tracking in models.	Hoffman, 1997
	Holozooplankton. Introduction to calanoid and euphausiid life histories. Biogeographic details.	Marshall & Orr, 1972 Mauchline & Fisher, 1969
	Holozooplankton populations within ecosystem models. Coupling to ***NPZ*** models.	Carlotti and Nival, 1992 Batchelder, 1989
	Holozooplankton within ecosystem models. Coupling to ***NPZ*** models.	Steele and Frost, 1977 Ambler and Hofmann, 1988
	Coupling zooplankton/ecosystem models to physics: vertical mixing, horizontal transport. Miscellaneous: bio-mass spectra, ***NPZ-D***, biogeochemical cycles.	Carlotti and Radach, 1996 Hofmann, 1988
	NPZ and PWP Coupling Including weight/individuals in zooplankton models	
	Meroplankton/Icthyoplankton – Thematic life histories of larvae and coupling to the physical environment. Simple diffusion modelling	Houde 1996 Taggart & Frank 1990 Jackson & Strathmann 1981

	Two-Dimensional Advection Diffusion Modelling	Hill 1991 deYoung & Davidson 1994 Kasai et al. 1992 Possingham and Roughgarden 1990
	Particle Tracking and larval drift	Handout
	Meroplankton – Advection/diffusion models of larvae. Coral/shrimp/transport models.	Possingham and Roughgarden 1990 Richards et al. 1995 Rothlisberg et al. 1983 Black et al. 1991
	Meroplankton – Coral/shrimp transport models (continued). Miscellaneous other meroplankton model topics (e.g. other taxa)	Black 1994 Wolanski et al. 1989 Oliver et al. 1992 Dekshenieks et al. 1996 Botsford et al. 1994 Higgins et al. 1997
	Icthyoplankton - Models simulating pattern for eggs and larvae – Banks and Shelves	Sinclair 1988 Werner et al. 1993 Bartsch 1993
	Icthyoplankton - Modelling recruitment in fish	Hillborn and Walters 1989