INDEPENDENT PROJECT TIMETABLE AND GENERAL INFORMATION – 2025

The independent project is often ranked by students as the most rewarding and enjoyable part of the SES experience. Early on in the semester, you will have a chance to start thinking about project topics and learning about the research carried out by the faculty. Based on your research interests, we begin to match you up with a faculty mentor. Some students also end up working together in a team in which each student pursues a stand alone part of a larger project; this should be a true collaboration, in which one person's work compliments, but does not duplicate the work done by others.

Once you have established a project concept and are matched to a mentor, you will be expected to develop a formal research proposal for the project and report on your work at the end of the project time through an oral presentation of results during a **final symposium** held **Friday December 12, 2025** and in written form as a **scientific paper** following the format of a peer reviewed journal, due on **Monday December 15, 2025.** The projects are graded as follows:

Concept paper of project proposal (5%)
Oral proposal presentation (10%)
Final Written Proposal (20%)
Oral Project Presentation (25%)
Written Paper (40%)

Though we have allocated 5 weeks for project work, this time goes *very* fast. We try to get you started before thinking about project ideas early on as well as learning how to do a literature search and principles of research design, proposal writing, oral presentations, data analysis, and writing your research papers. It will take you close to a week to really get going on your project (assemble the equipment and supplies you need, etc.), leaving about 2-2.5 weeks for data collection, and 1-1.5 weeks for analysis and writing. Thanksgiving break comes in the middle of the project period, and your project must be well underway by the time you leave for your well-deserved turkey, rest and relaxation. The weekly activities and most important deadlines and dates during the project period are given below:

Week 1– Library orientation (information on literature searches)
Week 2 – *Seminar:* Faculty research flash talks
Week 3 – *Seminar:* Research project concepts
Week 5 – *Seminar:* Research design
Week 6 – Free time to meet with faculty, Project Concepts due
Week 7 –*Seminar:* Writing a Proposal
Week 8 – Proposal prep time, Project Lab Procedures, Written proposal draft due
Week 9 – Proposal/project time, Proposal oral presentation
Week 10 – Free project time, *Seminar:* Data Visualization and Statistics, Final written proposal due
Week 11 – Free project time
Week 12 – Free project time, *Seminar:* Writing a Scientific paper and Scientific Paper Guidelines
Week 13 – Free project time
Week 14 – Free project time
Week 15 – Draft project paper due, Oral presentation rehearsals, Oral presentations-student research symposium
Week 16: Final written paper and data files due

Important dates:
10 October – Project concepts due

24 October –Draft project proposal due
31 October– Project proposal oral presentations
7 November – Final written proposal due
11/27-11/30 – Thanksgiving break (*tempting as it is to take a longer break, we encourage you to confine your break to these dates*
8 December – Draft written paper due (Introduction, methods, results/discussion)
11 December – Presentation rehearsals (Target for return of draft written paper with comments)
12 December – SES Student Symposium-Oral presentations
15 December – Final written paper & data due (**electronic files, Word & Excel, etc**).

SOME STUDENT PROJECT TOPICS & POSSIBLE MENTORS

You don't need to confine your work to the ecosystems we have visited, but hopefully the core labs and electives have given you a feeling for the types of ecosystems science we can do and perhaps helped to generate some questions or ideas for further work. We would like your projects to be focused on **ecosystem level questions** and to involve collection of **new data**, not simply literature review or modeling, though modeling can be part of a project.

A number of different possible mentors have expressed an interest in working with you on a variety of projects. The list and descriptions below are intended as a **starting point** to help guide you toward possible projects that will be most interesting to you. If one of these projects strikes your fancy, contact Program Director, Mirta Teichberg and she will assist you in setting up a meeting with potential mentors to discuss your ideas.

During your discussions you may discover that the topic is not what you were interested in after all. You may find that you can develop a new and different idea that is feasible given the expertise, methods and equipment available that you would rather pursue. Or you may decide to take the ball and run with it, refining the concept and design and building a full-fledged project proposal from these ideas.

Bear in mind, *we encourage you to work in groups of at least two students*, with each student conducting a stand-alone piece of the project and sharing a mentor. This might mean, for example, that one student works on the chemistry soils or sediments from a particular site or experiment, and another student works on the microbial or animal community at the same sites.

ZOE CARDON - Plant Physiological Ecology / Plant-Soil-Microbe Interactions
Interactions among plants and microbes are our lab's focus, whether in coastal brackish marsh vegetated by cattails (*Typha angustifolia*), coastal salt marshes vegetated by cordgrass (*Spartina alterniflora*), or local American beech (*Fagus grandifolia*) forests. We would enjoy working with students to develop projects within the context of our ongoing research, ranging from exploring interactions between axenic (no-microbe) plants and different microbial strains, to imaging oxygen being released by marsh plant roots to the rhizosphere under diverse environmental conditions or stressors, to sampling methane gas in sediment porewater and/or assessing the ability of plant stems to carry methane from sediment to the atmosphere, to sampling beech leaf nitrogen content as a function of seasonality and senescence, particularly in the context of ongoing beech leaf disease on the Cape.

KEN FOREMAN – Nutrients Pollution in the Coastal Zone. Contamination of coastal systems with wastewater and fertilizer derived nitrogen is a world-wide environmental problem and many of Cape Cod's estuaries have impaired water quality due to excess nutrient inputs. Ken is interested in learning about how ecosystems *respond* to and *recover* from excess inputs of N and P.

Assessment of Wastewater Remediation on ecology of Little Pond - The Town of Falmouth has spent $40 million to build a sewer system that diverts and treats wastewater from the watershed of Little Pond, a highly eutrophic coastal salt pond along the shores of Vineyard Sound. This large-scale ecosystem manipulation provides a great opportunity for studying how ecosystems recover from eutrophication. A group working on this site could:

- Compare inputs of nutrients to outputs of nutrients through the channel for the whole pond.
- Collect and sample groundwater for nutrients including organic N.
- Reconstruct the history of nutrient loading from deep sediment cores in the pond.
- Measure sediment infauna composition and respiration in the benthos of Little Pond.
- Measure total system metabolism, nutrient levels, etc. in surface water of Little Pond.

Biogeochemistry and effectiveness of wood-chip based permeable reactive barrier in remediating nitrate pollution in wastewater or ground water – In many coastal settings nitrogen is delivered to the shore as nitrate carried in groundwater. Currently, the most common solution to nitrate pollution is construction of centralized wastewater treatment facilities, which could cost more than $4 billion Cape wide. We have developed and tested a novel approach using wood chip bio-reactors to increase denitrification in groundwater. Possible projects related to this work could be:

- Feasibility of a woodchip based reactor to treat contaminated waters at the Wareham Pollution Control Facility.
- Studies of the stoichiometry and biogeochemistry of groundwater within the barrier and vs. control sites (e.g. measuring patterns of Fe, Mn, SO4, S2-, ammonium, nitrate, N2O and N2).
- Evaluation of the rates of wood decay and lifetime of the barrier measured in wood collected from the barrier system and incubated in microcosms.
- Evaluate the effectiveness of woodchip or carbon treatments by measuring algal or plankton growth in treated and untreated waters (bioassay).

KRISTIN GRIBBLE – Phytoplankton and zooplankton ecology, stress resistance, and life history

Many planktonic organisms have complex life cycles, including transitions between sexual and asexual reproduction, vegetative and dormant stages, and pelagic and benthic forms. Changing environmental conditions and stressors such as nutrient or chemical contamination, the presence of predators, or changing temperatures can shift these life stage transitions and thereby alter population and community dynamics in coastal waters. Kristin has studied the ecology and evolution of harmful algal bloom species, and her lab currently uses rotifers as a model to understand how the genome and environment interact to determine fitness. Potential student projects include studies of:

· Algal bloom ecology and life history strategy responses to anthropogenic contamination

· Impacts of combined environmental stressors--including temperature, eutrophication, pH, and chemical contaminants--on lifespan, health, reproduction, and gene expression in zooplankton.

KETIL KOOP-JAKOBSEN

Discover Exciting Research Projects in the Koop-Jakobsen's Lab!

Get ready to explore the hidden dynamics of aquatic ecosystems with hands-on research that's both exciting and impactful. Choose from these intriguing projects and dive into the science of how chemical gradients in soils and sediments shape our environment.

Project 1: "Belowground Oxygen Dynamics Controlled by Infauna" Did you know that just a few millimeters below the sediment surface, oxygen levels can plummet, creating an anoxic environment? This project explores how the activity of infauna—organisms living within the sediments—can significantly change oxygen levels, impacting nutrient cycles and organic matter turnover. You'll use cutting-edge planar optode imaging and microelectrode profiling to visualize these subtle oxygen variations around infauna burrows. Focus your research on chironomids in beaver pond sediment, affecting methane emissions, or fiddler crabs in salt marshes, influencing nutrient turnover.

Project 2: "Plants Taking Up CO2 via Roots?" Some amazing submerged freshwater plants, called Isoetids, have evolved to absorb CO2 through their roots rather than through their leaves. This project lets you explore this rare plant trait using advanced planar optode technology to visualize CO2 concentrations around the roots. Your research will focus on specialized plants from the Cape Cod Kettle ponds, a natural habitat for these fascinating species.

Project 3: "Daily Dynamics of Oxygen and H2S in Marsh Ponds and Their Control of Nutrient Fluxes" Tidal ponds experience extreme fluctuations in oxygen and sulfide levels throughout the day—supersaturated with oxygen by day and nearly anoxic by night. This project dives into the intriguing daily dynamics of these compounds and how they control the exchange of nutrients like NH4, NO3, and PO4 between sediment and water. This research is key to understanding nutrient cycling and carbon sequestration in the salt marshes of the Plum Island Estuary.

Project 4: "Storm-Driven Sand Deposition and Its Impact on Marsh Erodibility" Salt marshes, situated next to the ocean, face constant challenges from storms and hurricanes, which erode marsh edges and deposit sediment on top. Over time, these sand deposits can create layers buried deep in the marsh, potentially creating weak spots due to lower root and rhizome biomass. This project will investigate how these sand layers affect belowground biomass production and increase the erodibility of salt marshes, making them more vulnerable to future erosion.

RUT PEDROSA PAMIES - Ecosystems health and emerging environmental pollutants in Cape Cod.

Chemical tracers:

- Trace ecosystem energy and carbon cycling, as well as the impact of anthropogenic factors, by analyzing lipid molecular (lipid biomarkers) and isotopic (d13C and d 15N) composition in coastal marsh suspended particles and surface sediments.
- Use of lipid biomarkers to evaluate marine ecosystem health, dynamics, and stress factors of fauna and flora.

Plastic pollution:

- Quantification and characterization of microplastic pollution in Cape Cod beaches and marshes. The presence of microplastics in marine environments is rapidly becoming of global concern, affecting both humans and other organisms.
- Characterization of biofilm formation on different plastic types.
- Plastic degradation evaluation under different environmental conditions.

Pharmaceuticals and personal care products (PPCPs) pollution:

- Investigation of the impact of PPCPs like triclosan, ibuprofen, estradiol, clofibric acid, etc. in different Cape Cod fauna and flora.
- Evaluation of PPCPs sorption in plastics.
- Studies the PPCPs affect bioaccumulation in the estuarine/ coastal organisms.

LORETTA ROBERSON - Ecophysiology and coral biology.

Loretta is interested in how organisms respond to changes in temperature, light, oxygen concentration, and contaminants. Sensitive species like corals can become stressed if water temperatures change by only a few degrees, leading to bleaching or death, and can leave a record of the stress event in their calcium carbonate skeletons. However, despite being well studied, the underlying mechanisms of many aspects of coral biology and physiology are unknown (e.g., calcification, bleaching, larval settlement). Similarly, seaweeds play an important role in ecosystems, but we do not know how they will respond to increasing temperatures and changing ocean chemistry. Some possible projects related to corals and seaweed include:

- The effects of temperature and/or hypoxia on coral growth and symbioses, or seaweed productivity
- Impact of symbionts and bioeroders on calcification in corals
- Impact of seaweeds on coral growth and survivorship
- Cultivation of seaweeds for water quality improvement
- Conservation and restoration methods to improve corals and seaweeds

EMIL RUFF – Microbial ecology and physiology

Emil works on the ecology and ecophysiology of microorganisms, their metabolisms and metabolites, and interactions with the environment. His research combines field experiments, lab cultivations, biogeochemical measurements, microscopy, multi-omics analyses and bioinformatics. He has three topics/projects that SES students can be involved in:

1. Microbial necromass can make up a significant proportion of soil organic carbon, thereby sustaining organic carbon sequestration and supporting ecosystem resilience. However, important aspects of its decomposition remain unresolved. Emil's team investigates the pathways and dynamics underlying necromass breakdown. A SES student could be involved in laboratory soil enrichment experiments to examine the transformation of necromass macromolecules. Methods may include molecular biology techniques (e.g., DNA extraction and qPCR), cell staining and microscopy, headspace gas analysis, and measurements of biogeochemical process rates.
2. Microbial production of oxygen in the absence of light. In a recent publication, Emil and colleagues showed that groundwater microbiomes harbor microbes that can produce oxygen independent of photosynthesis through a process called dismutation https://www.nature.com/articles/s41467-023-38523-4 The team now wants to understand how widespread this process is. SES students could be involved in the laboratory to investigate spatial distribution of the microbial community. Methods may include DNA and RNA extraction, PCR, cell stainings and counts, bioinformatic analysis.

MIRTA TEICHBERG – Coastal ecology and physiology of marine plants and macroalgae

- Effects of environmental drivers of seagrass and macroalgal ecosystems, including climate change, top-down (nutrient) and bottom-up (grazing) processes
- Effectiveness of seagrass restoration methods (e.g. field and lab experiments growing seagrass plants and seedlings under varying environmental conditions)
- Seagrass seedling development, propagation, and tissue culture under varying plant regulating hormones
- Trait-based approaches to understanding seagrass and macroalgal responses to their environment and links to ecosystem function
- Seagrasses and shellfish (oyster, clam, scallop) or crab interactions-Harmful or beneficial relationships?

JOE VALLINO – Microbial biogeochemistry and structure of microbial communities

Joe's research involves understanding how microbial communities organize and function, as well as identifying fundamental rules that may govern them. His focus is on microbial biogeochemistry, but use of molecular approaches is sometimes possible with the help of collaborates at MBL or WHOI. He also makes extensive use of microcosms (chemostats, bioreactors, etc.) to study microbial processes in the lab under controlled conditions and uses Siders Pond as a local field site. Many of the possible projects below focus on Siders Pond, and WHOI installed a vertical profiler in the pond starting in 2023, data from which can be found here: https://www.siderspond.com/

- Importance of grazers (or viruses) in aerobic versus anaerobic zones (Siders Pond)
- Siders Pond chemical budgets: How much does the ocean contribute to Siders Pond biogeochemistry? Is Siders Pond becoming a marine system due to sea level rise?
- How much hydrogen sulfide do anaerobic phototrophs remove from Siders Pond water column?
- Are natural microbial communities inherently unstable (i.e., does their composition continuously change)?
- Response of microbial communities to disturbance (e.g. grazing, disruption of nutrient or energy supply).
- How important is bacterial predation (protists or viruses) in microbial biogeochemistry?
- Tests of the Maximum Entropy Production (MEP) theory in microbial communities in microcosms or mesocosms, or in the field. MEP theory proposes system organize to dissipate energy and drives evolution.
- How adaptive are phytoplankton circadian clocks? How far can they be pushed from 24 hr cycles and still function correctly?
- Allelopathy: Can garlic mustard (Alliaria petiolata) increase C storage in soils by its anti-fungal action.
- Sediment remediation via addition of carbon fibers or applied electric potentials? Cable bacteria?