COLUMBIA UNIVERSITY
School of Professional Studies

Master of Science Program in Sustainability Science

SYLLABUS Version 1/17/24

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 CO_2 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.

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
ISBN: 978-1-118-34907-6, 420 pages, October 2012, Wiley-Blackwell
***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**

2. Coasts and Estuaries, The Future; Edited by Eric Wolanski, John W. Day, Michael Elliott, Ramesh Ramachandran, ISBN: 978-0-12-814003-1 (Chapters 9, 10, 17, 25, 26, 28, 32, 34).

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:

England, M. H., S. McGregor, P. Spence, G. A. Meehl, A. Timmermann, W. Ci, A. S. Gupta, M. J. McPhaden, A. Purich, and A. Santoso (2014), Recent intensification of wind-driven circulation in the Pacific and the ongoing warming hiatus, Nat. Clim. Change, doi:10.1038/NClimate2106.

Trenberth, K. E., and J. T. Fasullo (2013), An apparent hiatus in global warming?, Earth's Future, 1, doi:10.1002/2013EF000165.

Oschlies, A., (2002), Can eddies make ocean deserts bloom? Global Biogeochemical Cycles, vol. 16, NO. 4, 1106, doi:10.1029/2001GB001830, 2002.

Gruber, N., et al., (2011), Eddy-induced reduction of biological production in eastern boundary upwelling systems, Nature Geoscience, 4, 787-792 DOI: 10.1038/Ngeo1273

Linsley, B. K., H. C. Wu, E. P. Dassié, and D. P. Schrag (2015), Decadal changes in South Pacific sea surface temperatures and the relationship to the Pacific decadal oscillation and upper ocean heat content, Geophys. Res. Lett., 42, doi:10.1002/2015GL063045, 2015.

Ocean Acidification and ^{13}C 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.

Linsley, B. K., R. B. Dunbar, E. P. Dassié, N. Tangri, H. C. Wu, L. D. Brenner, G. M. Wellington, Coral Carbon Isotope Sensitivity to Growth Rate and Water Depth with Palaeo-Sea Level Implications (2019), Published on-line May 3, 2019, Nature Communications, (2019) 10:2056| , shortened URL: https://rdcu.be/bz11c

Estuaries and Barrier Islands:

Glober C.J. et al., (2019) Accidental ecosystem restoration? Assessing the estuary-wide impacts of a new ocean inlet created by Hurricane Sandy, Estuarine, Coastal fand Shelf Science 221, 132–146.

Kemp, A. C., et al., (2017), Relative sea-level trends in New York City during the past 1500 years, The Holocene, vol. 27(8) 1169–1186, DOI: 10.1177/095968361668326.

Nitsche, F.O, T.C. Kenna, M. Haberman (2010), Quantifying 20th century deposition in complex estuarine environment: An example from the Hudson River, Estuarine, Coastal and Shelf Science 89, 163-174.

Schwab, W.C.; Baldwin, W.E.; Hapke, C.J.; Lentz, E.E.; Gayes, P.T.; Denny, J.F.; List, J.H., and Warner, J.C., 2013. Geologic evidence for onshore sediment transport from the inner continental shelf: Fire Island, New York. Journal of Coastal Research, 29(3), 526–544, ISSN 0749-0208.

Woodruff , J.D., W. R. Geyer, C.K. Sommerfield, N.W. Driscoll (2001), Seasonal variation of sediment deposition in the Hudson River Estuary, Marine Geology, 179, 105-119.

Marshes:

Kemp et al., 2017: Relative sea-level trends in New York City during the past 1500 years, The Holocene 2017, Vol. 27(8) 1169–1186, DOI: 10.1177/0959683616683263.

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

Smith et al., 2018, Living shorelines enhanced the resilience of saltmarshes to Hurricane Matthew (2016), Ecological Applications, 28(4), pp. 871–877, Data available from the Dryad Digital Repository: https://doi.org/10.5061/dryad.nh71t5c.

Bilkovic et al., 2016, The Role of Living Shorelines as Estuarine Habitat Conservation Strategies, Coastal Management, VOL. 44, NO. 3, 161–174, http://dx.doi.org/10.1080/08920753.2016.1160201.

Strafford, S., 2020, Encouraging Living Shorelines over Shoreline Armoring: Insights from Property Owners Choices in the Chesapeake Bay, Coastal Management, VOL. 48, NO. 6, 559–576 https://doi.org/10.1080/08920753.2020.1823667.

Oyster Reefs:

Harding, J. M., H. J. Spero, R. Mann. G. S. Herbert, J. L. Sliko (2010), Reconstructing early 17th century estuarine drought conditions from Jamestown oysters, Proc. Natl. Acad. Sci. *U.S.A*. 10.1073/pnas.1001052107.

Huyghe, D., et al. (2020), Oxygen isotope disequilibrium in the juvenile portion of oyster shells biases seawater temperature reconstructions, Estuarine, Coastal and Shelf Science, 240 (2020) 106777, https://doi.org/10.1016/j.ecss.2020.106777.

Kirby, M. X. (2004), Fishing down the coast: Historical expansion and collapse of oyster fisheries along continental margins. *Proc. Natl. Acad. Sci. U.S.A*. 101, 13096–13099.

National Marine Fisheries Service (NMFS), *Fisheries of the United States, 2017. U.S.* Department of Commerce, NOAA Current Fishery Statistics No. 2017. (2018).

Rodriguez, A.B., Fodrie, F. J. , Ridge, J. T., Lindquist, N. L., Theuerkauf, E. J., Coleman, S.E. Grabowski, J. H., Brodeur, M. C., Gittman, R. K., Keller, D. A., and Kenworthy, M. D. (2014). "Oyster reefs can outpace sea-level rise," *Nature Climate Change*; DOI:10.1038/nclimate2216, https://www.nature.com/articles/nclimate2216

Ridge, J. T., Rodriguez, A. B., Fodrie, F.J., Lindquist, N. L., Brodeur, M. C., Coleman, S. E., Theuerkauf, E. J. (2015). "Maximizing oyster-reef growth supports green infrastructure with accelerating sea-level rise," *Scientific Reports*, 5, 14785, doi: 10.1038/srep14785, https://www.nature.com/articles/srep14785

Ridge, J. T., Rodriguez, A. B., Fodrie, F. J. (2017). "Evidence of exceptional oyster-reef resilience to fluctuations in sea level," Ecology and Evolution, 10,410-10,419, DOI: 10.1002/ece3.3473, doi:10.1002/ece3.3473, https://onlinelibrary.wiley.com/doi/10.1002/ece3.3473

4. Secondary Textbook: *Estuarine Ecohydrology, 2nd Edition*. Authors: Eric Wolanski Michael Elliott, eBook ISBN: 9780444634146, Hardcover ISBN: 9780444633989, Elsevier Science, Published Date: 19th August 2015, Page Count: 322. *Selected chapters from this book will be utilized to supplement student readings and classroom lectures.*

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 text book 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 text book 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 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

Grade	Percentage
A+	98–100 %
A	93–97.9 %
A-	90–92.9 %
B+	87–89.9 %
B	83–86.9 %
B-	80–82.9 %
C+	77–79.9 %
C	73–76.9 %
C-	70–72.9 %
D	60–69.9 %
F	59.9% and below

ASSIGNMENT	% Weight
In-Class Paper Discussions and class participation	15%
Homework Assignments (2) with presentations	25%
Exam 1	15%
Exam 2	20%
Research Paper and Presentation on Wed. 5/8	25%

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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 Assign/Discuss Homework #1	Chester, Roy, and Tim Jickells. *Marine Geochemistry*, 3rd Edition. Wiley-Blackwell, 2012. Chapters 1 pp 1-6; and Ch 7, pp 127-153. Start Chapter 9, pp 163-195. HW #1: Working with gridded or site-specific instrumental data to understand oceanic and estuarine processes (in class demonstration).	n.a.
1/24	Continued: Nutrients, organic carbon, primary productivity and the carbon cycle, Radiocarbon (^{14}C) Introduction	Chester, Roy, and Tim Jickells. *Marine Geochemistry*, 3rd Edition. Wiley-Blackwell, 2012. Chapter 9, pp 163-195, continued Oschlies, A., (2002), Gruber at al., (2011) Dufois et al., (2016)	Read and be prepared to discuss papers.
1/31	**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	**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**

2/14 2/14 Con.	Ocean Acidification (OA)-plankton Possible OA effects on coral growth ^{13}C Suess Effect; effects on plankton, corals and oysters	Feely et al., 2009 pH effects on organisms Ries et al., 2009 Iglesias-Rodriquez et al, 2008 D'Amario et al., 2020 Linsley et al., 2019 (effects on corals)	Read and be prepared to discuss papers.
2/21	Micro and nano-plastics in the open ocean	Barboza et al., 2019: Chapter 18 on microplastics from 2019 book "World Seas: an Environmental Evaluation" (book available as zipfile download through CU library). 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 ($\delta^{18}O$) 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 Ecohydrolo* 2015 (48 pages).	Exam #1given via Courseworks with additional take-hor component

3/11- 3/15	****Columbia Break****		
3/20	*Possible instructor absence ??*	To be determined (t.b.d.) Work on research for final papers/presentations	
3/27	Sedimentology, Sediment texture and bedforms Hudson River Estuary Assign HW #2	Boggs Chapters on Sediment transport and Sediment texture Nitsche et al., 2010 Woodruff et al., 2001 Coch et al., 2016	Read and be prepared to discuss papers
4/3	Barrier Islands Geology/sedimentology Sediment budgets; Fire Island Fire Island 2012 Wilderness breach	Locker et al., 2017; USGS Open-file report 2017-1024 Schwab et al., 2013(18 pages). Book chapters on barrier island geology Prothero and Schwab (Sedimentary Geology) S. Boggs (Principles of Sedimentology and Stratigraphy)	Read and be prepared to discuss papers
4/10	Marsh accretion rates and health in New England and Long Island Beach nourishment, scraping etc. Fire Island geomorphology and beach scraping effects	Chapter 3 in Wolanski and Elliot, *Estuarine Ecohydrolo* 2015 (48 pages). Great South Bay: Glober C.J. et al., (2019) Engelhart et al., 2009 Kratzmann and Hapke, 2011 Lenz and Hapke, 2012	Read and be prepared to discuss papers
4/13 Sat.	***Possible Class visit to Lamont - Doherty, via LDEO shuttle bus Departs 9AM 120 St, returns at 5PM to 120th St.*		
4/17	**HW#2 due; ½ class** Barrier Islands, marshes continued	HW2 class presentations (5-10 minutes each) Beach Management, Part 1	**HW#2 due, Prepare 5-10 min. presentation to class**
4/24 Last class	**HW#2 due; 2nd ½ class** Beach management continued, Oysters and Oysters Reefs	Beach Management, Part 2 Rodriguez, A.B., et al. (2014), Ridge, J. T. et al. (2015; 2017)	**HW#2 due, Prepare 5-10 min. presentation to class**

4/24 cont.,	Marsh Fertilization Hypoxia in estuaries, Long Island Sound Review for Exam 2 **Exam 2 assigned, 2 sections Courseworks Take-home**	Davis et al., 2017 Hypoxia world-wide and in Long Island Sound	
Wed. May 8th 7:10-10PM Exam time slot	Student presentations on research paper topics (10 minutes each with 5 minutes for questions)		