DALHOUSIE UNIVERSITY

Faculty of Science and Faculty of Graduate Studies Course Syllabus
Department of Biology

Ecosystem Modelling for Aquaculture
MARI 4600.03
Cross list: BIOL 5660.03
(September 2018)

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Office hours: *by appointment*

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Lectures: Time: *Mondays, 11:35 am to 2:25 pm* | Location: *MCCAIN ARTS&SS 2019*

Course Description

Summary: *Learn a collection of tools for the sustainable utilization of aquatic resources. Emphasis is on bilateral interactions between aquaculture and the environment. Topics include water/sediment/biota variability, carrying capacity, invasive species, habitat destruction/creation, ecosystem functions/services, climate change, etc. Tools include data analysis/modelling/visualization/mapping using Python™ (prior programming experience is not required).*

This is a very practical course. It is taught in a computer lab via 3-hours long classes (1 per week) to allow plenty time for you to follow along on your own computer (tutorial style). Roughly, each 3-hour class is divided in (1) a Quiz/Review section (~30 minutes), (2) a PowerPoint lecture section (~1 hour), and (3) a hands-on laboratory section (~1.5 hours). The course has been designed to minimize student-stress via clear and frequent marking and feedback.

The Daily Quizzes are a hallmark of this course. For each quiz, you are required to bring (and use) a cheat-sheet with anything you want to write on it. It is an excellent way to spread the burden of studying over the entire term. After all the Daily Quizzes, it should be fairly easy to prepare for the Final exam.

In the labs you will learn many programming and data-handling skills, including how to download free data (from satellites, oceanographic buoys, gliders, etc.), how do graphs, maps and other visualizations, and how to feed data to Ecosystem Models to support decision-making to sustainably use aquatic resources. The labs are in Python Programming Language (prior programming experience is NOT required).

A collaborative project: Throughout the class, we will build a repository of code (i.e. models, data analysis tools, etc.), literature (i.e. papers and technical reports) and lists of parameters, which will form a very valuable asset for your future work. In upcoming years, future students will build-upon and continue to contribute to the repository.

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Differences between undergraduate (4600) and graduate (5660) levels

Graduate students taking this course are expected to do about 30% more work than the students taking the course at the undergraduate level. Detailed distinctions between undergraduate (4600) and graduate (5600) students are included throughout this document. Graduate students are marked following a grading scale that is stricter than the undergraduate scale, where a minimum of 70% (B-) is required to pass.

Course Prerequisites

Undergraduate	Graduate
MARI 3602.03 - Introduction to Aquaculture **OR** Instructor's approval	Instructor's approval

Key knowledge or skills expected of students coming into the course

- Students should be familiar with the basic concepts of aquaculture.
- Prior computer programming knowledge is NOT required.

Course Goals and Outcomes

Goals and Outcomes for both undergraduate and graduate students

- Explain environmental impacts of aquaculture (i.e. "aquaculture → environment" interactions)
- Explain effects of the environment on aquaculture production (i.e. "environment → aquaculture" interactions)
- Describe the concept of Environmental Carrying Capacity (ECC)
- List the relevant environmental variables (water-column, sediments and biota) involved in aquaculture-environment interactions
- Characterize methods and tools to assess and monitor the relevant environmental variables
- Describe mechanisms causing variability in the relevant environmental variables
- Explain the effects of aquaculture on ecosystem functions and services
- Explain the effects of global warming and ocean acidification on aquaculture and vice versa
- Demonstrate the use of Aquaculture Ecosystem Models for the estimation of ECC on an idealized aquaculture farm

Additional Course Goals and Outcomes for graduate students only

- Demonstrate critical thinking and capacity to solve quantitative problems related to aquaculture-environment interactions
- Develop, code and parameterize an original Aquaculture Ecosystem Model
- Evaluate mass-conservation and parameter sensitivity of your original Aquaculture Ecosystem Model

Course Materials

Class notes: Class notes are posted on BrightSpace.
Announcements: Electronic announcements and additional material will be posted from on BrightSpace. Students should check the site frequently.
Text book: There is no textbook required for this course.

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Other suggested resources:

IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution. 1991. Reducing environmental impacts of coastal aquaculture. Food and Agriculture Organization of the United Nations.	SH 171 R42 1991
Aquaculture. Farming Aquatic Animals and Plants. 2nd edition 2012. J. Lucas and P. Southgate (Editors), 629 pp.	SH 21 A68 2003
Encyclopedia of Aquaculture. (2000). R. Stickney (Editor)	SH 20.3 E53
Principles of Aquaculture. R Stickney	SH 135 S74 1994
Introduction to aquaculture. M. Landau	SH 135 L36 1992
Ecological Aquaculture. The evolution of the blue revolution B. Costa-Pierce	SH 135 E35 2002
Cold-water aquaculture in Atlantic Canada A. Boghen	SH 37 C64 1995

Course Assessment

Component	Weight (% of final grade)		Date
	Undergraduate	Graduate	
Daily Quizzes	20	15	Almost every class day
Laboratories	30	25	Lab day @ 11:59 pm*
Physiology model (Presentation)	-	5	Week 6
Physiology model (Short report)	-	5	Week 6
Physiology model (Python code)	-	5	Week 6
Article review (Presentation)	10	10	Weeks 11 and 12
Student project (Long report)	20	15	Week 13
Final Exam	20	20	Week 13
TOTAL	/100	/100	

** Unless other deadline is specified*
All component are individual (i.e. not in teams)
Attendance to class is mandatory: A deduction of 2% from the final mark will applied for every missed hour of class (see Course Polices for more details)

Daily Quizzes

At the beginning of most lectures, a Brightspace quiz (approx. 10 minutes) will be applied to test the material taught during the previous lecture. Students are not allowed to view class notes or any material in the computer other than the Brightspace quiz (i.e. no browsing the internet, power points notes, etc.). However, students are required to bring and use a **hand-written "cheat-sheet"** for each Daily Quiz, which is handed in at the end of the quiz. Cheat-sheets not meeting specifications (see below) will result in a zero grade in the corresponding quiz. Note that appropriate documentation (e.g. doctor's note) is required to justify missed quizzes.

Cheat-sheet specifications:

- Cheat-sheets **MUST** be hand-written on paper. Digitization, electronic manipulation, photocopying, photographing and/or printing of cheat-sheets is not allowed.
- Cheat-sheets are personal. **Copying somebody else's cheat-sheet is a serious plagiarism offence** requiring the instructor to report all involved parties to the Academic Integrity Office.
- Size: each cheat-sheet is limited to one side of a letter-sized sheet of paper (i.e. 215.9 by 279.4 mm).
- Content: Anything you want, but **must** demonstrate effort to synthetize lecture content.

NOTE: On the back of your cheat-sheet, write your name, B00 number, date and answers for the Daily Quiz.

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Laboratories

Most classes have a lab requiring students to run Python code in their lab computers. Interspersed within the lab instructions are several questions, which must be answered in the corresponding **Brightspace Lab quiz** (titled "LAB# - Lab Title"). Each Brightspace lab quiz can only be accessed from the beginning of the lab session until 11:59 pm of that day, unless otherwise specified.

Physiology model (Grad students only)

Each graduate student will choose a peer-reviewed publication describing a physiological model for an aquatic species that is either suitable for cultivation, or that is known to interact with aquaculture species. Articles (i.e. full reference) need to be posted in a Brightspace discussion board to avoid duplication. In case of duplication, the first post stays, the others must find another article.

Students must use the model equations in their chosen article to write the model in Python, and prove the model works (i.e. conserves mass, etc.). Students must (1) hand in a short report, (2) hand in the python code running the model, and (3) deliver a short PowerPoint presentation to the class. All the models will be uploaded to a repository and be made available to entire class so that the can all be used, if needed, in the student projects.

Rubric: Physiology model (Python code)

Component	Comments	Weights (%)	
		Undergraduate	Graduate
Model functioning	Does the model run?	-	50%
Commenting	Is the model adequately commented? In the comments, include the full reference of the peer-reviewed article where the model was published Also include a list of names of people that worked on the code (credits)	-	50%
		-	100%

Rubric: Physiology model (Short report)

Component	Comments	Weights (%)	
		Undergraduate	Graduate
Summary	Brief description of the work and findings. Maximum length: 1 page	-	10%
Model Diagram	Visual representation of all variables and processes of the model	-	10%
Table of symbols and units	List of symbols and units used in the model	-	10%
Table of parameters	List of all parameters (name and value used) as well as references justifying used values	-	10%
Test mass conservation	Prove that model conserves mass (include graphs with captions and correct units)	-	10%
Model run examples	Show 2 or 3 model simulations (include graphs with captions and correct units)	-	10%
Discussion	Did the article had all the information needed for you to write the model? Did you find any errors in the article? If you ran into road blocks, how did you dealt with them? Any other comments about the model?		35%
References	Format: Ecological Modelling Journal	-	5%
	TOTAL:	-	100%

DALHOUSIE UNIVERSITY

Rubric: Physiology model (Presentation)

Component	Comments	Weights (%) and time (min)	
		Undergraduate	Graduate
Time	Time allowed for each presentation (including questions)	-	15 min
Clarity of oral presentation	Delivery of material clearly and concisely	-	10%
Clarity of slides	Use figures, graphs and images effectively. Text should be minimal and for the purpose of aiding the audience (not the presenter)	-	10%
Responses to questions	Demonstrate a clean understanding of the model and problem	-	10%
Content	Brief introduction	-	10%
	Model Diagram: Visual representation of all variables and processes of the model	-	10%
	Model Equations: Show the main differential equations and ancillary equations defining the model (you don't have to show all of them!)	-	10%
	Test of mass conservation: Include graphs with captions and correct units	-	10%
	Model run examples: Include graphs with captions and correct units	-	10%
	Discussion (same as discussion in the short report)	-	10%
	Conclusions	-	10%
	TOTAL:	-	100%

Article review

Each graduate student will choose a peer-reviewed publication using an ecosystem model in an aquaculture setting (or for an aquaculture application). Ideally the model would include ocean dynamics and animal physiology. Articles (i.e. full reference) need to be posted in a Brightspace discussion board to avoid duplication. In case of duplication, the first post stays, the others must find another article.
Students must present their article review to the class via an oral presentation.

Rubric: Article review (Presentation)

Component	Comments	Weights (%) and time (min)	
		Undergraduate	Graduate
Time	Time allowed for each presentation (including questions and setup)	10 min*	10 min*
Clarity of oral presentation	Delivery of material clearly and concisely	10%	10%
Clarity of slides	Use figures, graphs and images effectively. Text should be minimal and for the purpose of aiding the audience (not the presenter)	10%	10%
Responses to questions	Demonstrate a clean understanding of the model and problem	10%	10%
Content	Brief introduction	10%	10%
	Model Diagram: Visual representation of all variables and processes of the model	10%	10%
	Model Equations: Show the main differential equations (you don't have time to show them all. Choose only the most important ones)	10%	10%
	Main results of the paper	10%	10%
	Discussion (pros, cons and limitation of the model)	20%	20%
	Conclusions	10%	10%
	TOTAL:	100%	100%

** Time may change depending on the actual number of students enrolled in the class*

Student project

Each student will work on a student project requiring to do a substantial written report. The project requires the use of an aquaculture-environment model to estimate the effect of aquaculture operations on the environment and to estimate the Environmental Carrying Capacity of the farm. Students can use the ecosystems models provided in class, or the ones contributed by the graduate students. For their projects, each student will need to apply their aquaculture-environment model to an "idealized" aquaculture farm, defined by an environment (shape of bay, depth, currents, tides, temperature, etc.) as well as the cultured species (one or more) and culture system(s). The final written report is due at the end of the term.

DALHOUSIE UNIVERSITY

Rubric: Student project (Report)

Component	Comments	Weights (%)	
		Undergraduate	Graduate
Summary	Brief description of the work and findings. Maximum length: 1 page	4%	4%
Introduction	Description of the "idealized" environment (e.g. bay, lake, pond, tanks, etc.). Where relevant, physical, chemical, geological and biological characteristics, culture species (one or more) and culture methods need to be defined. Maximum length: 3 pages	4%	4%
Objectives	Define objectives of the report. Maximum length: 0.5 page	4%	4%
Methods: Model Diagram	Visual representation of all variables and processes of the model	8%	8%
Methods: Table of symbols and units	List of symbols and units used in the model	4%	4%
Methods: Table of parameters	List of all parameters (name and value used) as well as references justifying used values	4%	4%
Methods: Sensitivity analysis	How was the model sensitivity estimated?	5%	5%
Methods: Test mass conservation	How was mass conservation tested?	5%	5%
Methods: Carrying capacity	How was carrying capacity estimated?	4%	4%
Methods: Environmental impacts	How where environmental impacts estimated?	4%	4%
Results: Sensitivity analysis	Include graphs with captions and correct units	5%	5%
Results: Test mass conservation	Include graphs with captions and correct units	5%	5%
Results: Carrying capacity	Include graphs with captions and correct units	4%	4%
Results: Environmental impacts	Include graphs with captions and correct units	4%	4%
Results: Text	Maximum length: 1 pages	4%	4%
Discussion	Maximum length: 3 pages	4%	4%
Conclusions	Maximum length: 1 page	4%	4%
Appendix: Model Equations	Include all differential equations and ancillary equations defining the model	15%	15%
Appendix: Code	Adequately commented	5%	5%
References	Format: Ecological Modelling Journal	4%	4%
	TOTAL:	100%	100%

Final exam

Unlike Daily Quizzes, it is **NOT** allowed to bring a cheat-sheet to the final exam.

Conversion of numerical grades to Final Letter Grades

Undergraduate students follows the Dalhousie Common Grade Scale. Graduate students follows a more strict scale, where a minimum of 70% (B-) is required to pass.

	Undergraduate			Graduate		
%	Letter Grade	Grade Point Value	Definition	Letter Grade	Grade Point Value	Definition
90 - 100	**A+**	4.30	Exceptional	**A+**	4.30	Exceptional
85-89	**A**	4.00	Excellent	**A**	4.00	Excellent
80-84	**A-**	3.70	Very Good	**A-**	3.70	Very Good
77-79	**B+**	3.30		**B+**	3.30	
73-76	**B**	3.00	Good	**B**	3.00	Good
70-72	**B-**	2.70		**B-**	2.70	
65-69	**C+**	2.30	Satisfactory	**F**	0.00	Failure
60-64	**C**	2.00		**F**		
55-59	**C-**	1.70		**F**		
50-54	**D**	1.00	Marginal Pass	**F**		
<50	**F**	0.00	Failure	**F**		

DALHOUSIE UNIVERSITY

Course Policies

Attendance is mandatory: Students are required to attend to all classes, and to remain in class for its entire duration. A deduction of 2% from the final mark will applied for every missed hour of class. Note that appropriate documentation (e.g. doctor's note) is required to justify missed classes.

Brightspace will be used to post lectures, updates and announcements.

Late assignments: A 10% reduction in grade will be applied for every day an assignment is late.

Assignment submission: Assignments should be submitted via Brightspace as .docx file by 11:59 pm on the due date.

Course Content

Week	Date	Lectures	Laboratories
1	Sep 10	• Course Introduction / Syllabus • Introduction to Aquaculture Modelling • Introduction to Python	• Python basics and course teaser
2	Sep 17	• Introduction to ecosystem (NPZ) modelling	• Building a simple plankton-mussel model (NPZM) from scratch
3	Sep 24	• Modelling physiology (energy budgets)	• Coding a mussel physiology model (SHELL-E) from the equations in a peer-reviewed paper • Playing with SHELL-E model
4	Oct 1	• Water-column: Physical Variables 1	• Forcing SHELL-E model with temperature from satellites (POES, AVHRR and GAC) • Assessing the effect of Global Warming on mussel aquaculture
5	Oct 8	Thanks giving – No class	
6	Oct 15	• Water-column: Physical Variables 2 • Coupling different models	• Coupling SHELL-E to a NPZD2 plankton model
7	Oct 22	• Student presentations: physiology models • Water-column: Biogeochemical Variables	• Forcing SHELL-E model with Oxygen climatology from NOAA • Assessing the effect of eutrophication and oxygen reduction (i.e. appearance of dead zones) on mussel aquaculture
8	Oct 29	• Sediments: Biogeochemical Variables	• Applying SHELL-E/NPZD2 to a two-box embayment
9	Oct 24	• Carrying Capacity • Sensitivity Analysis	• Carrying Capacity • Sensitivity Analysis
10	Nov 5	• Multi-Trophic Aquaculture and interactions with wild fauna and flora	• Adding fish and macroalgae to SHELL-E/NPZD2
11	Nov 12	Study Break	
12	Nov 19	Student presentations: term projects	
13	Nov 26	Student presentations: term projects	
14	Dec 3	Final Exam	
15	Dec 4	(Tuesday) No class	

DALHOUSIE UNIVERSITY

Note that the schedule may chance in short notice depending on university closures (e.g. weather) and pace of class delivery. Any changes will be posted in Brightspace.

ACCOMMODATION POLICY FOR STUDENTS

Students may request accommodation as a result of barriers related to disability, religious obligation, or any characteristic under the Nova Scotia Human Rights Act. Students with disabilities are encouraged to register as quickly as possible at the Student Accessibility Services if they wish to receive academic accommodations. To do so please phone 494-2836, e-mail access@dal.ca, drop in at the Mark A. Hill Accessibility Centre, or visit their website www.studentaccessibility.dal.ca.

ACADEMIC INTEGRITY

Academic integrity, with its embodied values, is seen as a foundation of Dalhousie University. Our Academic Integrity website (http://academicintegrity.dal.ca) is an exceptional resource that provides students and faculty access to current university policies. It highlights issues of concern to discourage violations of acceptable conduct, and provides many links to help students succeed honestly.

It is the responsibility of ALL students to be familiar with behaviours and practices associated with academic integrity – ***IGNORANCE IS NO EXCUSE FOR PLAGIARISM, CHEATING OR ANY OTHER ACADEMIC OFFENCE***.

At Dalhousie University, plagiarism is defined as "the submission or presentation of the work of another as if it were one's own." (Dalhousie Undergraduate Academic Calendar)

Instructors are REQUIRED to forward any suspected cases of plagiarism to the Academic Integrity Officer for their Faculty. If you are accused of plagiarism you will be informed of the allegation by the Faculty of Science Academic Integrity Officer, and a date will be set for a meeting. You may contact Dalhousie Student Advocacy Services to assist you in preparing a defense. Until the case is resolved, your final letter grade will be an "INC". If it is determined that you have committed an offence you will be penalized. Penalties are determined on a case by case basis. For more details see the Academic Integrity Website and Academic Regulations (http://academicintegrity.dal.ca).

"***Plagiarism is considered a serious academic offence that may lead to the assignment of a failing grade, suspension or expulsion from the University***." (Dalhousie Undergraduate Academic Calendar)

STUDENT CODE OF CONDUCT

Dalhousie University has a student code of conduct, and it is expected that students will adhere to the code during their participation in lectures and other activities associated with this course.

In general:

"The University treats students as adults free to organize their own personal lives, behaviour and associations subject only to the law, and to University regulations that are necessary to protect

- the integrity and proper functioning of the academic and non – academic programs and activities of the University or its faculties, schools or departments;
- the peaceful and safe enjoyment of University facilities by other members of the University and the public;
- the freedom of members of the University to participate reasonably in the programs of the University and in activities on the University's premises;
- the property of the University or its members."

DALHOUSIE UNIVERSITY

The full text of the code can be found here:
http://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html