Master of Science Program in Sustainability Science

SUSC PS5080 Monitoring and Analysis of Marine and Estuary Systems

Wednesday, 6:10-8:00 PM, Spring 2024; Room 607, Hamilton Hall

3 Credits

Instructor: Dr. B. K. Linsley, Lamont Research Professor
blinsley@ldeo.columbia.edu  (w) 845-365-8306; (c) 917-509-2484

Office Hours: Contact me and we will schedule a time to meet via Zoom, phone or in-person

Response Policy: Preferred means of communication: email to blinsley@ldeo.columbia.edu. I will respond within 24 hours.

Course Overview

From a global perspective, many of the earth’s most important environments and resources for global sustainability are located in marine and estuarine areas. This class will explore open-ocean and estuarine processes, reviewing evidence for temporal variability and interconnectedness of these physical and biologic systems. We will focus on both what is known and also what is less well understood about global sustainability of these important systems. A few examples include: 1.) Decadal changes in heat flux in and out of the ocean, 2.) Atmospheric CO₂ and oceanic pH change and effects on calcifying organisms, 3.) Micro and nanno plastics in the oceans, 4.) Effects of sea level rise on marshes, barrier islands, estuaries and coastal infrastructure/development, 5.) The decline of coral and oyster reefs and temperate marshes, and efforts to restore these “living shoreline” systems. Students and professionals currently or planning to work in the environmental and engineering fields will benefit from a wide-ranging discussion of the multi-scaled processes influencing these systems. Knowledge of the processes operating in these environments will lead to a more thorough understanding of the complexity of global and regional processes and the issues that will influence infrastructure and coastal development in and around estuarine environments in the near-future.

Throughout the class we will explore marine and estuarine processes by evaluation of instrumental and paleo-data and by studying regional and local responses to broader scale environmental forcing. Reading of textbook chapters and journal articles will supplement in-class lectures and discussion. Grading will be based on class participation, homework assignments, two exams and a research paper. At the end of the course, students will have a strong scientific understanding about the impacts made on marine and estuary systems through physical, chemical, and biological processes. The course will prepare students to be well-trained in the core features of these systems and the relationship between natural and human processes, and equip them with the skills needed to explore marine and estuary systems in diverse scales and functions in the future.

This course is approved to satisfy part of the Areas 2 and 3 requirements for the M.S. in Sustainability Science program.

Prerequisite class work: Introductory Earth Science and Chemistry preferred, but NOT required.

Learning Objectives

By the end of the class students will have accomplished the following:

L1: Identify the linkage of open-ocean and estuarine processes on interannual and decadal time scales in order to analyze the impact of natural and human processes.

L2: Identify and respond to threats to estuarine, coral and oyster reef environments and fisheries.

L3: Analyze estuarine and barrier island sediment dynamics.
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**L4:** Identify possible solutions to these oceanic and estuarine sustainability problems.

**L5:** Critically read and critique scientific papers in order to gain stronger understanding of the scientific process and how scientific papers are a valuable source of data for professionals managing marine and estuary systems.

**Readings**

Class reading will include a combination of textbook chapters and scientific papers. The instructor will upload all reading materials to Courseworks.

1. Textbook: *Marine Geochemistry, 3rd Edition.* Authors are Roy Chester, Tim D. Jickells
   *Relevant chapters for this book are on Courseworks (Chapters: 3, 7, 8, 9, 11, 13). Other resources in this book can be found at: www.wiley.com/go/chester/marinegeochemistry*


3. Scientific Papers (in class discussion, critiques and reviews of papers). Scientific papers to be assigned and distributed by instructor in parallel with, and supplementing, course content.
   Examples of papers listed below: Papers will be distributed by the instructor and/or uploaded to Courseworks as the class progresses. Papers will be discussed in class and student participation is encouraged. Questioners may be assigned ahead of time in some cases.

   **Ocean Scale:**

   **Ocean Acidification and 13C Suess effect:**
   Cai, Wei-Lun, Wei-Jun Huang et al., (2017) Redox reations and weak buffering capacity lead to acidification in the Chesapeake Bay, Nature Communications, 8: 369; doi:10.1038/s41467-017-00417-7.

   **Estuaries and Barrier Islands:**
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Marshes:


Horton et al., 2019, Predicting marsh vulnerability to sea-level rise using Holocene relative sea-level data, 2019, Nature Communications, Nature Communications | DOI: 10.1038/s41467-018-05080-0


Oyster Reefs:


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Resources
Lecture PowerPoint files, assigned papers for reading and in-class discussion, and all supplemental material will be available to students via the Columbia Courseworks platform.

Columbia University Library
Columbia’s library system has services and resources available online: http://library.columbia.edu/. With your UNI, the Columbia library is an excellent way to download journal articles.

https://library.columbia.edu/collections/eresources.html; select Articles or e-Journals, paste in DOI.

SPS Academic Resources
The Office of Student Affairs provides students with academic counseling and support services such as online tutoring and career coaching: http://sps.columbia.edu/student-life-and-alumni-relations/academic-resources.

Course Requirements (Assignments)
Participation: Students will be assigned to read textbook chapters and scientific papers pertinent to the material being covered in class lectures. Students will be expected to actively engage in the class discussions on these reading assignments. (L1, L2, L3, L5).

In-Class Paper Discussion: All students will read the assigned scientific papers and/or book chapters each week. Each student will be asked to lead the review of at least one scientific paper during the semester discussing scientific results on current topics involving marine and estuarine systems. The discussion exercise will consist of a 5-10 minute summary of the paper and including identification of points for discussion. The presenter will then lead a discussion of the paper. If needed, 1-2 “questioners” may be assigned beforehand to help stimulate discussion. All students will be expected to have closely read the material and to be prepared to ask questions. (L1, L2, L3, L5)

Exam 1: The first exam will have 2 sections. 1.) “in-class” portion on taken Courseworks within a time window and 2.) take-home format requiring paragraph length answers on the material discussed in class and from the textbook and papers. Students may be asked to interpret graphs of data. (L1-L5).

Exam 2: The second exam will also have 2 sections. 1.) “in-class” portion on taken Courseworks within a time window and 2.) take-home format requiring paragraph length answers on the material discussed in class and from the textbook and papers. Focus will be on the new material since Exam #1. Students may be asked to interpret graphs of data. (L1-L5).

Homework: Two homework assignments will be given involving data analysis and interpretation. Students will be given 2-3 weeks to complete the assignments and will present the results of their data analysis in class.

Research paper: For the research paper, students will research a scientific topic, process or issue relevant to this class and present a detailed review of the current state of knowledge of this topic, process or issue. This can include an outline of how the idea, field, or hypothesis has evolved over time. Students will need to gather original scientific papers on the topic and critique them. Material referenced/discussed will not include textbooks. Depending on the topic, include ~5 papers, but there is no specific target number. Copies of all the papers reviewed need to be handed in or sent as pdf files to the instructor. Note the reference list can contain more references than number of papers reviewed/critiqued. The final paper should be approximately 10 pages of double-spaced text followed by a detailed reference list. Note that referencing textbooks is not acceptable. Students need to track down the original
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references. The use of textbooks to get ideas and references is a good place to start the reconnaissance phase but students will need to acquire, read, and cite original references where possible. The instructor can help focus and fine-tune an idea so that it will be manageable. Students will be asked to briefly discuss their research paper during class time. (L1-L5).

Evaluation/Grading

In-Class Paper Discussions and Participation (15%): Students will be evaluated on their understanding of the sustainability-related scientific concepts discussed in the papers discussed as well as their ability to communicate the main concepts to their classmates. This assignment will be graded from 0-100.

Homework Assignments (25%): It is anticipated that there will be two homework assignments involving data analysis this semester. Students will be given approximately 2 weeks to complete the assignments.

Exam 1 (15%): The format of the exam will be long format questions with answers being approximately 200-500 words in length. Student answers must be clear, concise, and demonstrate their knowledge of the topics covered during class discussions. This assignment will be graded from 0-100.

Exam 2 (20%): The format of the exam will be long format questions with answers being approximately 200-500 words in length. Student answers must be clear, concise, and demonstrate their knowledge of the topics covered during class discussions. This assignment will be graded from 0-100.

Research Paper (25%) and Presentation: Grading of research paper will be based on how well the paper investigates the problem/subject students have chosen, how well the topic has been communicated, the scientific impact of the topic, quality of scientific content and literature, and organization of ideas. Students will be asked to briefly discuss their research paper during class. This component will not be graded. This assignment will be graded from 0-100.

The final grade will be calculated as described below:

**FINAL GRADING SCALE**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>A+</td>
<td>98–100 %</td>
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<tr>
<td>A</td>
<td>93–97.9 %</td>
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<tr>
<td>A-</td>
<td>90–92.9 %</td>
</tr>
<tr>
<td>B+</td>
<td>87–89.9 %</td>
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<tr>
<td>B</td>
<td>83–86.9 %</td>
</tr>
<tr>
<td>B-</td>
<td>80–82.9 %</td>
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<tr>
<td>C+</td>
<td>77–79.9 %</td>
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<tr>
<td>C</td>
<td>73–76.9 %</td>
</tr>
<tr>
<td>C-</td>
<td>70–72.9 %</td>
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<tr>
<td>D</td>
<td>60–69.9 %</td>
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<tr>
<td>F</td>
<td>59.9% and below</td>
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<table>
<thead>
<tr>
<th>ASSIGNMENT</th>
<th>% Weight</th>
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<tbody>
<tr>
<td>In-Class Paper Discussions and class participation</td>
<td>15%</td>
</tr>
<tr>
<td>Homework Assignments (2) with presentations</td>
<td>25%</td>
</tr>
<tr>
<td>Exam 1</td>
<td>15%</td>
</tr>
<tr>
<td>Exam 2</td>
<td>20%</td>
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<tr>
<td>Research Paper and Presentation on Wed. 5/8</td>
<td>25%</td>
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Course Policies

Participation and Attendance
You are expected to complete all assigned readings, attend all class sessions and engage during classroom discussions. If you need to miss a class for any reason, please discuss the absence with me in advance.

Citation & Submission
All written assignments must cite sources and be submitted to the course website (not via email).

School Policies

Copyright Policy
Please note—Due to copyright restrictions, online access to this material is limited to instructors and students currently registered for this course. Please be advised that by clicking the link to the electronic materials in this course, you have read and accept the following:

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted materials. Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specified conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research." If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use," that user may be liable for copyright infringement.

Academic Integrity
Columbia University expects its students to act with honesty and propriety at all times and to respect the rights of others. It is fundamental University policy that academic dishonesty in any guise or personal conduct of any sort that disrupts the life of the University or denigrates or endangers members of the University community is unacceptable and will be dealt with severely. It is essential to the academic integrity and vitality of this community that individuals do their own work and properly acknowledge the circumstances, ideas, sources, and assistance upon which that work is based. Academic honesty in class assignments and exams is expected of all students at all times.

SPS holds each member of its community responsible for understanding and abiding by the SPS Academic Integrity and Community Standards posted at http://sps.columbia.edu/student-life-and-alumni-relations/academic-integrity-and-community-standards. You are required to read these standards within the first few days of class. Ignorance of the School's policy concerning academic dishonesty shall not be a defense in any disciplinary proceedings.

Accessibility
Columbia is committed to providing equal access to qualified students with documented disabilities. A student’s disability status and reasonable accommodations are individually determined based upon disability documentation and related information gathered through the intake process. For more information regarding this service, please visit the University's Health Services website: http://health.columbia.edu/services/ods/support.
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## Course Tentative Class Schedule/Topics (Spring 2024)

Note: This schedule will likely be modified and updated versions posted on Courseworks as the semester progresses.

| Date      | Topics and Activities                                                                                                                                                                                                 | Readings (for each class)                                                                                                                                                                                                 | Assignments (due on this date) |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| 1/17 2024 | **Marine and Estuary environments**  
- Introduction  
- Class outline  
- Grading-Assessment  
- Overview: Ocean circulation  
  Ocean hydrography  
- Ocean Eddies: Nutrients, organic carbon, primary productivity and the carbon cycle  
  HW #1: Working with gridded or site-specific instrumental data to understand oceanic and estuarine processes (in class demonstration). | n.a.                                                                                     |
| 1/24 2024 | **Continued: Nutrients, organic carbon, primary productivity and the carbon cycle,**  
  Oschlies, A., (2002),  
  Gruber at al., (2011)  
  Dufois et al., (2016)  
  HW#1 due, Prepare 5 min. presentation to class  
  Read and be prepared to discuss papers.                                                                                                                                   |                                                                                   |
| 1/31 2024 | **HW #1 Student Presentations (1/2 class)**  
- Upper ocean heat content and atmospheric temperatures: PDO (Pacific Decadal Oscillation)  
- Global Warming hiatus and the PDO.  
- ENSO vs the PDO                                                                                                                                                    | Newman et al., 2016 (just pp 4399-4402 sec 1 &2 and pp 4408-4409 and Figure 6),  
  Trenberth and Fascullo 2013,  
  England et al., 2014,  
  Linsley et al., 2015.  
  HW#1 due, Prepare 5 min. presentation to class  
  Read and be prepared to discuss papers.                                                                                                                                   |                                                                                   |
| 2/7 2024  | **HW #1 Student Presentations (2nd half of class)**  
- Finish PDO and ocean heat uptake, review of Linsley et al., 2015  
- Intro: Carbon Dioxide and Ocean Acidification,                                                                                                              | Chester and Jickells, Chapter 8, pp 154-162; Ch. 9; pp 195-207.  
  Linsley et al., 2015  
  HW#1 due, Prepare 5 min. presentation to class                                                                                                               |                                                                                   |
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<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Notes</th>
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| 2/14 | Ocean Acidification (OA)-plankton  
Possible OA effects on coral growth  
$^{13}$C Suess Effect; effects on plankton, corals and oysters | Feely et al., 2009  
P pH effects on organisms  
Ries et al., 2009  
Iglesias-Rodriguez et al, 2008  
D’Amario et al., 2020  
Linsley et al., 2019 (effects on corals) | Read and be prepared to discuss papers. |
| 2/14 Con. |  |  |  |
Eriksen et al., 2014: overview, circulation effects  
Pinto da Costa et al., 2016: nannoplastics  
Forrest et al., 2019: White paper (unreviewed) on developing a circular plastics economy. | Read and be prepared to discuss papers. |
| 2/28 | Relative sea level, glacial isostatic adjustment, tide gage records of sea level on US east coast, marsh paleo-record of RSL in New York  
**Exam 1 assigned, 2 sections**  
**Courseworks**  
**Take-home** | Some background in-class Powerpoint slides.  
Global Ice Volume and Milankovitch orbital cycles.  
Oxygen isotopes ($^{18}$O) as an ice volume and sea level indicator  
Tamisiea and Mitrovica 2011  
Kopp et al., 2013  
Piecuch et al., 2018 | Read and be prepared to discuss papers. |
| 3/6 | Salt Marsh records of sea level  
Estuary circulation and sedimentation processes, Hudson River estuary and New York Harbor: estuary and sediment dynamics | Ezer and Atkinson 2014  
Engelhart and Horton 2012  
Kemp et al., 2017  
Engelhart et al., 2011  
Chapter 3 in Wolanski and Elliot, *Estuarine Ecohydrology* 2015 (48 pages). | Exam #1 given via Courseworks with additional take-home component |
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<tr>
<th>Date</th>
<th>Schedule</th>
<th>Assignments</th>
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<tr>
<td>3/11-3/15</td>
<td><em><strong>Columbia Break</strong></em></td>
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<td>3/20</td>
<td>Possible instructor absence ??</td>
<td>To be determined (t.b.d.)</td>
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<td></td>
<td>Work on research for final papers/presentations</td>
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<td>3/27</td>
<td>Sedimentology, Sediment texture and bedforms</td>
<td>Boggs Chapters on Sediment transport and Sediment texture</td>
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<td></td>
<td>Hudson River Estuary</td>
<td>Nitsche et al., 2010</td>
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<td>Woodruff et al., 2001</td>
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<td></td>
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<td>Coch et al., 2016</td>
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<td>Assign HW #2</td>
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<td>4/3</td>
<td>Barrier Islands</td>
<td>Locker et al., 2017; USGS Open-file report 2017-1024</td>
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<td></td>
<td>Geology/sedimentology</td>
<td>Schwab et al., 2013(18 pages).</td>
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<td>Sediment budgets; Fire Island</td>
<td>Book chapters on barrier island geology</td>
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<td>Fire Island 2012 Wilderness breach</td>
<td>Prothero and Schwab (Sedimentary Geology)</td>
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<td>S. Boggs (Principles of Sedimentology and Stratigraphy)</td>
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<td>Read and be prepared to discuss papers</td>
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<tr>
<td>4/10</td>
<td>Marsh accretion rates and health in New England and Long Island</td>
<td>Chapter 3 in Wolanski and Elliot, <em>Estuarine Ecohydrology</em> 2015 (48 pages).*</td>
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<td>Beach nourishment, scraping etc.</td>
<td>Great South Bay: Glober C.J. et al., (2019)</td>
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<td>Fire Island geomorphology and beach scraping effects</td>
<td>Engelhart et al., 2009</td>
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<td>Kratzmann and Hapke, 2011</td>
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<td>Lenz and Hapke, 2012</td>
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<td>Read and be prepared to discuss papers</td>
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<td>4/13 Sat.</td>
<td><strong>Possible Class visit to Lamont - Doherty, via LDEO shuttle bus</strong></td>
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<td>Departs 9AM 120 St, returns at 5PM to 120th St.</td>
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<td>4/17</td>
<td>HW#2 due; ½ class</td>
<td>HW2 class presentations (5-10 minutes each)</td>
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<td>Barrier Islands, marshes continued</td>
<td>Beach Management, Part 1</td>
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<tr>
<td>4/24 Last class</td>
<td><strong>HW#2 due; 2nd ½ class</strong></td>
<td>Beach Management, Part 2</td>
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<td>HW#2 due, Prepare 5-10 min. presentation to class</td>
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<tr>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
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<tr>
<td>4/24 cont.,</td>
<td>Marsh Fertilization Hypoxia in estuaries, Long Island Sound Review for Exam 2 Exam 2 assigned, 2 sections Courseworks Take-home</td>
<td>Davis et al., 2017 Hypoxia world-wide and in Long Island Sound</td>
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<tr>
<td>Wed. May 8th</td>
<td>Student presentations on research paper topics (10 minutes each with 5 minutes for questions)</td>
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