Strategic Plan for the

Department of Ocean Sciences (OCE)

October 2024

Near-term Vision Statement: Because of modern society's dependence on fossil fuels, the ocean and its processes are rapidly and dramatically changing, with growing impacts on society. In the immediate future, the Department of Ocean Sciences (OCE) will continue to strengthen its leadership in research, education, and service, to address the urgent challenges that ocean change is placing on society. The priorities given in this document are strongly motivated by the need to better measure and understand ocean change, on scales from global to local, and project its impacts on ocean ecosystems, coastal hazards, and future climate. The department's faculty are doing their part, with a new undergraduate oceanography program, highly competitive grant support from American federal agencies, and exemplary service on the global stage. However, we urgently need renewed, expeditious, and intentional involvement and investment by the University of Miami administration.

Summary of Actions Required: Realizing the OCE vision demands targeted investment in key areas vital to both education and research. New faculty hires are essential to balance these efforts, especially as shrinking faculty numbers within OCE mean that expanding or even maintaining teaching will necessitate a reduction in research activities, and vice versa. Investments in engineering facilities, technical staff, research and teaching labs, and sea-going opportunities for students are crucial. Moreover, enhanced support for graduate students through fellowships and additional teaching assistantships are necessary to advance the department's mission and compete with peer institutions. Finally, maintaining the visibility and reputation of OCE and the Rosenstiel School of Marine, Atmospheric and Earth Science on national and international stages will require active participation in key organizations and programs.

1 DEPARTMENT OF OCEAN SCIENCES - MISSION

The Rosenstiel School has been a national and international leader in ocean sciences for many decades, with a distinguished history of making fundamental advances in our understanding of ocean processes. The Department of Ocean Sciences (OCE) conducts cutting-edge research that advances our understanding of the ocean and its role in the Earth system, with special attention on climate-driven changes and associated impacts. We train the next generations of marine scientists and ocean industry leaders through our robust undergraduate and graduate academic programs. Our mission has three objectives:

1) Advance understanding of physical, chemical, and biological oceanographic processes occurring in the world's oceans, both as independent subjects and within the context of multidisciplinary studies, including research on hurricanes, air-sea interactions, carbon cycle, marine plankton, and coastal resilience;

2) Convey and apply gained understanding of the ocean system through undergraduate and graduate education and outreach activities; and,

3) Provide the basis for informed application of our scientific findings to societal challenges such as climate change, environmental pollution, and natural hazards.

Success in achieving these objectives and capitalizing on important research opportunities requires: (i) recruiting and retaining excellent students, postdoctoral researchers, research staff, and faculty; (ii) providing the facilities necessary for cutting-edge research; and (iii) fostering a culture of belonging, grounded in the principles of diversity, equity, and inclusion.

2 LOOKING INTO THE FUTURE OF OCEAN SCIENCES AT THE SCHOOL

The coming decade will be the most exciting period for OCE since initiation of global ocean surveys using newly capable ships and satellites in the 1990s. The United Nations Ocean Decade is bringing

awareness to the impact of our changing oceans on human populations and driving rapid growth in applied and operational oceanography. The United States will build new icebreakers to ply changing polar seas and new global-class research vessels capable of investigating every corner of the global ocean. The rollout of a global fleet of robotic sensors profiling carbon, pH, nutrients, and oxygen throughout the world ocean (Global Ocean Biogeochemical Array; BGC-Argo) will revolutionize our understanding of oceanic change, while the rapid growth of affordable sensors and mini-sensors will revolutionize open-ocean and coastal oceanography. Advances in remote sensing capabilities, including the recent launch of the new SWOT satellite and upcoming interferometric SAR satellite missions (e.g. HARMONY) with capabilities to measure sea surface heights and surface currents at unprecedented spatial resolution, will open the door to significant progress in our understanding of not only the surface but also the interior ocean dynamics. The newly launched NASA satellite PACE will investigate the changing dynamics of marine plankton, aerosols, clouds, and ocean ecosystems in unprecedented detail. PACE's data will help us better understand how the ocean and atmosphere exchange carbon dioxide and its connection to plankton dynamics, how aerosols fuel phytoplankton growth, and identify the extent and duration of harmful algal blooms. The satellite package will take Earth's metabolic pulse in new ways for decades to come. The Department of Ocean Sciences must position itself to take advantage of these revolutionary capabilities and to prepare our students for associated professional lives.

2.1 *Main scientific thrusts*

Three main research themes in our department are motivated by the Earth's changing climate, its impacts on and controls by the global ocean, and economically important feedback to society (e.g., hazards and resilience):

1. **Ocean processes as part of the climate system:** Influence of ocean dynamics and biochemistry and plankton on the variability in the distribution of anomalous heat and anthropogenic carbon, along with their impact on the carbon cycle, sea surface temperature (SST) and sea ice.
2. **Impacts of climate change and pollution on the oceans:** Variations in sea level, marine heat waves, changes in stratification, mixing and ocean currents, acidification, deoxygenation, increase in toxicity, noise pollution, compressed pelagic habitat, reductions in biodiversity, and shifts of ecosystems.
3. **Impacts of climate change and pollution on coastal zones and hazards:** Sea-level rise, storm surges, coastal erosion, noise and light pollution, increased runoffs, and harmful algal blooms.

2.2 *Evolving research topics in OCE*

OCE faculty have identified several **promising topics coming into Ocean Sciences**, covering the above research themes. Importantly, these topics involve more than one discipline, which allows OCE to capitalize on its interdisciplinary strengths in ocean physics, chemistry, and biology.

- Ocean currents and their contributions to the regional budgets of heat, carbon, nutrients, and other climatically important constituents.
- Multiscale physical ocean processes, including mixing and turbulence, and their impact on stratification, air-sea-exchanges, sea ice, and other climatically important properties.
- Changes in primary productivity and population at lower trophic levels, and their influence on carbon, nutrients, and oxygen budgets and ocean connectivity.
- Changes in biochemical budgets and the carbon cycle, and their influence on atmospheric carbon concentrations and oceanic biomass.

- Improvements of ocean sensing and forecasting capabilities and accuracy for coastal hazards, marine heat waves, and oceanic pollution (such as plastic, oil spills, and noise and light pollution), which have been major factors in reducing damages and the costs of response
- Technical innovations in mitigation and management of coastal hazards: sea level rise, storm surges, marine heat waves, and coastal erosion.

These evolving opportunities require:

- multiple new hires in most critical areas (Section 2.5), especially in light of past and anticipated future retirements;
- improved support of graduate students through additional teaching assistantships (Section 2.4)
- investments in engineering and computing facilities (Section 2.3) and support of the infrastructure on the Virginia Key campus;
- continuing support of the R/V *F.G. Walton Smith* (Section 3.6) and more efforts to advertise the ship's capabilities and benefits of the Rosenstiel School based mobilization to potential University-National Oceanographic Laboratory System (UNOLS) users;
- commitment to representing the OCE department and Rosenstiel School at national and international levels, including active membership in organizations that advocate for the importance of Ocean Sciences.

2.3 *Emerging technologies, methods, and tools*

The ability to explore these topics critically depends on the **development and application of new technologies, methods, and tools**. Our planned renewal of faculty, and evolution of our academic programs, facilities, and courses, will be guided by our expectation to remain at the forefront of research and academic training that addresses these questions and builds these new methods and tools.

Emerging opportunities:

- Development of instrumentation and technologies for sea-going and aircraft programs, as well as underwater acoustic monitoring systems.
- Development and use of innovative remote-sensing technology in support of climate science and solutions, including the new advanced altimeters and upcoming Doppler scatterometers and along-track InSARs, marine Doppler radars, large number SAR satellite constellations, and advanced altimeters.
- Improvements in fidelity of ocean models, including operational models.
- Data analytics pipelines for large data in climate; large data in bioinformatics (for biological oceanography), use of machine learning and artificial intelligence in analysis of complex systems.
- "Blue technology" in support of sustainable climate solutions, such as emerging "marine carbon dioxide removal" technologies.
- Involvement in global survey programs such as GO-SHIP, BioGeoSCAPES, BGC-Argo, and PACE.

These emerging opportunities require :

- investments in engineering facilities (space and equipment);
- continuous support of engineering personnel (technicians); and
- investments in computing facilities at UM (tech support and funding for start-up projects)

2.4 *Innovation in education in OCE*

The oceans are undergoing unprecedented changes due to human-environmental pressures and global warming. Many of these changes involve complex interactions and feedbacks between physical, chemical, and biological processes. The goal of OCE's multidisciplinary educational programs is for our students to understand the ocean as an integrated system. Going forward, our students will continue to engage in a dynamic learning experience that involves both learning from research activities and advancing scientific knowledge through independent, state-of-the-art research endeavors. They will leverage top-tier research facilities and receive guidance and inspiration from leading experts in ocean science sub-disciplines and interdisciplinary studies within OCE. Moreover, they will actively contribute to the dissemination of acquired knowledge by showcasing their research at national and international conferences and publishing their findings in top-tier scientific journals.

These initiatives require:

- additional faculty hires who will support innovation in education and experiential learning;
- investment and development in Rosenstiel School teaching labs and research facilities;
- enhanced sea-going, lab-based, and other field/research opportunities for students, including the use of R/V *F.G. Walton Smith*;
- support for additional Teaching Assistant positions particularly needed for research-based courses.

2.4.1 Undergraduate experiential learning on the Rosenstiel campus

OCE strives to provide education inspired by research and facilitated by the subtropical location, ocean access, and modern facilities at the Rosenstiel campus. Toward this goal, OCE faculty will enhance the educational experience by research-based learning and will offer a group of upper-level undergraduate courses at the Rosenstiel campus on Virginia Key. The working title for this endeavor is "KeyMester". In addition to existing courses, a suite of new oceanographic courses will be developed and taught, including *Ocean Acidification* (approved but not yet offered)*, Coastal Oceanography*, *Science Communication, and Data Analysis and Visualization*. In addition to covering the respective science disciplines, these courses provide students with important high-demand technical skills, including oceanographic data analysis and visualization, Geographical Information System (GIS), laboratory skills and techniques, mathematics, statistics, and scientific communication. We will use samples collected by students from FLOTSUM and other R/V *F.G. Walton Smith* cruises in these courses (Section 3.6). These data and samples will also be used in senior theses, as they have in the past.

2.4.2 Master of Professional Science (MPS)

We plan to expand the OCE component of the MPS academic program by developing three new tracks:

Blue Economy/Carbon Dioxide Removal (Sequestration): Preliminary analysis shows a big market for this concentration given the wide interest at many start-up companies in "Blue Economy". We expect significant job growth in this sector and an increasing need for scientific knowledge, as the problem of environmentally sustainable carbon removal is highly challenging and the technologies are still in early stages of development. The required courses will mostly be already existing ones, but one new course that specifically targets the proposed mechanisms of CO2 removal is required. A new hire in Biogeochemistry, Dr. Mariana Bif, who has expertise in the carbon cycle can be expected to contribute to this activity.

Data Analysis, Mining, and Visualization: These skills are in high demand by many potential employers, including resilience and (re)insurance sectors. The required courses will include existing and new graduate courses taught by OCE and ATM faculty. New faculty member Milan Curcic, who is an expert in machine learning, will be a key contributor to this track. For this initiative, it would be

beneficial if at least one new hire, regardless of their specific scientific discipline, has expertise in the analysis of Big Data.

Oceanic Instrumentation and Lab Technologies: MakerSpace facility is an asset that can be utilized in some of the courses. Courses in instrumentation will be of interest to other PhD/MS, MPS and undergraduate students. Faculty members who are committed to instrument development and usage can be expected to contribute significantly to this track.

2.4.3 PhD programs

We will continue to strengthen our PhD programs by increasing student enrollment and introducing new tracks. The growth of the program is closely tied to the success of OCE faculty research, with sustained strength in key areas and proposed new hires (Section 2.5) driving this progress. Additional University support, including the expansion of TA positions for new experiential learning initiatives (Section 2.4.1), will further contribute to the programs' development. Moreover, new opportunities for collaboration with the College of Engineering, particularly in remote sensing and coastal resilience, should be explored.

2.5 *Critical areas and future hires to the OCE academic faculty*

The success of the existing and new educational initiatives hinges on the availability of excellent instructors who provide research-inspired, up-to-date experience. The contemporary research themes and questions identified above (section 2.1) further guide future hires. With the collective strengths in our current OCE faculty, along with the new hires, the department will continue its leading role in research on such pressing topics as sea-level rise, marine heatwaves, Atlantic Meridional Overturning Circulation, and the changing ocean carbon cycle and ecosystems. It is also highly desired that at least one of the proposed hires employ modern technologies and instrumentation, and another one specializes in innovation in data analysis. Instrument and technology development has been one of the main driving forces behind major advances in multiple fields described above. This field also has high potential for attracting top undergraduate and MPS students to research-inspired learning and will give our graduates a competitive edge in the modern job market.

Motivated by Earth's changing climate as it relates to the ocean, and economically important feedbacks to society (e.g., hazards and resilience), OCE needs near-term faculty renewal and broadening in targeted disciplines. The following list identifies critical areas where we must maintain and enhance our strength to support our teaching and research missions, particularly in light of increasing demand for expertise and anticipated retirements. These hires are directly relevant to the Main Scientific Thrusts (section 2.1)~~:~~:

- *Biogeochemical Oceanography*: Main Scientific Thrust #1, "Importance of oceans in climate change"**.** The new hire will pursue opportunities for the global surveys of climate-relevant elements, teaching of the research-intensive undergraduate courses, and to the training of students in the marine Carbon Dioxide Removal MPS track.
- *Biological and Biophysical Oceanography*: Main Scientific Thrust #2, "Impacts of climate change on the oceans". The new faculty member can be involved in the studies of impacts of ocean acidification and deoxygenation, reduction in biodiversity, plankton dynamics and ecosystem shifts in the ocean, using NASA's new PACE mission and Earth System Models. The new hire will be expected to develop new courses in biological oceanography and passive acoustic monitoring, that will emphasize experiential learning and lead to the growth of the Oceanography program.
- *Coastal Oceanography*: Main Scientific Thrust #3, "Climate hazards for coastal zones and communities". Research directions include sea level rise, coastal hazards, pollution, and coastal resilience. The new faculty member will develop courses in coastal oceanography for students in the Marine Science and Oceanography programs, contribute to the Ocean Engineering program, and strengthen technological development and collaboration with the UM College of Engineering.

- *Ocean Dynamics*: Main Scientific Thrusts #1 and #2. The new faculty member will maintain and expand OCE's reputation in experimental and sea-going Physical Oceanography, with a focus on the role of ocean currents in the distribution of heat and carbon, and the impacts of climate change on these processes. Key priorities include developing courses and OCE programs on instrumentation and technologies, as well as contributing to instrument development, and supporting engineering facilities and personnel.
- *Remote Sensing*: Main Scientific Thrusts #1, #2 and #3. The new faculty member will make vital contributions to our department's interdisciplinary research, as well as to the teaching and development of undergraduate, MPS, and PhD/MS courses. These contributions will bolster our reputation as a key leader in ocean remote sensing on both the national and international stage. A key priority is the field of passive sensing, which was led by Prof. Peter Minnett for over 25 years until his recent retirement. Passive sensors provide SST, surface salinity, chlorophyll concentrations, and other critical data products essential for climate change and carbon cycle studies.

The above areas will evolve in response to changing demands and emerging opportunities. The hiring strategy will prioritize acquiring top talent to maintain the school's high national and international reputation in research and education.

3 CURRENT STRENGTHS

3.1 *Research*

Presently, our nation confronts unparalleled challenges stemming from climate change, environmental degradation, and increasing vulnerabilities to natural hazards. These issues demand intricate solutions developed through collaborative efforts among multidisciplinary teams. The diversity of expertise within our faculty stands as a distinctive asset for OCE, crucial for driving forward multidisciplinary research initiatives.

OCE faculty conduct research in several broad research topics listed here; they are interconnected via collaborations and include strong links to our education programs:

Air-sea interactions affect heat, moisture, and momentum fluxes at the air-sea interface, in the atmospheric marine boundary layer, and in the ocean mixed layer through the seasonal thermocline. Studies rely on laboratory experiments, field observations (shipboard, buoys, and aircraft) and remote sensing techniques: coastal High Frequency (HF) radar, land- and ship-based nautical radar, airborne sensors, and a wide range of satellite data available online or acquired / obtained through the Center for Southeastern Tropical Advanced Remote Sensing (CSTARS, see "Remote sensing" below). Laboratory experiments are carried out in the world-renown SUrge-STructure-Atmosphere INteraction (SUSTAIN, led by Prof. Haus) facility for studying air-sea transfers of heat, momentum, moisture and chemicals as well as structures and coastal community impacts during extreme winds (up to ~100 m s^{-1}), water surface dynamics, waves, and turbulence.

Marine Biogeochemistry, a discipline within Chemical Oceanography, largely considers the cycling of major elements within the Earth system, including carbon, nitrogen, phosphorus, and bioactive trace elements. Practitioners infer the dynamics of biologically mediated ocean processes, such as productivity, export, and respiration, by interpreting the chemical fingerprints left behind. Carbon is a particularly important currency that is traceable through the Earth system, given its forcing of a warming climate (as CO_2 accumulating in the atmosphere). Understanding the oceanic fate and transformations of carbon, as controlled by the other major elements, remains a priority. Studies entail global ocean surveys, time-series observations, process studies, and modeling of the system. In OCE, this work is supported by active field

programs and a number of analytical labs capable of a variety of wet chemical preparations and instrumental analyses, including highly specialized mass spectrometric methods.

Biological Oceanography focuses on fundamental and applied interdisciplinary research in marine ecology, and requires understanding of biophysical interactions involved in the transport and fate of living and abiotic particles. Key topics include plankton distribution and patchiness, larval behavior in response to cues, movement and clustering of *Sargassum*, harmful algal blooms, marine population connectivity and ecosystem shifts. Applications include ocean conservation, MPA networks, fisheries recruitment, environmental impact assessments, pollution response, and climate change effects on pelagic ecosystems. Innovative platforms (e.g., DISC) enhance understanding of these impacts.

Coastal Oceanography studies implement numerical modeling in realistic domains that address issues of interest to the scientific, industrial, and resource management communities. Topics include coastal studies of fisheries and coral reef ecosystems, with the push for closer involvement in regional environmental programs. These studies rely on several facilities and technologies, including CSTARS, which provides remote sensing of coastal areas, and the Aircraft-Center for Earth Studies (ACES), which offers very high-resolution topographic mapping (both described in "Remote sensing" below). Equally critical are the Upper Ocean Dynamics Laboratory HF radars (led by Prof. Shay), which map surface currents in the Florida Strait, the Aircraft and Air-Sea Interaction Spar buoys (ASIS, led by Prof. Haus), which provide coastal air-sea flux observations, and the SUSTAIN laboratory.

Currents and transport are important to climate variability on seasonal-to-interdecadal time scales, and geochemical and biophysical linkages to ecosystem dynamics in the ocean. OCE faculty conducts research on large-scale, mesoscale and submesoscale currents, with applications for regional heat, salt, and biogeochemical budgets, as well as on transport of such biological constituents as *Sargassum* and meroplanktonic larvae. The Ocean Technology Group (OTECH) provides technical and personnel support for sea-going experiments locally, nationally, and around the globe. OTECH maintains a large inventory of oceanographic equipment, including current meters, acoustic Doppler current profilers, temperature/salinity/pressure recorders, and acoustic mooring releases, as well as heavy equipment for mooring fabrication and more than 40,000 lbs. of mooring flotation (syntactic buoys, glass floats). OCE scientists also manufacture a unique patented biodegradable compact drifter, which was designed on the basis of controlled testing in SUSTAIN tanks to minimize wind and wave drag (led by Prof. Ozgokmen). Thousands of these drifters have been deployed in various regions, including the Gulf of Mexico and the Mediterranean Sea, to characterize surface transport, three-dimensional pathways, and submesoscale turbulence.

Field studies: OCE faculty lead and participate in both small-scale and international global campaigns such as: GO-SHIP, mapping physical and chemical properties across major ocean basins; EXPORTS, determining the factors controlling carbon export from the surface to the deep; and RAPID-MOCHA and OSNAP, monitoring the Atlantic Meridional Overturning Circulation. Innovative techniques and instruments are also developed for Lagrangian observations of planktonic organisms' behavior and their response to environmental signals. OCE is poised to continue leading the field through roles in evolving global campaigns including BioGeoSCAPES and the Global Ocean Biogeochemistry Array.

Numerical modeling is used in a wide range of multidisciplinary problems including turbulence, wave dynamics, sediment and larval transport, flows over coral reefs, biophysical interactions, plankton and ecosystems dynamics, fisheries, and harmful algal blooms. Numerical simulations are involved in all research topics identified above and our faculty actively develop numerical models and methods. Lagrangian modeling with the open-source Connectivity Modeling System developed and maintained at OCE is increasingly used worldwide for studying topics ranging from ocean dynamics and marine

population connectivity to the effects of solar irradiance on the fate of planktonic organisms and pollutants. OCE also possesses robust capabilities in data assimilation, uncertainty quantification, and machine learning. These activities greatly benefit from the advanced high-performance computing facilities at the UM Institute for Data Science and Computing (IDSC).

Instrumentation and technology: OCE faculty have created numerous technologies and facilities for advancing ocean research, including developing a one-of-a-kind SUSTAIN laboratory, which can generate Category-5 hurricane winds over a wave tank for studying air-sea interactions and surface ocean properties; developing and deploying air-sea interaction spar (ASIS) and extreme air-sea interaction (EASI) buoys, EM techniques on profiling floats for air-sea interaction and upper ocean dynamical studies and other innovative instruments for air-sea interaction studies, and developing and deploying cutting-edge hyperspectral sampling tools on remotely operated platforms that are changing the way we assess sea beds and coral reef status.

Remote Sensing has been a signature strength of OCE and two of its predecessor divisions, Applied Marine Physics and Meteorology and Physical Oceanography, for decades. New satellite sensors coupled with advanced machine learning techniques and artificial intelligence allow to observe the oceans in high-resolution details and with daily to hourly frequency. CSTARS, the Center for Southeastern Tropical Advanced Remote Sensing is a leader in satellite remote sensing. The Center for Southeastern Tropical Advanced Remote Sensing (CSTARS, led by Prof. Graber), a downlink and processing facility for a variety of satellite data established in the early 2000s, provides enhanced capabilities on a global scale to monitor natural disasters, study the Marginal Ice Zone in the Arctic, coastal ocean and near-shore environments as well as the open ocean. These activities supported numerous graduate students in our PhD programs since the 1990s and in the MPS "Applied Remote Sensing" track since 2015. Other well-established capabilities include operational surface current measurements off the Florida coast by shore-based HF radars and the utilization of modified nautical X-band radars for wave and current measurements from ships and other platforms.

The recently established Aircraft Center for Earth Studies (ACES, led by Prof. Chirayath) oversees the Helicopter Observation Platform, multiple electric research vessels, and a drone fleet and center serving Florida and the United States. ACES develops novel instrumentation for ocean imaging, such as FluidCam and MiDAR, and information systems technologies, such as NeMO-Net, to advance Earth Science objectives. The facilities include lab space with an optical bench, payload testing, instrument integration, machining, 3D printing, optical observatories for space imaging, and a recently federally funded ACES drone center that fabricates custom aerospace hardware and aircraft. All these activities have links to Engineering and include the participation in new instrument and algorithm developments and in the definition and selection of future satellite missions in international collaborations.

3.2 *Education*

OCE's educational mission is closely connected to research activities and covers a wide range of student demographics. We provide these students with strong technical skills that are in particularly high demand by present-day employers: data analysis and visualization, instrumentation, math, statistics, programming, and laboratory methods. Our teaching includes lab courses and incorporates lab/experimental components into lecture courses. Below is the list of educational programs OCE supports:

PhD and MS programs: The department's graduate program in Ocean Sciences offers four track concentrations: 1) Ocean Dynamics, 2) Air-Sea Interaction and Remote Sensing, 3) Marine Biogeochemistry, and 4) Biophysical Interactions. In addition, the MPO program is a long-standing joint program between ATM and OCE. Our PhD graduates have a strong record of receiving competitive

national and international postdoctoral fellowships, advancing in research and academic careers at top universities and our nation's federal agencies (NOAA, EPA, DOD and more), and building careers in ocean policy.

Joint MS in Ocean Engineering with UM's College of Engineering: Coastal infrastructure and natural systems are under severe threat from natural and manmade disasters, amplified by climate change impacts such as sea-level rise and oceanic heat waves. There have also been significant demands for the exploration and exploitation of offshore and marine resources, as well as an increased emphasis on port and harbor security. The program has two tracks: coastal engineering, and remote sensing and maritime security. Graduates have been successful in obtaining employment in engineering consulting companies, government agencies and several have transferred to PhD programs.

Master of Professional Science: OCE developed and leads two MPS tracks, Natural Hazards and Catastrophes and Applied Remote Sensing. A new track in sustainable Marine Carbon Dioxide Removal, an engineering approach to removing CO_2 from the atmosphere, is currently under development. Here too we have high success rates with our alumni taking positions in industry and government agencies.

Undergraduate programs: The department administers the single-major Oceanography program and the long-standing double-major Marine Science program, in which undergraduates pair a major in Marine Science with a second major in one of 11 different science fields. In addition to directly advising and teaching the students in these tracks, we teach many of the core courses that train students across all the Rosenstiel School undergraduate majors as well as most of the marine science service courses at UM, which provide STEM education delving into ocean processes for non-major undergraduates. We actively engage undergraduate students in research labs, advising many senior theses each year, supporting students achieving Honors in Marine Science.

Experiential Learning: OCE has pioneered a "MakerSpace" at the Rosenstiel School, providing a facility with an array of equipment for designing, engineering and producing scientific equipment, and most importantly expertise available to train students in how to use the tools. A new course is offered to graduate students to learn about and use the tools; the facility and training have been very beneficial to graduate student research projects.

Florida Ocean Time Series by undergrads at UM (FLOTSUM) takes students to sea for hands-on oceanographic experience aboard the R/V *F.G. Walton Smith*. This program epitomizes experiential learning, and is wildly popular with undergraduate students, providing over 400 students over the past 5 years the opportunity to contribute to seasonal time-series sampling in the Florida Straits, collecting physical, chemical, and biological oceanographic data at the origin of the Gulf Stream. The data and samples collected on these trips are integrated into more than five undergraduate courses and many senior thesis projects, giving the students opportunity to delve more deeply into the data and to see the outcome of their at-sea work link across their academic experience at UM.

3.3 *Societal relevance*

These activities, along with an increased emphasis on research and education involving problems such as coastal dynamics and their impact on ecosystems, climate change, and the variability and prediction of hurricanes and their impacts, space remote sensing, and their monitoring of the deforestation of the Amazon Biome and the rapid melting of ice in the Arctic, serve to fulfill the third part of our mission, which is to bring our scientific expertise to bear on important societal needs. In summary, the department seeks to address societally relevant issues related to the ocean through vibrant teaching and robust basic and applied research.

3.4 *Faculty*

There are presently (September 2024) 25 faculty members within OCE: 19 tenured, 1 tenure-track, 4 research-track, and one lecturer. OCE has 1 joint appointment, and 3 emeritus faculty. Over the last decade, the department academic faculty has undergone a 20% reduction in size, from 25 tenure/tenure-track members in 2014 to 20 today, while greatly growing its teaching programs. Because the department is by necessity multidisciplinary, the reduction in critical mass within disciplines threatens several areas of traditional and prospective OCE strengths in teaching and research and, more importantly, our ability to respond to evolving, urgent challenges. Most importantly, these include the impacts of climate change on the ocean, the ocean's role in regulating climate, and the consequences for our nation and the world.

Faculty members are listed in Table 1, organized by general scientific themes. We are clearly missing critical mass in biological and coastal oceanography. In addition, we will soon have high turnover due to six retirements in other research areas. The new hires listed in Section 2.5 are clearly needed to maintain and expand the leadership of OCE and the Rosenstiel School in these key areas.

Table 1: OCE faculty organized into several research areas based on their main expertise in teaching and research. Each faculty member is listed once, unless marked with an asterisk, which indicates that their research spans two categories.

Scientific Themes	Current Faculty
Air-Sea Interactions and Surface Waves	Milan Curcic*, William Drennan, Hans Graber*, Brian Haus*, Nick Shay*
	Research-track: Linwood Vincent
Biogeochemistry and Chemical Oceanography	Mariana Bif (new hire), Hilary Close, Dennis Hansell, Kimberly Popendorf
	Research-track: Jim Happell
Biological and Biophysical Oceanography	Donald Olson, Claire Paris-Limouzy, Josefina Olascoaga*
Coastal Oceanography	Brian Haus*, Nick Shay*
	Research-track: *Vassiliki Kourafalou (retiring)*
Computational Oceanography and Data Analysis	Milan Curcic*, Mohamed Iskandarani, Arthur Mariano
Ocean Currents, Mixing and Transport	Lisa Beal, *William Johns* (*retiring*), Igor Kamenkovich, Josefina Olascoaga*, Tamay Ozgokmen
	Research-track: Shane Elipot
Remote Sensing	Ved Chirayath, Hans Graber*, Roland Romeiser

3.5 *Support Staff*

The Department presently supports 8 research and senior research associates, 6 scientists at the assistant and associate ranks, 3 post-doctoral associates, 2 marine technicians, and 1 administrative assistant. All personnel, with the exception of the administrative assistant, are supported from extramural grants.

3.6 *R/V F.G. Walton Smith*

The R/V *F.G. Walton Smith* is the Rosenstiel School's primary research vessel that has been in service since 2000. It operates as a member of the American Academic Research Fleet (ARF) in support of the U.S. oceanographic community, as coordinated by the University-National Oceanographic Laboratory System (UNOLS). Use of the vessel as a research platform is granted to researchers who request its capabilities for their field work when proposing projects to the National Science Foundation (NSF), Office of Naval Research (ONR), the National Oceanographic and Atmospheric Administration (NOAA), and other federal agencies. R/V *F.G. Walton Smith* has thus served not only as an essential resource to the Rosenstiel School sea-going researchers, but also to the US-wide oceanographic community. Important benefits of this vessel for the Rosenstiel School include:

- **Research**: Ability to carry out at sea field work in the western Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico on behalf of the American oceanographic community, including operational capabilities that are unique within the ARF, namely the ability to operate in both deep (>3000 m), open ocean, and very shallow (<3 m), coastal waters;
- **Education**: Day-long cruises for undergraduate students who experience sea-going oceanography (FLOTSUM), with opportunities offered each Spring and Fall semester;
- **Student Recruitment**: The FLOTSUM student cruises are used to recruit undergraduate and graduate students into our programs.
- **Reputation**: Through operating the *F.G. Walton Smith* as an important asset within the ARF, the Rosenstiel School ensures that it remains a leader in sea-going oceanography and the only institution in the Southeast US with such federal government-sponsored capabilities. The school earns recognition and appreciation nationally for providing critical capability toward the nation's scientific and economic interests.

R/V *F.G. Walton Smith* is thus an essential facility that furthers the Rosenstiel School's research mission and increases the School's capacity to train the next generation of ocean scientists, including top-tier undergraduate and graduate students. It serves as a high-profile flagship for the University of Miami to reach its highest education and research ambitions.