UNIVERSITY
OF MIAMI
FACULTY SENATE

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MEMORANDUM

To: Julio Frenk
University President

From: Tomás A. Salerno
Chair, Faculty Senate

Date: December 1, 2017

Subject: Faculty Senate Legislation #2017-09 (B) –New Undergraduate Major in Oceanography Within the Existing Bachelor of Science in Marine Atmospheric Science (BSMAS), Rosenstiel School of Marine and Atmospheric Science (RSMAS)

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The Faculty Senate, at its November 29, 2017 meeting, voted unanimously to approve the proposal of the Rosenstiel School of Marine and Atmospheric Science (RSMAS) to create a new undergraduate major in Oceanography within the existing Bachelor of Science in Marine Atmospheric Science (BSMAS). This program will be offered by the Ocean Sciences (OCE) department, which currently does not offer an undergraduate degree. This new major will be composed of existing courses. A majority of the program will not be offered via distance learning.

This proposed BSMAS in Oceanography will require completion of 120 credit hours including the University's general education requirement. This new program does not require notification or approval from SACSCOC. The planned effective date is fall semester of 2018.

This legislation is sent to you for your action.

TAS/rh

Enclosure

cc: Jeffrey Duerk, Executive Vice President and Provost
Roni Avissar, Dean, RSMAS
Marjorie Oleksiak, Associate Dean, Undergraduate Programs, RSMAS

CAPSULE: Faculty Senate Legislation #2017-09 (B) –New Undergraduate Major in Oceanography Within the Existing Bachelor of Science in Marine Atmospheric Science (BSMAS), Rosenstiel School of Marine and Atmospheric Science (RSMAS)

PRESIDENT'S RESPONSE

APPROVED: _____ DATE: 12/12/17
(President's Signature)

OFFICE OR INDIVIDUAL TO IMPLEMENT: Dean Roni Avissar

EFFECTIVE DATE OF LEGISLATION: IMMEDIATELY
(if other than June 1 next following)

NOT APPROVED AND REFERRED TO: _____

REMARKS (IF NOT APPROVED): _____

UNIVERSITY OF MIAMI

Proposal Submission Checklist

Proposals are to be submitted to the Office of Assessment and Accreditation (OAA), if applicable, the Graduate Council (for graduate programs excluding Law and Medical), if applicable, and the Faculty Senate. Refer to the Procedures for Program Changes document for information on the approvals and notifications needed for program changes and the Proposal Submissions Specifications document for an explanation of the process and a list of the materials required.

(Please note that change approvals can take 2 semesters to complete.)

Include this checklist at the beginning of each proposal.
(Complete the information below, save the form as a pdf, and insert it with the background materials that are specified, in the order listed, and send the package electronically as noted above.)

KEY CONTACT PERSONNEL INFORMATION

First Name	Last Name	Proponent's Title
Marjorie	Oleksiak	Associate Dean of Under

Department, if applicable	School/College
MBE	RSMAS

E-mail	Phone
moleksiak@miami.edu	305-421-4341

Title of Proposal

RSMAS Departmental Majors Proposal

(-continue to next page-)

MANDATORY MEMORANDA AND FORMAT

Please check that each item listed below is included in the proposal package of materials. The applicable title (i.e. Letter of Explanation, Memo from the Dean, etc.) must precede each section in the materials.

Only proposals conforming to this format will be accepted.

1. This completed checklist.

2. Letter of explanation. (2-3 pages only, double spaced, 12 pt font)

◉ Yes ○ No

If no, explain why.

3. A memo from the dean(s) signifying approval of the faculty of the relevant School(s) / Colleges(s).

◉ Yes ○ No

If no, explain why.

4. A memo that all affected or relevant School / College Council(s) have approved.

◉ Yes ○ No

If no, explain why.

5. A memo from the department chair(s) signifying approval of the faculty of the relevant department(s).

◉ Yes ○ No

If no, explain why.

6. A memo from the Office of Accreditation and Assessment (OAA) if the proposal involves academic programs (degrees, certificates, majors, minors, concentrations, specializations, tracks, etc.) such as new programs, closing programs, or program changes (such as changes in requirements, program length, modality, name, location).

(To be submitted by OAA to the Graduate Council or the Faculty Senate, as appropriate.)

◉ Applicable ○ Not applicable.

If not, explain why.

Proposal has been discussed with Patty Murphy in OAA and was submitted to OAA November 6, 20

7. A memo from the Graduate School Dean signifying approval of the Graduate Council (for graduate programs only).
(To be submitted to the Faculty Senate by the Graduate Council.)

○ Applicable ◉ Not applicable.

If not, explain why.

8. Academic Deans Policy Council (ADPC) approval, for interdisciplinary issues and as appropriate. Please consult with the Dean of the Graduate School or the Secretary of the Faculty Senate to check if this is needed.

○ Yes ○ No

If no, explain why.

9. Additional required documents as listed on the "Proposal Submissions Specifications," i.e. market analysis, budget information, assessment of library collections, etc. as specified.

List additional documents included.

MBE and OCE departmental major proposals, including market analysis.

End form.

Letter of Explanation

The Rosenstiel School of Marine and Atmospheric Science (RSMAS) is proposing two new departmental majors within its existing degree program. These majors will be offered within RSMAS departments that currently do not offer an undergraduate degree, namely Ocean Sciences (OCE) and Marine Biology and Ecology (MBE). The three other RSMAS departments (Atmospheric Sciences, Marine Geosciences, and Marine Ecosystems and Society) already each operate a departmental-major degree. OCE is proposing a departmental major in Oceanography, and MBE is proposing a departmental major in Marine Biology and Ecology. These Bachelor of Science majors will be for resident students (i.e., the proposed majors are not online majors). Resulting degrees will show up as a Bachelor of Science in Marine and Atmospheric Science both on the students' diplomas and transcripts. The planned effective date is Fall semester of 2018.

The OCE and MBE majors will provide a STEM cognate and build on existing courses within the RSMAS degree program. Thus, many of the classes taken by RSMAS undergraduate students in the first three semesters will be in common, irrespective of the final degree, with specialization occurring later. This common course core will facilitate the transition to the new departmental major degrees and also allow students to easily transition into a specific major should their interests change. New courses and tracks within departments will be phased in over time based on enrollment and student needs. Furthermore, all courses in these proposed majors rely on the expertise of existing RSMAS faculty. The Ocean Science major requires 120 credits, and the Marine Biology and Ecology major requires 125 credits; each major's requirements are

detailed in the attached proposals. At this time, no minors in these majors are proposed; however, minors may be developed at some point in the future.

The development of these two new majors will mean that all RSMAS departments have responsibility for a departmental major, and they are a logical extension of RSMAS' recent reorganization into five departments. The departments already operating their own departmental-major degrees (Atmospheric Sciences, Marine Geosciences, and Marine Ecosystems and Society) formally voted to continue to take academic responsibility for their respective majors. By offering departmental majors in all RSMAS departments (Ocean Sciences, Marine Biology and Ecology, Atmospheric Sciences, Marine Geosciences, and Marine Ecosystems and Society) in addition to maintaining the existing MSC dual-major program, we hope to expand and enhance all of our undergraduate programs. Importantly, the departmental majors and our ability to define major-specific core-course curricula will leverage the strong ongoing research at RSMAS to enhance our undergraduate programs with research-intensive learning approaches. Furthermore, these departmental majors maintain the liberal arts education while allowing students to gain greater depth of learning in their chosen scientific field of interest. Finally, these departmental majors do not preclude students from also pursuing other majors and minors. As is common practice at UM, students will be encouraged to do a dual major or add minors as their interests dictate. As with any new initiative, programmatic success will be assessed and modified to continually improve these undergraduate education programs.

An overview of RSMAS undergraduate programs follows as an introduction to the OCE and MBE departmental major proposals.

Departmental Major Proposal Overview

Building on our recent School departmentalization, the five RSMAS departments are now in a strong position to focus on enriching RSMAS' involvement in our undergraduate program to enhance undergraduate education and learning experiences in the marine and atmospheric sciences. Several options to enhance our undergraduate programs were discussed at the School by different groups, and the final consensus is that each of the five departments will lead its own departmental major program in addition to maintaining our existing Marine Science dual major (MSC). All programs will remain highly coordinated through an Undergraduate Programs Academic Committee (UPAC) to avoid duplication, enhance efficiency, and provide complementary and enriching educational experiences. To develop this important strategic initiative for the School, each department met and approved the departmental major proposals.

RSMAS proposes the operation of departmental majors for each department that takes advantage of a breadth of scientific and liberal education and yet allows us to enhance upper-level course development to strengthen our undergraduate degrees. In addition, RSMAS will continue operating our dual major (MSC). In practice, three of the five departments already have or operate their own departmental-major degree: 1) Atmospheric Sciences (ATM) runs the Meteorology degree, 2) Marine Geosciences (MGS) recently inherited the Geological Science (GS) degrees from the College of Arts and Sciences, and 3) Marine Ecosystems and Society (MES) runs a B.A. degree in Marine Affairs (MAF). These departments formally voted to continue to take responsibility for their respective majors. The most significant changes address Ocean Sciences (OCE) and Marine Biology and Ecology (MBE). Both OCE and MBE propose separate departmental-major degrees to enhance undergraduate education. Although we will have a total of six undergraduate degrees, we anticipate that many of the classes taken by most of the RSMAS undergraduate students in the first three semesters will be in common, irrespective of the final degree, with specialization occurring later. This will facilitate the transition to the new departmental major degrees. To provide an overview of RSMAS' entire undergraduate program, all departmental major programs are summarized below (see *Program Summaries*). Finally, as with any new initiative, programmatic success will be continuously assessed, and logical changes will be made to continually improve our undergraduate education programs.

Rationale

As part of our mission at the Rosenstiel School, we are committed to offer a powerful undergraduate education in the Earth, Marine and Atmospheric sciences. This education provides an intuitive way to educate students in fundamental sciences (physics, chemistry, and biology) and gives students the opportunity to be involved in cutting-edge research to enhance their education, improve their career opportunities and enlighten human society. With this in mind, we reorganized the School into five departments that will be able to better deliver this mission: (1) Ocean Sciences; (2) Marine Geosciences; (3) Marine Biology and Ecology; (4) Atmospheric Sciences; and (5) Marine Ecosystems and Society. We propose to take advantage of this reorganization to strengthen the undergraduate programs by creating departmental majors.

The MSC undergraduate degree program (RSMAS's dual-major program) attracts top students nationally and internationally and greatly contributes to the reputation of the University of Miami. We hope to expand and enhance our undergraduate programs by offering departmental majors in all RSMAS departments (OCE, ATM, MGS, MBE, and MES) in addition to

maintaining the MSC dual-major program. The departmental majors provide for more efficient departmental administration and greater faculty contributions. More importantly, the departmental majors and ability to define major-specific core-course curricula will leverage the strong ongoing research at RSMAS to enhance these programs with research-intensive learning approaches. These approaches will have the dual benefit of enhancing both undergraduate education and research experiences and thus will contribute to our goal of offering our undergraduate students a unique learning experience. Furthermore, the departmental majors allow us to provide students a greater depth of learning in the respective scientific field while still maintaining the strengths of a liberal arts education. Thus, the departmental major programs will capitalize on existing strengths and research expertise in the five departments with the long-term goal of increasing undergraduate enrollment in RSMAS undergraduate programs. This outcome will enrich the vitality of the School and the University of Miami.

Impact on Existing RSMAS Programs

Because departmental majors effectively already exist for MGS, MES and ATM, the new departmental major proposals will not affect these programs. However, we anticipate that the creation of a departmental-major degree in Marine Biology will impact MSC enrollment as many of the students currently choosing the MSC dual major are likely to opt for a Marine Biology departmental major, which more closely aligns with their interests. Similarly, OCE's major will attract students desiring a broader biological, chemical, and physical science ocean-related degree. However, a significant number of students will want to retain the dual-major offered by the MSC program, and consequently, the enhanced options offered by the different programs should lead to an overall increase in the total number of students. Offering more options for undergraduate programs is expected to significantly enhance our capability to reach out to potential students in the various disciplines studied by our existing faculty at RSMAS that are currently not visible to them.

Impact on other University Programs

We anticipate that the creation of two additional departmental-major degrees will only positively impact other University programs by attracting students with additional and diverse interests and backgrounds just as the MSC dual major degree program adds students to other schools and department programs. Importantly, the departmental majors do not reduce the required courses offered by Arts and Sciences. All RSMAS undergraduates will be required to take the breadth of liberal arts and science courses that are currently required with the dual major. The difference is a reduction in the electives and other course requirements needed to sustain two majors. Depending on students' interests, they may pursue majors or minors in any one of a number of other departments. For example, given many students' high interest in medically related careers, regardless of degree, many of the MBE departmental majors also will pursue either majors or minors in other biology related degrees such as Biochemistry and Molecular Biology, Biology, and Microbiology and Immunology. Both MBE and OCE departmental majors interested in the fast growing field of big data analysis will likely pursue major or minor degrees in Computer Science. As the departmental major programs grow and evolve, we expect that new collaborations will be formed both among RSMAS majors and among University-wide majors.

Logistics

Administratively, RSMAS' undergraduate programs will follow RSMAS' graduate programs model. An Undergraduate Student Office (USO) will be administered by the Associate Dean of Undergraduate Education and staff. This staff will grow, as needed, with program growth. Each department will have a Program Director in charge of the department's departmental major program and will coordinate educational goals through the Undergraduate Programs Academic Committee (UPAC) led by the Associate Dean of Undergraduates and chaired by an elected member of the UPAC. Departmental Program Directors are expected to regularly consult with their faculty on the course offerings, program objectives and enhancements. With consultation and cooperation among the Program Directors, the UPAC will oversee the enhancement of all undergraduate programs. The UPAC also will assess overall program success and work to continually improve all undergraduate education programs.

The new departmental majors are proposed to begin in Fall 2018. The transition to departmental majors will be gradual, taking advantage of the MSC dual major program to ensure all existing student needs are met and relying on informed decisions of new students or transfer of existing students to new departmental majors.

Market Analysis and Marketing

More than 100 industry executives polled in 2016[1] generally agree that academic institutions can better prepare the talent pipeline by providing students with practical skill development and hands on experimentation as well as opportunities to solve complex problems, connecting students to real world research applications, and providing training in soft skills: communication, collaboration and teamwork, and leadership. Our new departmental major programs are designed to address these needs by providing students with research-intensive educational experiences, which also entail strong communication skills, teamwork and leadership (e.g., the capstone research projects and the courses leading up to these projects will require students to collaborate in independent authentic research enhancing these skills). Thus, undergraduate students will be well prepared for careers in science and other public and private sector employment as well as for admission to graduate schools.

The development of upper-level courses that focus on research intensive learning and authentic research will be strong incentive for attracting students from other competing Marine Science programs. RSMAS will leverage its strength in research and follow the National Academy of Science's and A.A.A.S'[2] advice to provide research intensive learning experiences that should attract students who would be considering other marine science degree programs.

Finally, marketing RSMAS as an "oceanography" institution has not been done in the past, and the oceanography departmental major provides both a new educational and marketing opportunity. This departmental major provides a concrete educational program to educate students in oceanography and the application of this science to global climate change and the resulting problems facing coastal communities.

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[1] 2016 Talent Integration: California Workforce, BayBio Institute and Biocom Institute. The BayBio Institute became the California Life Sciences Institute in 2015.

[2] Froyd, J. E. 2008. White Paper on Promising Practices in Undergraduate STEM Education. The National Academy of Sciences, Engineering and Medicine.
Brewer, C. A., and D. Smith. 2011. Vision and change in undergraduate biology education: a call to action. American Association for the Advancement of Science, Washington, DC.

Program Summaries

The overriding theme of the proposed RSMAS departmental majors is the inclusion of research opportunities and the incorporation of practical applications of knowledge to real world problems, in addition to mastering a broad set of fundamental knowledge. Additionally, these majors allow students to gain a greater depth of learning in their field of interest. Existing and proposed departmental major programs are summarized to provide an overview of all Marine Science related majors.

Marine Affairs

The Bachelor of Arts degree in Marine Affairs is designed for students planning either non-technical careers with government agencies or private industries directly or indirectly concerned with the ocean, or graduate studies in such areas as business, law, economics, political science, education, or communication. Students are required to complete the University's general education requirements in addition to core requirements for the Marine Affairs major and a chosen minor. Required courses include:

Biology: BIL 150, 160
Chemistry: CHM 111, 112
Economics: ECO 211
Geological Science: GSC 110 *or* 111
Marine Science: MSC 111, 112, 217, 230, 313 *or* 314, 310 *or* 340, 345, 460 plus 9 credits of approved electives
Approved course in computer programming *or* Statistics (*e.g.,* MSC 204)
Upper Division Electives: (6 credits)
Minor: (12-15 cr)

Atmospheric Sciences

The Bachelor of Science degree in Meteorology is based on the recommendations of the American Meteorological Society and is also aligned with the National Weather Service requirements for forecasters. An emphasis is placed on a solid mathematical and physical foundation, and the required curriculum allows its seniors to graduate with a minor in mathematics. Due to the requirements in Math and Physics, double majors with each of those programs are relatively easily achieved (with even the occasional triple major). Another double major is available in Broadcast Meteorology, in coordination with and administered by the School of Communications. The program offers a Minor in Meteorology, which requires 15 credits of introductory ATM courses. Meteorology majors can also pursue Minors in Broadcast Journalism and in Climate Science and Policy. Required courses include:

Marine and Atmospheric Science (32 credits): ATM 103, 220, 243, 303, 305, 405, 406, 407 409, MSC111
Mathematics: MTH161, MTH162, MTH210, MTH224, MTH310, and MTH311 *or* MTH320.
Physics: PHY205, PHY206, PHY207, PHY208.

Chemistry: ATM 265 (Atmospheric Chemistry) *or* CHM111 and CHM113.
Computer Science: CSC120

Geological Sciences

The Geological Science degrees are transitioning to the Rosenstiel School. MGS seeks to better integrate geology undergraduates into the Rosenstiel School environment with a more cohesive curriculum, enhanced opportunities for students to participate in cutting-edge research in the company of graduate students and faculty, and a richer educational experience for majors in the marine and atmospheric sciences.

For a B.S. in Geological Sciences, students must complete a core curriculum of 35 credits:

Geological Science GSC 110 or 120, 114 or 115, 111, 260, 360, 380, 410 or 420, 440, 480, 482 and 561.

In addition, the B.S. candidates must complete a 4 credit summer field course (GSC 580 or an approved field course through another university) and must choose a minor from the following: Biology, Chemistry, Computer Science, Ecosystem Science and Policy, Marine Science, Mathematics, or Physics.

For a B.A. in Geological Sciences, students must complete a core curriculum of 32-34 credits:

Two courses in the GSC 101, 102 or 111, 103 or 110 or 120 series;
GSC 114 or 115; 260; 360; 482; two of 380, 410, 440; 420 or 480; 482; and 561

In addition, B.A. students are strongly encouraged to take the summer field course (GSC 580) and/or field courses offered during spring break (GSC 231 or GSC 311).

For a B.A. in Earth Systems, students must complete a core curriculum of 17-18 credits:

GSC 101, 102 or 111, 103 or 110 or 120, 105, 106, 107, 114 or 115, 301, and
6 credits from GSC 131, 132, and 133; and
Marine Science 101.

In addition, a minimum of 15 additional elective credits must be taken from Geological Sciences, Biology, Chemistry, Marine and Atmospheric Science, and Environmental Science.

Marine Biology and Ecology

The Bachelor of Science degree in Marine Biology and Ecology provides a rigorous education where students learn by participation in authentic research and have a closer personal educational experience by working directly with faculty in small classes that develop and explore scientific principles important for their careers and their future impact on societal problems. The departmental major is designed to teach fundamental concepts and precepts in marine biology and ecology. Required courses are described in the attached departmental major proposal and include:

Biology 150, 151, 160, 161, 250 (*or* MSC 318), 255, 330 (*or* MSC 366)
Chemistry 111, 112, 113, 114, 201, 205
Geological Science 111 *or* Marine Science 215, 216 *or* 301, 302
Marine Science 111, 112, 230, 232, 320, 323, 318 (*or* BIL 250), 366 (*or* BIL 330)
Marine Biology and Ecology 366 *or* Marine Science 422
Marine Science 318 Ecological Genetics *or* BIL250 Genetics
Marine Science 3XX Research Fundamentals
Mathematics 161, 162
College Physics *or* University Physics
Statistics

In addition to these required courses, students must complete 12 or more credits of elective, 300+ level Marine Biology and Ecology courses, some of which will be offered as research-intensive learning course sets incorporating active learning strategies. Finally, students seeking honors will complete a two-semester independent project doing active research that will include experimental design, sample collection, statistical analysis, data processing and presentation, interpretation and report writing *or* one semester of research following participation in the "*Saltwater Semester*".

Oceanography

The Bachelor of Science degree in Oceanography provides not only knowledge, but also hands-on skills in ocean related fields to their undergraduate population. In some tracks, students are expected to engage in a senior capstone project, or alternatively, they can seek internships as a transition to work outside of the universities. Required courses are described in the attached departmental major proposal and include:

Mathematics MTH 161 or 171 and MTH 162 or 172
Physics PHY 205, 206, 208
Chemistry CHM 111, 113, 112, 114
Biology BIL 150, 151
Marine Science MSC 111, 112, 204, 220 or 346,

One additional class in marine and/or environmental policy, and one of these cognates:

Marine Policy
Environmental Politics & Policy
Global Sustainability, Living on a Finite Planet
Social & Scientific Perspectives on Global Environmental Change

In addition to these required courses, students must specialize in a track, taking 10 courses from a suggested curriculum including an Honors Thesis.

Marine Sciences Dual Majors

The Marine Science dual major program is an interdisciplinary program dealing with the study of

the world's oceans: their physical and biological constituents, the influence of oceanic resources on human society and the conservation and future development of those resources.
The program offers the following dual majors:

Marine Science/Biology
Marine Science/Chemistry
Marine Science/Physics
Marine Science/Computer Science
Marine Science/Mathematics
Marine Science/Microbiology and Immunology
Marine Science/Biochemistry and Molecular Biology
Marine Science/Meteorology
Marine Science/Geological Sciences

MSC dual majors take a core set of common courses, and, depending on the dual major, then take courses specific to the dual major. The common Marine Science courses include:

Marine Science 111, 112, 215, 230, 232, 301, 216 *or* 302, and 12 elective credits in Marine Science, at least 6 of which must be at the 300-level or higher

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MEMORANDUM

TO: Tomas Salerno, Chair of University of Miami Faculty Senate
FROM: Roni Avissar, Dean

Marjorie Oleksiak, Associate Dean for Undergraduate Programs
DATE: November 06, 2017
SUBJECT: New Undergraduate Programs in Oceanography and Marine Biology

The purpose of this memo is to emphasize our unambiguous and enthusiastic support for the departmental major proposals put together by the faculty in Ocean Sciences and Marine Biology and Ecology and request that these majors be approved by the Faculty Senate. These departmental majors will enrich opportunities for our students and allow them to gain a greater depth of learning in their fields of interest. Additionally, the research conducted at RSMAS will be integrated with our undergraduate programs to deliver a quality, powerful undergraduate education that will be exciting and valuable for students and faculty alike. In addition to the proposed new departmental majors, all school departments will be formally taking academic responsibility for the departmental majors they currently administer. Thus, all RSMAS departments will provide leadership for their respective departmental majors. This leadership will serve to strengthen and enhance learning opportunities for RSMAS students.

As explained in the attached document, with our recent adoption of the Geology Undergraduate Programs, three of our five departments are currently aligned with an undergraduate program that they have agreed to be academically responsible for (see attached memos from the chairs of (1) Atmospheric Sciences; (2) Marine Ecosystem and Society; and (3) Marine Geology). Our two other departments, namely Ocean Sciences and Marine Biology & Ecology, however, do not currently "own" such a program.

The purpose of the attached proposal is to request the approval for the creation of two new undergraduate programs, one that will align with the Department of Ocean Sciences (Oceanography) and one that will align with the Department of Marine Biology & Ecology (Marine Biology & Ecology). We trust that these two programs have a tremendous potential of bringing to UM very talented students who have not been aware of and/or attracted to our school in the past. We are convinced that this will be quite beneficial for the students, RSMAS and UM in general, and we could not be more excited and more supportive of this opportunity.

Each program will be formally supervised by a Program Director, who will become, as part of her or his appointment, a member of the Undergraduate Program Academic Committee (UPAC). UPAC will be run by a chair elected by the program directors. All programs are administratively supported by the Undergraduate Students Office (USO) that is supervised by the Associate Dean for Undergraduate Programs. This office is currently in place and operating. We will recruit more employees for that office if and as needed due to the increase of students. We currently have enough faculty members to teach in these programs though new recruitment of faculty (within the existing faculty allocation) will be given preference in the programs that attract more students. Thus, the financial needs and allocation to RSMAS will grow

proportionally to the number of its students and no major change in budget (except for the allocation of TA's) is currently needed.

As you can see in the attached memos, RSMAS is very supportive of this proposal. It has been approved by all five departments, unanimously approved by the School Council, and unanimously approved by the School Leadership (which at RSMAS consists of the five department chairs, the five associate deans, the Director of CIMAS, the School Council Speaker, and our three senators).

We respectfully request the Senate approval to allow us to develop and offer these two new undergraduate programs. Thanks in advance for your consideration, and we are happy to answer any questions.

UNIVERSITY OF MIAMI
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SCHOOL of MARINE &
ATMOSPHERIC SCIENCE

MEMORANDUM

To: University of Miami Faculty Senate

From: Peter J Minnett, Professor, Ocean Sciences
Speaker, RSMAS School Council

Peter Minnett

Subject: School Council Support for RSMAS Undergraduate Programs

Date November 4, 2017

Over many meetings in the past year or so, the addition of two departmental majors by the Departments of Ocean Sciences and Marine Biology and Ecology has been discussed extensively by the School Council, and we provided opinions and guidance to the Departments and Chairs. The School Council noted that all Departments had approved the proposal to the Faculty Senate and unanimously endorsed this outcome.

School Council, Rosenstiel School for Marine and Atmospheric Science, University of Miami
4600 Rickenbacker Causeway, Miami, FL 33149, USA Phone: 305 421-4104 Email:pminnett@rsmas.miami.edu

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MEMORANDUM

To: Dr. Roni Avissar, Dean
From: Dr. Dennis A. Hansell, Chairman
Date: November 3, 2017
Subject: Vote tallies on OCE's proposed undergraduate major *Oceanography*

Dean Avissar:

The Department of Ocean Sciences held votes of the faculty on two motions addressing their proposed development of an undergraduate major entitled *Oceanography*. The motions and results of the votes follow:

Motion 1: OCE approves the single major proposal as described in the "Proposal submitted to the UM Faculty Senate for the Establishment of an *Oceanography (OCE)* Major"

YES	(23)
NO	(2)
ABSTAIN	(0)

Motion 2: The department of OCE will be responsible for and administer the *OCE* single major

YES	(24)
NO	(1)
ABSTAIN	(0)

The majority of the OCE faculty support the two motions.

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Department of Marine Biology and Ecology
Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149, USA

Phone: 305-421- 4614 Email: clangdon@rsmas.miami.edu

Memorandum

To: Dr. Roni Avissar, Dean

From: Dr. Chris Langdon, Chairman

Date: November 4, 2017

Re: Vote tallies on MBE's proposed Marine Biology and Ecology departmental major

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During the week of Nov 2, 2017, the faculty of the Department of Marine Biology and Ecology held a discussion and vote on the following motions:

Motion 1: MBE approves the departmental major proposal as described in the "Proposal submitted to the UM Faculty Senate for the Establishment of a Marine Biology and Ecology (MBE) departmental major."

Motion 1 passed with a vote of 12 yes, 1 no. (Vote held by email)

Motion 2: The Department of Marine Biology and Ecology will be academically responsible for the Marine Biology and Ecology departmental major.

Motion 2 passed with a vote of 9 yes, 0 no. (Vote held at monthly meeting, only 9 present at time of vote).

Chris Langdon, Chair

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ATMOSPHERIC SCIENCE

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www.rsmas.miami.edu/research/departments/marine-geosciences

MEMORANDUM

From: Sam Purkis (Chair - Department of Marine Geosciences)

To: Faculty Senate

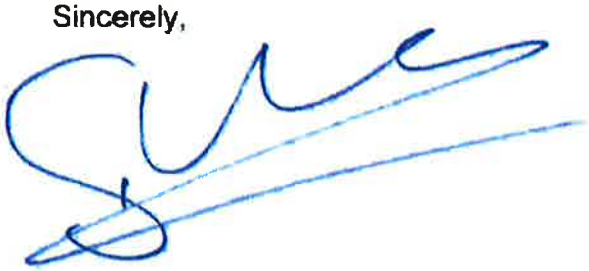
Date: 10/23/2017

Dear Tomás Salerno - Chair, Faculty Senate

This memo to inform that the faculty of the Department of Marine Geosciences (MGS) have voted *unanimously* in support of the motion that we intend to be academically responsible for the existing Geological Sciences undergraduate program (GSC) within the RSMAS framework of each department offering a single major undergraduate program.

We look forward to nurturing and being part of this exciting new initiative.

Sincerely,



Prof. Sam Purkis
Chair of the Department of Marine Geosciences

UNIVERSITY OF MIAMI
ROSENSTIEL
SCHOOL of MARINE &
ATMOSPHERIC SCIENCE

Department of Atmospheric Sciences
Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149, USA

Phone: 305-421-4930 Email: dnolan@rsmas.miami.edu

Memorandum

To: Marjorie Oleksiak, Associate Dean of Undergraduate Programs
Cc: Roni Avissar, Dean of RSMAS

From: David S. Nolan, Chair, Department of Atmospheric Sciences

David S Nolan

Date: October 26th, 2017

Re: ATM Vote on Responsibility for the Meteorology Major

During the week of October 23rd, 2017, the faculty of the Department of Atmospheric Sciences held a discussion and vote, by email, on the following motion:

"The Department of Atmospheric Sciences will be academically responsible for the Meteorology Major."

The motion passed with a vote of 8-0, with the chair not voting.

UNIVERSITY OF MIAMI
ROSENSTIEL
SCHOOL of MARINE &
ATMOSPHERIC SCIENCE

Department of Marine Ecosystems and Society
Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149, USA

Phone: 305-421-4884 Email: jault@rsmas.miami.edu

Memorandum

November 4, 2017

TO: Dr. Roni Avissar, Dean of RSMAS

FR: Dr. Jerald S. Ault, Chairman of MES

RE: MES Faculty Vote on Responsibility for the Marine Affairs UG Major

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During the week of October 23rd, 2017, the faculty of the Department of Marine Ecosystems and Society held a discussion and vote, by email, on the following motion:

"The Department of Marine Ecosystems and Society will be academically responsible for the Marine Affairs Major."

The motion passed with a vote of 13-0.

UNIVERSITY OF MIAMI
ROSENSTIEL
SCHOOL of MARINE &
ATMOSPHERIC SCIENCE

Associate Dean of Graduate Studies
Graduate Studies Office
Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149, USA

Phone: 305-421-4155 Email: smajumdar@rsmas.miami.edu

Dear Faculty Senate,

This letter is to express my enthusiastic support for the establishment of two new undergraduate majors in Ocean Sciences (OCE) and in Marine Biology and Ecology (MBE). The programmatic alignment with the respective M.S. and Ph.D. programs in their departments will provide substantially improved synergies between the undergraduate and graduate programs. In particular, the Research Intensive Learning activities highlighted in the proposed undergraduate programs will also likely involve many of our graduate students. I am highly supportive of our graduate students being provided with new structured opportunities to mentor undergraduates and collaborate on lab research, to enhance their own professional development and educational training. I am looking forward to working with the new programs moving forward.

Sincerely,

S Majumdar

Sharanya J. Majumdar
Associate Dean of Graduate Studies
RSMAS

UNIVERSITY
OF MIAMI

MEMORANDUM

DATE: 11/8/2017

TO: Marjorie Oleksiak, Associate Dean of Undergraduate Studies
RSMAS

FROM: Patty Murphy, Executive Director
Office of Assessment and Accreditation

RE: **New Undergraduate Majors in BSMAS Program: Oceanography and Marine Biology & Ecology**

On November 6, 2017 RSMAS notified my office of its intent to create two new undergraduate majors in the existing Bachelor of Science in Marine Atmospheric Science (BSMAS) degree program effective in Fall 2018: 1) Oceanography; and 2) Marine Biology and Ecology.

The proposed BSMAS in Oceanography program will require completion of 120 credit hours including the University's general education requirements. Six tracks will eventually be developed within the major: Climate Science, Marine Environmental Chemistry, Microbial Oceanography, Coastal Impacts, Big Data in Ocean Applications, and Oceanography.

The proposed BSMAS in Marine Biology and Ecology will require completion of 125 credit hours including the University's general education requirements.

These new undergraduate majors do not "represent a significant departure, either in content or method of delivery" from what we are currently approved by SACSCOC to offer due to the following:

- The proposal involves the creation of new majors within an existing degree offered by the University.
- The program length for the two new bachelor's degree programs meets the SACSCOC requirement of a minimum of 120 credit hours.
- The new majors will be composed of existing courses.
- The new majors will be supported by current qualified faculty.
- The University is currently approved to offer the following programs in related areas:
    - MPS in Applied Remote Sensing
    - MPS in Computational Meteorology and Oceanography
    - MPS in Marine Mammal Science
    - MPS in Natural Hazards and Catastrophes
    - MPS in Tropical Marine Ecosystem Management
    - MS in Marine Biology and Ecology
    - MS in Meteorology and Physical Oceanography

  - MS in Ocean Sciences
  - PhD in Marine Biology and Ecology
  - PhD in Meteorology and Physical Oceanography
  - PhD In Ocean Sciences
- The majority of the program will not be offered via distance education and, in any case, the University is approved to offer 100% distance education programs.
- The program will be offered on the University's campuses.

SACSCOC only requires notification of new programs that represent a significant departure from our current programs. Therefore, no notification or approval is required for this change.

Please contact me if you have any questions at pattymurphy@miami.edu or (305) 284-3276.

CC: Faculty Senate
Roni Avissar, Dean of the Rosenstiel School of Marine and Atmospheric Science
Karen Beckett, University Registrar
Ray Nault, Executive Director of Student Financial Assistance and Employment

Proposal to UM Faculty Senate for the Establishment of a *Marine Biology and Ecology (MBE)* Major

1. RATIONALE

A. Signature Program Aligned with New Undergraduate Education Mission

The Department of Marine Biology and Ecology (MBE) seeks to develop a departmental major that teaches fundamental concepts and precepts in marine biology and ecology. The departmental major will be structured to enhance students' abilities to take advantage of advanced, upper-level research oriented courses. The opportunity to do active research is embodied both in in Research Intensive Learning (RIL) courses and the senior Capstone Research Project.

Research Intensive Learning (RIL) courses provide a more vigorous undergraduate education by applying the principles, theories and practices of active learning detailed by National Research Council, National Academy of Science, National Science Foundation, National Institution of Health, Howard Hughes Institution, American Association for the Advance of Science and the President's Council[1-8]. These courses provide a greater faculty-to-student ratio and thus a richer student experience in undergraduate research. RIL courses have students participating in fieldwork, laboratory experiments and data analyses while learning theory, tools and how to apply these to active research. The basic design for RIL courses is reflected in the "*Saltwater Semester*", where students take integrative sets of RIL courses to master biological fields. The *Saltwater Semester* takes advantage of having undergraduates at the Rosenstiel School of Marine and Atmospheric Science (RSMAS) for two full days a week where the students will focus on a specific Program of Study. An example is the Marine Genetics and Genomics Semester (three courses: Conservation Genetics, Marine Genomics, and Computational Biology) where students discuss textbook lessons and primary literature to help design experiments, complete the fieldwork for their experiment and use genomics and bioinformatics to address relevant and important marine biological questions. Other potential RIL course sets include Marine Ecology and Conservation, Environmental Physiology and Toxicology, Marine Health and Biomedicine as well as MBE's participation in the "*Galapagos Semester*". By unifying MBE's undergraduate program into a departmental major, we can enhance the number and frequency of RIL courses. Thus, this initiative provides a foundation to invoke more active learning and better prepare MBE's undergraduate students to achieve upper-level education goals and pursue science related careers.

The other advanced, upper-level research oriented experience that MBE departmental majors will provide is a Senior Capstone Independent Project. The focus of the Senior Capstone Independent Project is to provide the honors students with the tools required to design and complete an

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[1]Fang D & Meyer RE (2003) Effect of two Howard Hughes Medical Institute research training programs for medical students on the likelihood of pursuing research careers. *Acad Med* 78(12):1271-1280; [2]Handelsman J, *et al.* (2004) Education. Scientific teaching. *Science* 304(5670):521-522; [3]Labov JB (2004) From the National Academies: the challenges and opportunities for improving undergraduate science education through introductory courses. *Cell Biol Educ* 3(4):212-214; [4]National Research Council (2005) *How Students Learn: Science in the Classroom.* (National Academy Press., Washington, DC); [5]PCAT (2012) *President's Council of Advisors on Sceince and Techonolgy: Engaging to Excel. Report to the President: producing on milling additional college graduates with degres in science, technology, engineering and mathematics.*, (President EOot); [6]Freeman S, *et al.* (2014) Active learning increases student performance in science, engineering, and mathematics. *Proc Natl Acad Sci U S A* 111(23):8410-8415; [7]Bradforth SE, *et al.* (2015) University learning: improve undergraduate science education. *Nature* 523:282-284; [8]Science AAftAo (2015) Vision and Change in Undergraduate Biology Education: Chronicling Change, Inspiring the Future. *American Association for the Advancement of Science.*

independent active research project. In preparation for the completion of their independent project, students will master a specific set of skills and tools, and understand the literature that forms the foundation for any scientific endeavour. The Senior Capstone Independent Project takes advantage of the skills taught in RIL courses (*e.g.*, statistics, laboratory practices, field specific techniques) allowing student to make significant and important scientific contributions. Importantly while a Senior Capstone Independent Project is necessarily focused on a specific topic, the skills learned are applicable to a wide breadth of future endeavours. Understanding the scientific method and the ability to do experimental research, analyze data and communicate (both orally and written) will enhance our undergraduates' careers and contributions to society.

In summary, the MBE undergraduate departmental major provides a rigorous education where students learn by doing and have a closer personal educational experience by working directly with faculty in small classes that develop and explore scientific principles important for their careers and their future impact on societal problems.

B. Market Considerations

Sixty-one universities and colleges around the country offer a B. S. in Marine Biology (eight are shown Appendix I). UM's location in Miami and in the subtopics is clearly going to attract to the program many students interested in working with tropical organisms and ecosystems. The proximity of RSMAS with its state-of-the-art facilities and research active faculty will also be highly attractive. However, to capitalize on these advantages, the MBE departmental major program needs to emphasize an enhanced undergraduate research experience because this is what will attract the top students in the country who know they want to prepare themselves for admission to graduate school and careers in science and other public and private sector employment. The top five Marine Biology programs in the country offer research courses that teach sophomores what research is all about and the basic skills they will need. These programs also offer a wide range of elective courses for students in their junior and senior years to spend time in faculty labs developing specific laboratory skills and ultimately reaching the point where they propose and carry out an independent research project and disseminate the results. The structure of the MBE departmental major will provide a foundation of courses that teach the fundamental concepts and precepts and will also remove obstacles to taking advance upper-level RIL courses so that undergraduates can perform active research.

2. RESOURCES

A. Human Resources

The MBE departmental major program has the full participation and support of existing faculty. In addition, it will require an Academic Director, who is expected to be an MBE faculty member and who will manage the overall academic effort. The Undergraduate Studies Office (USO) based in the Unger Building on the Coral Gables Campus, where most of the undergraduate teaching takes place, will service the needs of all RSMAS undergraduate programs, including the MBE program. As the size of the undergraduate population increases, the USO will proportionally increase as well. If the MBE program develops as anticipated, clearly the faculty size and the number of graduate students capable of providing teaching assistance to the classes offered by the program will increase as well but within the RSMAS allocation for faculty lines. Obviously, if the program grows much above expectation, additional allocation will be discussed with the Provost

B. Libraries

The Office of Information Technology at the University of Miami provides technical assistance, including support for supported software, desktop environments and peripherals, network connectivity, computer password maintenance, and hardware and software configurations. UM libraries rank among the top research libraries in North America. The Richter Library and UM's main library house collections that serve the arts, architecture, humanities, social sciences, and the sciences. RSMAS also maintains a world-class library focused on the marine sciences, with a dedicated librarian for RSMAS faculty, staff, and students. This librarian and her staff provide extensive support for literature searches, locate educational resources in print and in digital formats, and provide support for all information-related work in education. Students have unlimited access to the library collections via the Internet.

C. Laboratory Facilities, Equipment, Space

Students in the MBE departmental major program will have access to unique facilities and research opportunities that will significantly enhance their educational experience at RSMAS. The MBE department is housed in the brand new, state-of-the-science Marine Technology and Life Sciences Seawater (MTLSS) building. This is the only building at UM with direct access to running seawater required for marine animal and plant husbandry. The laboratory facilities at the MTLSS building include those run by individual faculty where controlled experiments are routinely conducted on the impacts of multiple disturbances (*e.g.*, light, temperature, salinity, nutrients, acidification, and contaminants) on marine vertebrates, invertebrates, and plants. In addition to the faculty laboratories, students will have access to fully equipped (*e.g.*, microscopes, scales, glassware, aquaria) teaching labs where directed and independent studies can be conducted. The MTLSS building is home to two unique facilities that provide additional educational and research opportunities to students: the National Resource for *Aplysia* and the SUSTAIN (SUrge-STructure-Atmosphere INteraction) research facility. The *Aplysia* facility is the only laboratory in the world where the sea hare, *Aplysia californica*, is cultured and raised for scientific research. The relatively simple nervous system of *Aplysia* offers an ideal model for research on neurophysiology, brain function, memory and learning, and aging. The SUSTAIN facility is the only place in the world with a wind-wave-storm surge simulator capable of generating Category 5 hurricane-force winds in a 3D test environment. Designed by the world's leading aquarium architects, the new seawater tank provides students and scientists with access to critical observations within a realistic, but scaled and controlled environment. Finally, the MTLSS building also has numerous spaces for holding small-group discussions and meeting rooms for student presentations.

The students in the MBE departmental major program also will have access to the UM Broad Key research station. This research station is located a short boat-ride away from the RSMAS campus on a small island in the Florida Keys and it is surrounded by diverse mangrove, seagrass, and coral reef ecosystems that can be easily accessed from the shoreline. The station is routinely used as a teaching resource in graduate and undergraduate classes and can host daily trips or overnight stays for up to 16 students. The station is equipped with teaching and laboratory facilities as well as kayaks and paddleboards for easy access to nearby natural ecosystems.

For another exotic and rewarding academic experience, MBE students can participate in the study abroad program being taught by MBE, MES, MGS and OCE faculty in the Galapagos Islands.

UGalapagos offers a field-oriented semester of study. Through an academic partnership with the Intracultural Outreach Initiative, located in the community of Puerto Villamil on Isabela Island, UM offers a full six-course (17 credit) semester experience tailored to the needs and interests of students.

UM/RSMAS also has a fleet of small boats (16-25 ft) that are used for teaching and research activities in Biscayne Bay and the reefs of the Florida Reef Tract. Students in the MBE departmental major program will get the opportunity to gain hands-on boating experience and training and obtain their Motorboat Operator certification (MOCC). In addition, UM has a shallow draft research vessel, the RV Walton Smith (a 96-foot-long catamaran), that is used by UM and non-UM scientists for scientific cruises in Florida and the Caribbean.

RSMAS has a very active research diving program with > 150 certified research divers conducting research in all marine habitats and locations in Florida and around the world. Students will have the opportunity to get their scientific diving certification (AAUS) as part of their program, allowing them to participate in the hands-on field research being conducted by UM scientists.

D. Undergraduate Research Support

Research Intensive Learning (RIL) courses and the senior Capstone Research Projects have students actively engaged in fieldwork and open-ended experiments. These activities will require supporting funds that will be allocated by the Dean's Office.

3. CURRICULUM

A. Program Outcomes

The MBE departmental major curriculum will provide the rigor, flexibility, depth and integration to enable students to:

1. Design their course of study that provides both depth and breadth in marine biology and ecology and related science courses.
2. Undertake active research experiences, which will allow them to gain a strong understanding of the scientific process.
3. Learn from the diverse and outstanding group of professors, researchers, and classmates.
4. Prepare themselves for the public and private sector employment, graduate school, and successful careers.

B. Student Learning Outcomes

Students completing the MBE departmental major will be able to:

1. Master a broad set of fundamental biological knowledge including how to search for, understand, and synthesize primary scientific literature, and understand how fundamental biological principles relate to the marine environment.
2. Solve problems competently by identifying the relevant features of the problem and developing a strategy to solve the problem.
3. Use computers and computational approaches to acquire and process data as well as use software to analyze data.
4. Understand and synthesize the objectives of research experiments, properly conduct experiments, and appropriately record, analyze, and communicate the results.

5. Effectively communicate the concepts, results, and implications of their laboratory experiments and independent research both orally and in the written form to experts in the field, scientists in other disciplines, and the general public.

Learning outcome assessment will be based on questions embedded in tests, projects, and laboratory reports, all according to uniform rubrics. Additional assessment may be based on the oral and written presentation of the Capstone Independent Project, when applicable. These assessments may be supplemented by additional direct measures incorporated into a Senior Exit Exam and via indirect measures collected from questions on the University-administered Graduating Senior Survey. Additional details are provided in Appendix II.

C. Program Structure

The Marine Biology and Ecology departmental major will entail 125 credits.
**Courses currently listed as Marine Science (MSC) but have been developed and consistently taught by MBE faculty will be re-coded as Marine Biology and Ecology*

(i) Core course requirements (required coursework toward the degree; 68 credits)

MSC 111, 112 (4 cr) Introduction to Marine Science
MSC 230, 232 (4 cr) Marine Biology*
MSC 3XX (1 cr) Research Fundamentals*
Zoology
MSC 320 (3 cr) Marine Vertebrates
or MSC 323 (3 cr) Invertebrate Zoology
Genetics
MSC 318 (3 cr) Ecological Genetics*
or BIL 250 (3 cr) Genetics
Ecology
MSC 366 (3 cr) Tropical Coastal Ecosystems*
or MSC 422 (3 cr) Marine Ecology of the Galapagos*
or BIL 330 (3 cr) Ecology
Biology
BIL 150, 151, 160, 161 (10 cr) Introduction to Biology
BIL 255 (3 cr) Cell and Molecular Biology
BIL 360 (3 cr) Comparative Physiology
Chemistry
CHM 111, 112, 113, 114 General Chemistry (8cr) plus CHM 201, 205 Organic I, (4 cr)
or CMH 121, 113, 221, 114, 222, 205 Chemistry for BioSciences (15 cr)
Physical Science
GSC 111 (4 cr) Earth System History
or MSC 215, 216 (4 cr) Chemical Oceanography
or MSC 301, 302 (4 cr) Physical Oceanography
Mathematics
MTH 162 (4 cr) Calculus II (and any prerequisite)

Physics
College (10 cr)
PHY 101, PHY 102 PHY 106 Laboratory I, PHY 108 Laboratory II
or University Physics (10 cr)
PHY 201, PHY 202 with PHY 106 laboratory and PHY 108 Laboratory II
Statistics (3 cr) (one of four choices: MSC 204, PSY 291, BIL311 or MTH 224)

(ii) Elective 300+ level Marine Biology and Ecology courses (12 or more credits; Appendix III). Within those 12+ credits, students will be required to complete one 300+ level laboratory or field course. Students are encouraged to focus on 300 level and above courses in their program of study (Appendix IV). Different fields of study will be offered as RIL course sets incorporating active learning strategies during the RSMAS *Saltwater Semester* at the dynamic RSMAS research campus taught by MBE faculty who are leaders in these fields and during a semester at the Galapagos at the Intracultural Outreach Initiative, located on Isabela Island and taught by faculty from MBE, MES, MGS and OCE. The skills taught and experience gained in RIL courses (*e.g.*, statistics, laboratory practices, field specific techniques) will prepare students to make significant and important scientific contributions during their Senior Capstone Independent Project (see below).

(iii) *The Saltwater Semester* is offered on RSMAS campus as an intense research experience with 8 to 12 contact hours per week. Courses within different Programs of Study (Marine Ecology and Conservation, Marine Genetics and Genomics Environmental Toxicology and Physiology or Marine Health and Biomedicine) will be offered Saltwater Semester. These courses are a blend of lectures and active research, which have resulted in student authored peer-reviewed publications.

(iv) Senior Capstone Independent Project (3- 6 credits). Building on the skills and experience gained from the RIL courses, students that receive Departmental Honors designation will be expected to complete a two-semester independent project doing active research that will include experimental design, sample collection, statistical analysis, data processing and presentation, interpretation and report writing *or* one semester of research following participation in the "*Saltwater Semester.* Students will be required to write a proposal outlining a project that aligns with one of the MBE faculty of the Saltwater Semester. Projects will be mentor by individual faculty with oversight by the MBE Academic Director and two or more faculty members who will make up the evaluation committee for each student.

(v) General Science Electives (6 to 9 credits) within the areas of Biology (BIL), Biochemistry and Molecular Biology (BMB), Ecosystem Science and Policy (ECS), Computer Science (CSC), Microbiology and Immunology (MIC), and Neuroscience (NEU) (Appendix IV).

(vi) Free Electives (6 to 9 credits) to be taken from any school within the university

(vii) General Education Requirements (24 credits) to satisfy the areas of proficiency and areas of knowledge required of all University of Miami undergraduate students:
ENG 105, 106 (6 cr) English Literature, English Composition
Arts and Humanities (A&H) cognate (9 cr)
People and Society cognate (P&S) (9 cr)

D. Teaching and Faculty

Required courses in the MBE departmental major will be taught by existing and new tenure-track faculty hires in MBE (future faculty hires will be necessary for program growth and subsequent involvement in RIL courses and Capstone Independent Projects) as well as University faculty (Biology, Chemistry, Geology, Physics, Marine Geosciences, Mathematics, Ocean Sciences, … *etc.*). New faculty hires will be required to address increases in predicted teaching loads associated with enrolment into the MBE departmental major program. It is anticipated that all MBE faculty-taught courses will incorporate active learning components, *i.e.*, primary literature or case-study reading and discussion, individual and team projects, and project or assignment presentations. Capstone Research Projects will be will be mentor by individual faculty with oversight by the MBE Academic Director of the program and evaluated by and two or more faculty members who will make up the evaluation committee for each student.

E. Academic Advising

Academic advising related to degree requirements and Programs of Study will be coordinated by the Academic Director of the program with active faculty representation in each of the Programs of Study. Capstone Research Project advisors will provide active mentoring to students pursuing research in their laboratories.

F. Learning Outcomes Assessment

See Appendix II.

4. STUDENTS

The MBE departmental major program is targeted at, and designed for students with a strong interest in academic research, graduate school, and professional careers that require critical thinking skills. For these high performing students, this program will develop competencies with which to successfully advance their careers in the field of marine biology and ecology.

A. Admission and Retention

Students will be admitted through the University of Miami Admissions office. Currently, students with an interest in marine biology enroll in the rigorous RSMAS Marine Science/Biology double major program. The proposed RSMAS MBE departmental major program will give students more flexibility than the existing Marine Science/Biology double major program, allowing for the opportunity to become more diversified. At the same time, the proposed MBE departmental major program will have a strong emphasis in field and laboratory research technique, analysis, critical thinking and science writing taught by leaders in the field. We believe that the combination of flexibility, diversity and in-depth research training at a state-of-the-art marine research station will attract many new students to RSMAS who would have decided to go to competing programs (see Section 1B Market Analysis and Appendix I). Our program may also appeal to STEM-oriented students interested in attending other programs within the University of Miami (for example, Biology, Ecosystem Science and Policy, Marine Science/Biology, Microbiology and Immunology, Neuroscience). Because of the rigor and integrative nature of the program, we anticipate similar retention as the Marine Science/Biology program. Further, students who seek to be credentialed in additional fields will be encouraged to conduct double majors between Biology and Chemistry, Microbiology and Immunology, Neuroscience Computational Sciences, etc.

B. Teaching and Research Assistants

Teaching assistants (TAs) will be required for the RIL and other research intense courses with significant experimental or field components. The predicted TA needs for courses administrated by MBE faculty are listed below:

	AY 2018	AY 2019	AY 2020	AY 2021	AY 2022
Marine Science 232 Marine Biology Lab	3	3	4.5	6	6
Marine Science 366 Tropical Marine Ecology Field Course	1	1	1	1	1
Marine Science 3XX Research Fundamentals	0	1	1.5	1.5	2
Marine Science 323 Invertebrate Zoology	0	1	1	1	1
Marine Science 326 Marine Genomics	0	0.5	0.5	0.5	0.5
Marine Science 422 Galapagos Marine Ecology	1	1	1	1	1
Marine Science 463 Marine Conservation Genetics	0	0.5	0.5	0.5	0.5
Marine Science 465 Marine Comparative Immunology + lab	0	1	1	1	1
Marine Science 466 Environmental Physiology	0	0.5	0.5	0.5	0.5
Marine Science 403 Marine Environmental Toxicology	0	0.5	0.5	0.5	0.5

5. ADMINISTRATION

A. Estimated administrative increments imposed by the program

The proposed MBE departmental major program (together with all other undergraduate programs administered by RSMAS) will benefit from the excellent administrative framework already supporting the existing undergraduate programs within RSMAS. Administrative staff for the current RSMAS programs are housed on the Coral Gables campus in the Ungar 210 suites and include the Associate Dean of Undergraduate Studies, an Academic Director, an Associate Academic Director, two full-time staff and several part-time student workers. This Undergraduate Students' Office (USO) will be strengthened by recruiting new staff members, as needed based on the growth of the overall student population serviced by this office.

B. Proposed arrangements for administration and for academic direction of the program

Day to day administration of the program will be carried out by the Academic Director, who will report directly to the RSMAS Associate Dean of Undergraduate Studies. All programmatic changes (*e.g.*, course additions, curriculum changes) will be brought to the MBE faculty for approval. The Associate Dean of Undergraduates will, in consultation with the RSMAS Academic Directors of undergraduate programs, ensure cohesion among RSMAS undergraduate programs.

6. COMPARISONS

The table in Appendix I provides a contrast of our proposed program with those offered by six comparable peer schools and primary competitors.

APPENDIX I

Table 2: Comparison of select existing programs in other academic institutions.

COMPARISON PROGRAMS				
Institution	**Type of Program**	**Focus**	**Requirements**	**Unique features**
University of California Santa Cruz	Marine Biology B.S.	Basic processes that shape life in the marine environments	Adv courses required: Genetics, Evolution, Mar Ecol	Sequence of UG research courses from Exploring Research to Independent Research to Senior Thesis
UCLA	Marine Biology B.S.	Marine organisms and their environment	Org Chem 1 and 2 not required but mentions that some graduate/professional programs may still require it.	Marine Biology Quarter field research taught at off campus location (4 courses, 16 cr)
University of Rhode Island	Marine Biology B.S.		Org Chem 1 and 2 or Org I + Biochem 120 cr	
Florida International University	Marine Biology B.S. Org Chem 1 and 2 required		Org Chem 1 and 2 required 120 credits, >48 must be upper division, 9 cr outside the major	
Stony Brook University of Marine & Atmospheric Sciences	Marine Sciences B.S.	Honors program in Marine Sciences.	Students must contact director of undergraduate studies to design & approve an acceptable course of study prior to declaring major..	Semester-by-the-Sea, field courses, research of coastal & oceanic environments.
Coastal Carolina University	Marine Science B.S.	Students not required to complete a minor or cognate. However, they may elect to minor in any field.	Minimum grade of "C" or better is required to maintain major.	Students may double major in any program which offers a B.S. degree.
University of South Carolina	Marine Science B.S.	Interdisciplinary, major can be declared end freshman year/beginning of sophomore year.	Admitted as freshman. A cumulative grade point average of 2.8 & a minimum grade of C in all marine science core courses is required	*Students are also required to undertake at least three weeks of independent field research, at the Baruch Marine Field Laboratory in Georgetown, SC or via an alternative of their choosing.*
Texas A & M University at Galveston	Marine Science B.S.	Electives in the junior & senior year allow students to obtain a broader back ground.	Admitted as freshman.	Students can be eligible for a secondary teaching field in Physical Sciences, pending a passing score on the state certification test.

APPENDIX II

Mission Statement and Program Objectives

University of Miami Mission Statement

The University of Miami's mission is to educate and nurture students, to create knowledge, and to provide service to our community and beyond. Committed to excellence and proud of the diversity of our University family, we strive to develop future leaders of our nation and the world.

Rosenstiel School of Marine and Atmospheric Science Mission

Our mission at the Rosenstiel School is to train the next generation of Earth scientists while conducting cutting-edge research and creating the knowledge that we communicate to our students and our community.

Program Objectives

The MBE departmental major curriculum will provide the rigor, flexibility, depth and integration to enable students to:

1. Design their course of study that provides both depth and breadth in marine biology and ecology and science related courses.
2. Undertake active research experiences, which will allow them to gain a strong understanding of the scientific process.
3. Learn from the diverse and outstanding group of professors, researchers, and classmates.
4. Prepare themselves for the public and private sector employment, graduate school, and successful careers.

Assessment of Intended Outcomes:

- Student Learning Outcome 1. Master a broad set of fundamental biological knowledge including how to search for, understand, and synthesize primary scientific literature, and understand how fundamental biological principles relate to the marine environment.

  Assessment Measure 1: Final exams in Marine Biology, Ecological Genetics, and Marine Ecology will be reviewed for randomly selected students for appropriate content knowledge.

  Assessment Measure 2: Embedded questions in program coursework exams.

  Assessment Measure 3: For Honor students, capstone research thesis oral and written presentation as assessed by a common rubric.

- Student Learning Outcome 2. Solve problems competently by identifying the relevant features of the problem and developing a strategy to solve the problem.

  Assessment Measure 1. For Honor students, capstone research thesis oral and written presentation as assessed by a common rubric.

  Assessment Measure 2: Embedded questions in program coursework exams.

- Student Learning Outcome 3. Use computers and computational approaches to acquire and process data as well as use software to analyze data.

  Assessment Measure 1: For Honor students, capstone research thesis oral and written presentation as assessed by a common rubric.

  Assessment Measure 2: Projects in modeling and laboratory-based courses will be reviewed for randomly selected students for appropriate content knowledge.

- Student Learning Outcome 4. Understand the objectives of research experiments, properly conduct experiments, and appropriately record, analyze, and communicate the results.

  Assessment Measure 1: For Honor students, capstone research thesis oral and written presentation as assessed by a common rubric.

  Assessment Measure 2: Select questions of Senior Exit Survey.

- Student Learning Outcome 5. Effectively communicate the concepts, results, and implications of their laboratory experiments and independent research both orally and in the written form to experts in the field, scientists in other disciplines, and the general public.

  Assessment Measure 1: For Honor students, capstone research thesis oral and written presentation as assessed by a common rubric.

APPENDIX III

Marine Biology and Ecology RIL courses organized by Program of Study. Note that undergraduate students with the necessary prerequisites and in accordance with the policy statement in the University of Miami Academic Bulletin are eligible to take graduate level MBE courses. **Courses currently listed as Marine Science but have been developed and consistently taught by MBE faculty will be re-coded as Marine Biology and Ecology*

(a) Marine Ecology and Conservation

MSC 366 (3 cr) Tropical Marine Ecosystems*
MSC 365 (1 cr) Tropical Marine Ecosystems Field Course*
RSM 521/621 Object Oriented Programming and Agent-Based Modelling

(b) Marine Genetics and Genomics

MSC 326 (3 cr) Marine Genomics*
MSC 463 (3 cr) Marine Conservation Genetics*
MBE 535 (3 cr) Practical Computing for Biologists*

(c) Environmental Physiology and Toxicology

MSC 327 (3 cr) Marine Animal Neurophysiology and Behavior*
MSC 403 (3 cr) Environmental Toxicology*
MSC 404 (1 cr) Marine Organismal and Environmental Health Research Trip*
MSC 466 (3 cr) Environmental Physiology + Lab*
MBE 586/MBE 686 (3 cr) Environmental Fish Biology
RSM 580/RSM 680 (3 cr) Techniques in Respirometry of Aquatic Organisms

(d)) Marine Health and Biomedicine

MSC 465 (4 cr) Marine Comparative Immunology + Lab*
MBE 576/676 (3 cr) Diseases of Marine Organisms

(e) Galapagos

MSC 420 (3 cr) Political Ecology of the Galapagos
MSC 421 (3 cr) Terrestrial Biology and Adaptations of the Galapagos*
MSC 422 (3 cr) Marine Ecology of the Galapagos*
MSC 423 (3 cr) Marine Conservation Biology and Fisheries of the Galapagos*
MSC 424 (3 cr) Origin and Geology of the Galapagos Islands
MSC 425 (2 cr) Galapagos Community-Based Research and Service

APPENDIX IV

General Science Electives within the areas of Biology, Biochemistry, Ecosystem Science and Policy, Healthcare Sciences, Marine Biology and Ecology, Microbiology and Immunology, Marine Science, and Neuroscience that fall into the different Programs of Study. Undergraduate students with the necessary prerequisites and in accordance with the policy statement in the University of Miami Academic Bulletin are eligible to take graduate level courses appropriate for the different MBE fields of study. **Courses currently listed as Marine Science but have been developed and consistently taught by MBE faculty will be re-coded as Marine Biology and Ecology*

(a) Marine Ecology and Conservation

BIL 539 (3 cr) Conservation and Protected Areas
MSC 220 (3 cr) Climate and Global Change
MSC 313 (3 cr) Coastal Law
MSC 340 (3 cr) Ocean Policy
MSC 410 Marine Conservation*
MSC 415 (3 cr) Coral Reef Science and Management*
MSC 350 (3 cr) Survey of Marine Mammals
MSC 316 Global Primary Production
MBE 515/615 (3 cr) Tropical Marine Ecology
MBE 518/618 (3 cr) Reef Coral Biology, Ecology and Conservation
MBE 521/621 (3 cr) Field Techniques Instrumentation Tropical Marine Ecology

(b) Marine Genetics and Genomics

BMB 401 (3 cr) Introduction to Biochemistry
BIL 455 (3 cr) Developmental Biology
BIL 565 (3 cr) Evolution and Development
MSC 318 (3 cr) Ecological Genetics*
NEU 400 (3 cr) Neurogenetics
NEU 468 (3 cr) Developmental Neuroscience
MBE 529/629 (3 cr) Population Genetics & Genomics

(c) Environmental Physiology and Toxicology

BMB 401 (3 cr) Introduction to Biochemistry
BIL 268 (3 cr) Neurobiology
BIL 365 (3 cr) Endocrinology
BIL 343 (3 cr) Animal Communication
BIL 352 (3 cr) Techniques and Scanning Electron Microscopy
MSC 328 (3 cr) Introduction to Aquaculture
MSC 350 (3 cr) Survey of Marine Mammals
NEU 342 (3 cr) Neural Mechanisms of Disease

d) Marine Health and Biomedicine

ECS 309 (3 cr) Microbes and the Environment

Healthcare Sciences (HCS) 206 (3 cr) Introduction to Public Health
HCS 208 (3 cr) Introduction to Epidemiology
HCS 309 (3 cr) Health and Environment
MSC 300 (3 cr) Water Resources: History, Management and Policy
MSC 462 (3 cr) Marine Biomedicine
MSC 371 (1 cr) Readings in Marine Invertebrate Disease*
MSC 371 (1 cr) Readings in Shark Immunology*
MBE505/605 (3 cr) Marine Mammal Disease and Medicine

A Proposal for OCE Single-Major Undergraduate Program

Contents

1 Executive Summary

Our objective is to develop a new educational structure to train the next generation of talented and driven individuals, who will contribute to the global community, and help shape the future societies. The program will capitalize on existing strength and expertise in the Ocean Sciences Department, and expand teaching and advising opportunities for its members.

We are proposing to initiate a new *single-major Oceanography* undergraduate program. This single-major program will co-exist with the well-established double-major MSC program and will attract students who want to concentrate on specific future-looking applied tracks that provide both the fundamental background and specific skills that are in high demand in the modern job market. Our main purpose is to develop a future-looking new program to address growing environmental concerns, and socioeconomic impacts on coastal regions globally.

Six tracks are proposed within the new single-major Oceanography Program. These tracks will come online gradually (over the next 3 to 5 years) as the major grows and will potentially include *Climate Science, Marine Environmental Chemistry, Microbial Oceanography, Coastal Impacts, Big Data in Ocean Applications and general Oceanography.* Each track consists of 10 specialization courses that will be taken during junior and senior years, after following closely the existing MSC courses during the freshman and sophomore years. The curricula consist mostly of existing courses that are offered within the University, but we propose the addition of 17 new courses with program growth. These courses are intended to provide not only knowledge, but also hands-on skills to the undergraduate population. These tracks will provide more in-depth marine science training with opportunities for experiential learning, preparing students to apply their knowledge to solve problems on current issues facing society, or to pursue further research in graduate school. In some tracks (but not all), students are expected to engage in a senior capstone project, or alternatively, they can seek internships as a transition to work outside of the university.

2 Motivation

A new undergraduate program for the Ocean Science Department is motivated by two factors:

a) **The need for safe and sustainable coastal societies:** There have been significant changes in modern societies leading to a tenuous balance with the oceanic environment. Ever since the beginning of the industrial revolution about 200 years ago, modern societies focused on production of goods and services with emphasis on steady growth of consumption. This idea certainly improved the standard of living and the world population grew from 1 to 7 billion people during that time. Major population centers naturally developed along the coast, with the ocean being a conduit for transportation and commerce as well as providing food and resources. This essential role of the ocean in society is reflected today by the fact that 80% of people live on the coast and the world's largest cities are located near the water. According to the UN Atlas of the Oceans, about two-thirds of the world's population live within 60 kilometers of the coast, and this number is rising. Growing population and development in coastal zones increases society's vulnerability to natural and anthropogenic hazards and adds additional stress on the coastal environment. Nevertheless, awareness about the ongoing changes in coastal environment, and societal impact on water resources have been slow to develop.

Extreme vulnerability of ocean and coastal zones is becoming increasing clear. Driven by anthropogenic climate change and natural climate variability, the sea level is rising globally, with regional changes often overstripping the global increase. These regional changes lead to largely irreversible and potentially catastrophic damage to coastal communities, inundating large swaths of land, compromising the freshwater supply, transportation, water drainage and natural ecosystems (e.g. Everglades), and dramatically amplifying damage from storms and other extreme events. Regardless of any mitigation measures that the global community may take in the future, understanding of these changes and adaptation to them is urgently needed for all coastal communities. These issues are particularly critical to South Florida, which is already experiencing adverse effects of sea-level rise, with the potential for negatively impacting real-estate values, tourism and economic development.

Pollution from natural and anthropogenic causes is another major threat to coastal communities and local economies. For instance, more than 400,000 people were without clean drinking water as a results of toxic algal blooms in Lake Erie in 2014. In 2016, a third of Lake Okeechobee was covered in algal blooms, mostly from nutrient runoff from fertilized farm lands and gulf courses. Releasing Okeechobee water through canals led to a situation in which the algal blooms blanketed Florida beaches in the summer of 2016. The Deepwater

Horizon oil spill event in 2010, the largest accidental marine oil spill in history, led to $60 billion in damages and penalties to be paid by BP, an amount comparable to Florida's $80 billion annual tourism industry. In the aftermath of the Fukushima earthquake and nuclear reaction meltdown in 2011, one million tons of debris washed ashore near the US West Coast across the entire Pacific Ocean only two years later, raising awareness that human societies are all connected and exposure to nuclear materials might have been transported over large distances as well. Since 2010 it has been shown by water regulatory agencies, with the help of RSMAS and UM faculty, that FPL's Turkey Point nuclear power plant cooling canals are leaking the radioisotope tritium into the coastal aquifer and Biscayne Bay. The City of Miami built water collection canals in order to avoid flooding during king tides and started pumping them into Biscayne Bay, a practice with perhaps long-term consequences for water quality and public health in the most expensive and popular locations in Miami. Due to the expansion of the Panama Canal, entrance to Port of Miami has been also modified, but due to the changes in the circulation, it appears that some of the coral reef habitat was destroyed.

Such familiar examples are too many to list here. Nevertheless, it is clear that human activities are having an immediate negative impact on the marine environment. *As such, sustainable coastal societies require trained individuals who understand the global and regional coastal environmental vulnerability, can analyze and interpret observational data and model predictions, and work out science-based solutions by working together with the industry, governments, and non-profit organizations, as well as possessing excellent communication skills. These individuals are expected to be able to see the "big picture", thus need to obtain a wide skill set to operate across different groups.*

b) **The need to modernize undergraduate programs:** Modernization of undergraduate programs at universities is a growing need, because of increasing complexity of problems facing societies and growing demand for highly educated workforce. At the same time, the tuition and student debt have been increasing nationally. Currently, student debt stands at $1.4 Trillion in total (which is larger than the national credit card debt) and close to $40 thousand per student. Despite the significant increase in tuition cost over the past decade, universities often have failed to match their education with quickly evolving societal needs. Because the rate of tuition increase exceeds the national inflation, it is fairly clear that university undergraduate programs will be subject to scrutiny regarding their value in the near future. In addition, high-cost private universities are facing increasing competition with public universities, community colleges and online universities. We are in a situation where the past is not an accurate guide for the future. Subsequently, there is a genuine and growing need for the next generation of graduates from educational programs that combine

fundamental understanding of problems facing coastal communities with practical knowledge and skills for societal use. New types of jobs are likely to emerge for communities under coastal environmental stress. Thus, it is crucial to develop forward-looking innovative programs, such as the one proposed here, that are built on existing academic excellence and experience, but are also actively adapting to opportunities and evolving societal needs.

3 Key Characteristics of the Programs

a) **Building on success of the Program:** Given the tremendous success of the current double-major MSC Program (40 years in the development, 400 students enrolled, consisting of applicants with the highest SAT scores at the University of Miami), a key consideration was to develop new opportunities. Our goal is to create new educational opportunities and increase the total number of students in the field of Marine Science. Our intension is, therefore, to attract students who want to concentrate their learning along six single-major tracks tailored to specific challenges facing coastal communities. These opportunities will be built on existing MSC strength in undergraduate education. Thus, the new Program is envisioned as a single-major program effectively sharing the first 3 semesters of the MSC courses, with 10 specialization courses in sophomore, junior and senior years.

b) **Multiple tracks:** The Program is made attractive by offering six different tracks:

i) *Marine Environmental Chemistry:* This track will offer courses on solutions to the challenges of clean water, pollution, ocean acidification, environmental toxins (from harmful algal blooms and human sources), and exploration in natural products (pharmaceuticals).

ii) *Microbial Oceanography:* This track will offer courses on solutions for the ecological impacts of ocean acidification, coastal pollution, understanding the causes and impacts of harmful algal blooms, dead zones, ecosystem management including reef preservation, restoration from oil spills, applications in aquaculture for food supply and energy.

iii) *Coastal Impacts:* Courses on this track will stress the importance of understanding of the hazards threatening coastal regions and their linkages to global oceans, exploring ways to increase the resilience of coastal communities and to bolster efforts at environmental protection. Students in this track will be presented with a comprehensive view on the modern science of interactions between land and oceans, threats to coastal communities and environment from sea-level rise and accelerating coastal development, as well as available solutions to these problems.

iv) *Big Data in Ocean Applications:* This track is based on the recognition that there has been a tremendous increase in information (such as satellite data and re-analyses by national centers) with the wide-spread availability of computers and internet access globally over the past two decades. The large amounts of data contain valuable information, which is only accessible by those who know how to do data processing and analysis. This trend is likely to grow exponentially in the future, creating opportunities for employment.

v) *Climate Science:* This track is intended to capitalize on general public interest in climate change, its scientific quantification, local and global socioeconomic impacts.

vi) *Oceanography:* Instead of following one of the four tracks above, the students will have the opportunity to define a program of 10 courses drawn from these course tracks, guided by a faculty member, to align with a specific oceanography interest (e.g., biological, chemical and physical).

c) **Adaptive Update of Tracks:** We envision frequent reviews and updates of tracks depending on student intake and their demands and opening of new tracks in order to keep the Program dynamic, fresh and adaptive to emerging trends.

d) **Emphasis on Knowledge and Skills:** One of the core objectives, is to provide the students not only with a general education and understanding of the subject matter, but also with skills that would make them better prepared for graduate education and eventually employable in the job market of the future.

e) **Reliance on both existing and new courses:** The Program relies both on existing courses offered from multiple departments at the University of Miami, and RSMAS in particular, and new courses developed by OCE faculty. The new courses will be tailored to the needs of students in the proposed tracks and capitalize on the expertise of OCE faculty.

f) **Research-Based Honors Project or Internships:** Perhaps the most important characteristics of the OCE faculty is their experience in leading-edge research. In order to exploit this quality, undergraduate students are expected to complete a research project, advised by OCE faculty for their senior thesis. Alternatively, students will be required to have internships.

4 Market Research and Existing Marine Science Programs

During the preparation of this Program, the Committee interviewed ten individuals for reasons of market research. These included senior people from energy companies (Chevron, Shell and

Exxon), from the reinsurance industry, from a local construction company, the South Florida Water Management District, local government as well as a relevant center from the University of Miami.

These individuals all recognized the increasing deterioration of the environment due to overpopulation, climate change and the sea-level rise. It was also recognized that effective communication skills will become increasingly important in an interconnected global community. It is also becoming important to have an understanding of multiple fields, so an interdisciplinary education is preferred, as opposed to specializing narrowly on a single area. Critical, logical and independent thinking was identified as the most important skill by all experts we interviewed. Overall, companies are interested in hiring individuals not only with good technical skills, but also those who can see the big picture and work across different groups to attain clear objectives and provide financial benefits for the company. In general, analytical, technical and communication skills are considered more important than general knowledge (knowledge is something that driven individuals can attain through a lifetime of learning). Internships are viewed as a good way to grasp what is important outside of academia.

The Committee also investigated existing marine and/or environmental science programs in other universities. In particular, the programs at Eckerd College, Florida State University, University of California at Davis, Coastal Carolina University, University of South Carolina, Middlebury College, Duke University, Humbolt State University and Quest University. We also find that there is a healthy demand in all these marine undergraduate programs listed above.

5 Curriculum of Oceanography Program

I General Structure of the Curriculum

During the first three semesters:

Courses taken here follow the Marine Science Core curriculum.

Take each of:

- Calculus I (MTH 161 or 171)
- Calculus II (MTH 162 or 172)
- Statistics for Environmental Science (MSC 204)
- Physics I (PHY 205, mechanics, heat, fluids, waves)
- Physics II (PHY 206)

- Phys lab (PHY 208)
- Chemistry I (CHM 111)
  - Chem lab (CHM 113)
- Chemistry II (CHM 112)
  - Chem lab (CHM 114)
- Biology I (BIL 150)
  - Bio lab (BIL 151)
- Intro to Marine Science (MSC 111)
  - Mar Sci lab (MSC 112)
- Introduction to Programming for Marine Science

Pick 1 of:

- Climate & Global Change (MSC 220)
- Climate Science & Policy (MSC 346)

Pick 1 additional class in marine and/or environmental policy, and complete one of these cognates:

- *Marine Policy*
  https://cognates.miami.edu/PS_0027
  includes MSC 111 & MSC 346
- *Environmental Politics & Policy*, https://cognates.miami.edu/PS_0053
  includes MSC 220 & MSC 346
- *Global Sustainability, Living on a Finite Planet*, https://cognates.miami.edu/PS_0052
  includes MSC 220 & MSC 346
- *Social & Scientific Perspectives on Global Environmental Change*, https://cognates.miami.edu/PS_0050
  includes MSC 220

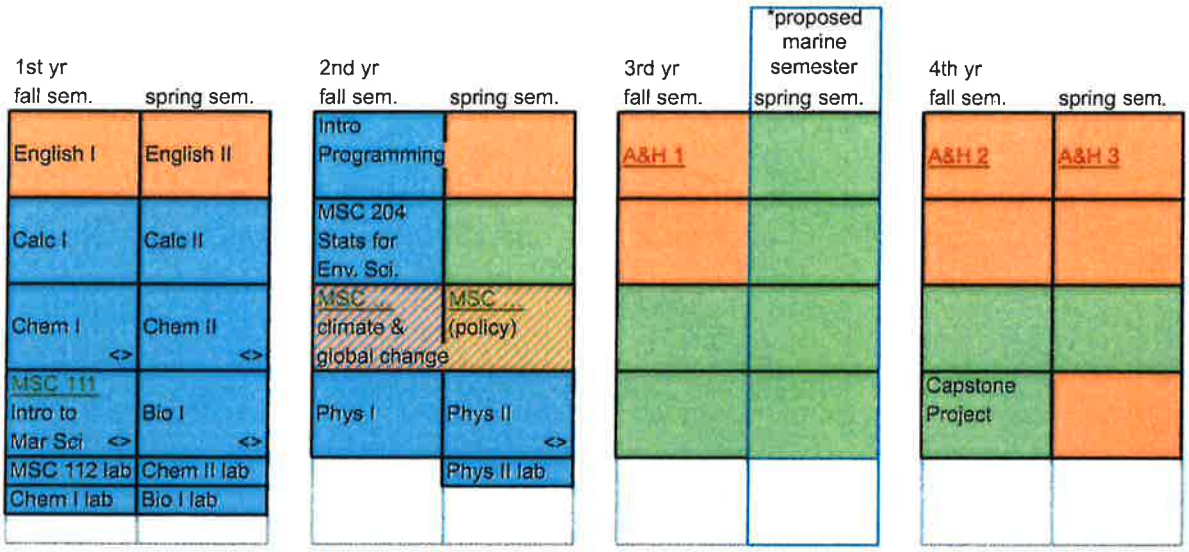
Oceanography Tracks:

During last five semesters:

Specialize in a *track*, taking 10 courses from a suggested curriculum including a Honors Thesis

Project (suggested fall semester of 4th year), and either a Science Writing or a Science Communication course. Tracks are designed to facilitate a *marine semester* (suggested for the 3rd year) focused on field-based and hands-on inquiry courses. These could be based at RSMAS or abroad.

The curriculum structure is summarized in Figure 1.



Color key:

"Core" classes for major in first 3 semesters
"Focus" classes for major (**track**) in last 5 semesters
Other **UM classes**
MSC ... = recommended for P&S cognate*
A&H= Arts & Humanities cognate*

*Cognates: students majoring in STEM will need to do 3 classes in a 'People & Society' cognate (P&S), and 3 classes in an 'Arts & Humanities' cognate (A&H)

Credit info:

120 total credits to graduate = average 15 credits/semester
typical class = 3 credits, lab =1 credit
typical semester = 4 classes, plus some labs; some semesters could have 5 courses
<> denotes class with lab

Figure 1: Course layout common to all tracks.

II Curriculum of Marine Environmental Chemistry Track

Applications: Solutions to the challenges of clean water, pollution, ocean acidification, neurotoxins (harmful algal blooms), and exploration in natural products (pharmaceuticals).

Skills attained: Analytical chemistry, instrumentation technology (a little hardware + a little software), data analytics.

Job opportunities: Clean water (both analytical approaches and policy applications, domestic and international), environmental monitoring including experimental design and implementation, pharmaceuticals, geochemistry in energy industries.

Course list:

Track classes for Marine Environmental Chemistry Track - 10 total:

- Required courses:
  - Organic Chemistry I (CHM 201)
    - Orgo Chem lab (CHM 205)
  - Chemical Oceanography (MSC 215)
    - Chem Oce lab (MSC 216)
  - Marine organic chemistry (new)
- Take at least 5 courses (3 must be from * list):
  - Environmental chemistry (CHM 401)*
  - Marine biota and biogeochemical cycles (MSC 417)*
  - Air pollution and climate change (new)*
  - Marine Biomedecine (MSC 462)*
  - Humans and Oceans (new)
  - Geophysical data analysis and visualization
  - Physical and Chemical Processes in Coastal Ecosystems (MSC 217)
  - Intro to physical oceanography (MSC 301, lab MSC 302)
  - Spatial Applications in Marine Science (MSC 460) (intro to GIS)
  - Introduction to Marine Geology (MSC 240; note it has prereq GSC 110 or 111)
  - Coastal processes field course (new)*

- Environmental assessment field techniques (new)*
- Marine instrumentation (new)*

- Pick 1 of:
  - Science communication (new)
  - Scientific writing (ENG 107)

- Required: Capstone project
  - Internship in a relevant program OR
  - Research project: environmental assessment or instrumentation development

Capstone Research Project: Focused on solving an environmental challengeX is an issue in the environment, how do you measure X?

Two options: students could undertake either a more *field-focused environmental assessment project*, or *a lab-focused instrumentation development project.*

(i) *Environmental assessment:* design and execute a sampling and analysis plan to measure X, e.g. determine if X is different in one environment vs another, or if X is changing over time, or if X is impacted by Y. ex: is nitrate higher at beaches with more frequent city-mandated beach closures based on fecal indicator bacteria? tools: sampling equipment, wet lab sample prep, analytical instruments including spectrophotometer for nutrients, oxygen probe, pH meter, thermometer

(ii) *Instrumentation development:* build a detector for X (target may be deployable instrument for ROV or AUV mounting, or stationary sensor with high time resolution). Involves some hardware, some software, and knowledge of environment and parameter of interest. *Example:* build a detector for nitrate that could be mounted on a mooring for continuous sampling. *Tools:* arduino or raspberry pi processor, add-on components, basic electrical connection tools.

Marine Environmental Chemistry

1st yr fall sem.	1st yr spring sem.	2nd yr fall sem.	2nd yr spring sem.	3rd yr fall sem.	3rd yr spring sem.	4th yr fall sem.	4th yr spring sem.
English I	English II	Intro. programming for mar. sci.	(UM elect.)	A&H 1	Environ. assessment field tech.	A&H 2	A&H 3
MTH 161 Calc I	MTH 162 Calc II	MSC 204 stats for Env. Sci.	MSC 215 Chem Oce	(UM elect.)	Marine instrument.	(UM elect.)	(UM elect.)
CHM 111 Chem I	CHM 112 Chem II	MSC 220 Climate & global change	MSC 346 Climate Sci & policy	MSC 417 Marine biota & biogeoch.	Marine organic geochem.	Geophys. data analy. & visualiz.	(UM elect.)
MSC 111 Intro to Mar Sci	BIL 150 Biology I	PHY 205 Phys I	PHY 206 Phys II	CHM 201 Orgo Chem	Coastal processes	Capstone Project	ENG 107 Science writing
CHM 113 lab	CHM 114 lab		PHY 208 lab	CHM 205 lab			
MSC 112 lab	BIL 151 lab		MSC 216 lab				

Color key:

"Core" classes for major in first 3 semesters
"Focus" classes for major (**track**) in last 5 semesters
Other UM classes
P&S = 3 courses required in People & Society cognate--can be satisifed with policy-focused MSC classes
A&H = 3 courses required in Arts & Humanities cognate

Figure 2: Example course layout for Marine Environmental Chemistry Track.

III Curriculum of Microbial Oceanography Track

Applications: Solutions for the ecological impacts of ocean acidification, coastal pollution, understanding the causes and impacts of harmful algal blooms, dead zones, ecosystem management including reef preservation, restoration from oil spills, applications in aquaculture for food supply and energy.

Skills: Molecular biology techniques, microbial analytical tools, ecosystem assessment, computational data analytics tools.

Job opportunities: Aquaculture (commercial applications for food and energy, as well as regulatory jobs surrounding the industry), clean water (both environmental assessment and policy applications, through consulting, government, NGOs, both domestic and international), coastal sustainable development as it relates to natural ecosystems

Course list:

Track classes for Microbial Oceanography Track - 10 total:

- Required courses:
  - Biological Oceanography (MSC 218)
  - Marine microbial dynamics (**new**)
    - marine microbe lab (new)
  - Marine Biota and Biogeochemical Cycles (MSC 417)
- Take at least 5 courses (3 must be from * list):
  - Chemical Oceanography (MSC 215, lab MSC 216)*
  - Evolution and Biodiversity (BIL 160, lab 161)*
  - Marine Genomics (MSC 326)*
  - Marine Conservation Genetics (MSC 463)* (take with MSC 326)
  - Life in Moving Fluids (MSC 364) *
  - Marine Biochemistry* (new or BMB 401, Biochemistry for the Biomedical Sciences): Basics principles of biochemistry in the context of single-celled organisms living in an ionic solution
  - Global Primary Production (MSC 316)
  - Marine Conservation Science (MSC 410)

- Coastal Oceanography (human impacts, hydrology; new)
- Spatial Applications in Marine Science (MSC 460) (intro to GIS)
- Geophysical data analysis and visualization (similar to OCE 531, UG version, new)
- Humans and Oceans (new)
- Marine Biomedicine (MSC 462)
- Coastal processes field course (new)*
- Environmental assessment field techniques (new)*

- Pick 1 of:
  - Science communication (new)
  - Scientific writing (ENG 107)
- Required: Capstone project
  - Internship in a relevant program OR
  - Research project: environmental assessment or microbial function

Capstone Research Project: Focused on addressing an environmental challengeX is an issue in the environment, in the context of microbes, what leads to X, or what is the impact of X?

Two options: students could undertake either a more ***field-focused environmental assessment project***, or *a lab-focused microbial function project.*

(i) *Environmental assessment*: design and execute a sampling and analysis plan to investigate X in the environment, e.g. determine if X is different in one environment vs another, or if X is changing over time, or if X is impacted by Y. example: In areas that are expected to have high human inputs of nutrients (e.g. South beach), is the ratio of phytoplankton to bacteria different from less impacted areas?

(ii) *Microbial function*: design and execute an experiment to determine what microbe X is doing in an ecosystemeither how it responds to something in the environment (e.g. nitrate), or a particular role it is playing in the environment (e.g. breaking down aromatic hydrocarbons) *Example*: In response to antibiotic concentrations similar to those used in fish aquaculture, do diatom phytoplankton abundance increase or decrease? *Tools*: sampling equipment; wet lab sample prep space; light & temp controlled space for cultures; culture equipment including vials and sterile transfer equipment; analytical instruments including flow cytometer and/or imaging microscope for microbial counts, oxygen sensor, pH meter, thermometer, potentially

spectrophotomter for nutrient analysis, equipment for DNA extraction, thermocycler, potentially fluorescent probe or sequence analysis.

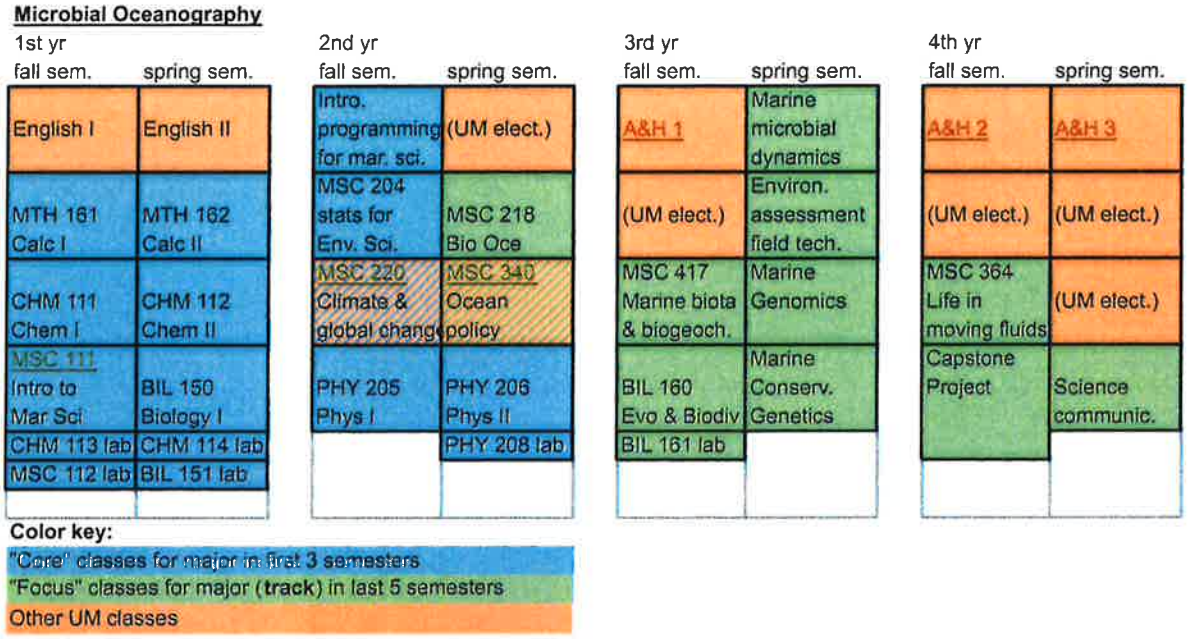


Figure 3: Example course layout for Microbial Oceanography Track.

IV Curriculum of Coastal Impacts Track

Applications: According to the UN Atlas of the Oceans, about two-thirds of the world's population live within 60 kilometers of the coast, and this number is rising. Growing population and development in coastal zones increases society's vulnerability to natural hazards and adds additional stress on the coastal environment. Sea-level rise and climate change amplify these hazards and stressors and increase uncertainty in the future of coastal zones. These changes outline the importance of understanding of the hazards threatening coastal regions and their linkages to the global ocean, exploring ways to increase the resilience of coastal communities and to bolster efforts at environmental protection. Students in this track will be presented with a comprehensive view on the modern science of interactions between land and oceans, threats to coastal communities and environment from sea-level rise and accelerating coastal development, as well as available solutions to these problems.

Focus classes for Coastal Impacts Track - 10 total:

- *Required courses:*
  - Ocean Hazards: Sea-level rise and storms (200-level, SPRING, **new**)
  - Coastal Oceanography (**new**)
  - Coastal Hydrology (300-level, SPRING, **new**)
  - Coastal Processes Field Course (**new**)
- *- Pick at least four courses from the following electives:*
  - Environmental Fluid Mechanics (300-level, SPRING **new**)
  - Introduction to Marine Geology (GSC 240, SPRING)
  - Geophysical Data Analysis and Visualization (400-level, SPRING, **new**)
  - Spatial Applications in Marine Science (MSC 460) (GIS methods)
  - Geophysical Fluid Modelling (400-level, FALL, **new**)
  - Introduction to Remote Sensing (400 level, FALL, **new**)
  - Coastal Observing Systems (200-300 level, SPRING, **new**)
  - Climate and Global Change (MSC 220, FALL/SPRING)
- *Pick at least three courses from the following electives:*
  - Humans and Oceans (**new**)
  - Coastal Law (MSC 313, FALL)
  - Ocean Law (MSC 314)
  - Climate Science and Policy (MSC 346, SPRING)
  - Ocean Policy (MSC 340)
- *OR pick one of these Cognates:*
  - Environmental Politics and Policy
  - Social and Scientific Perspectives on Global Environmental Change
  - Making Environmental Policy Decisions

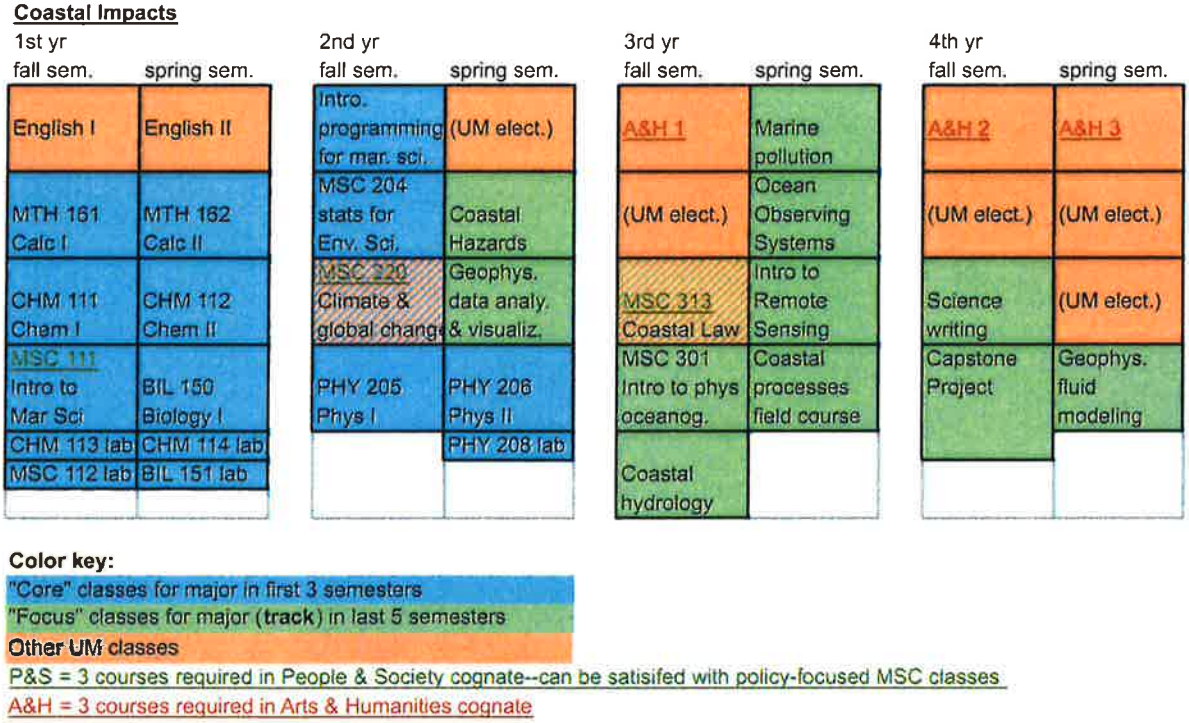


Figure 4: Example course layout for Coastal ImpactsTrack.

V Curriculum of Big Data in Ocean Applications Track

Applications: Oceanographic data sets of observations in space and time are growing at an ever increasing rate owing to advanced is satellite remote sensing, new underwater acoustic sonar applications, commitment to fixed ocean observation systems and advanced in other ocean measurement technology such as expendable drifters new chemical and biological measurements. Likewise computer capability to handle and analyze such large data is keeping pace.

Specializing in the analysis of any one of these data sets offers challenges and career opportunities. For example; underwater acoustics is most important to geo-petroleum exploration, the studies of the effects of anthropological sounds on marine mammals, and, a great variety of military applications. Similarly, satellite remote sensing data analysis offers a wide range of opportunities.

On a larger scale, analysis of combined data sets offers new challenges and career opportunities. The classic oceanographic data analysis methods of time series analysis have evolved and expanded into a more generalized statistical approach of multivariate regression often referred to as "Big Data, that has applications in a wide range of industries. The idea is to discover statistically significant relations between variables and/or combination of variables that were previously unrecognized. For example, the occurrence of Red Tides seems to depend on a complicated and unknown relation of multiple chemical, biological and ocean dynamic factors that has yet to be discovered. This is a prime target for a Big Data approach.

The Ocean Data Analysis track for the first two years provides a general background in oceanography with emphasis on bio-chemical variability and ocean dynamics. The last two years emphasizes development of skill sets to acquire, sort and otherwise analyze ocean data sets. Modern scientific programing languages such as MATLAB are emphasized. Data acquisition systems and instrumentation are developed in detail for three categories on ocean data types; underwater acoustic, satellite remote sensing and conventional oceanographic instruments. Statistical analysis method taught along with dynamic regression for the analysis of Big Data.

Focus classes for Big Data in Ocean Applications Track - 10 total:

- *Pick 4 of:*
  - MTH 320: Introduction to Numerical Analysis, 3 credits: Interpolation, quadrature, numerical solution of algebraic and transcendental equations, and optimization. Prerequisite: MTH 210 and (211 or 310).
  - ECE 118. Introduction to Programming. 3 credits: Introduction to computing, problem solving, program design, C++ language fundamentals, and software engineering principles. Software design projects are included.

- ECE 336. Discrete-Time Signals And Systems. 3 credits: This course provides the basics connecting continuous-time (CT) and discrete-time (DT) signal processing, and an introduction to discrete-time signals and systems and applications. Topics include communication, sampling, discrete-time linear time-invariant (LTI) signals and systems, difference equations, z Transform, transform domain analysis of DT systems, DT Fourier transform (DTFT), digital filters, applications to audio, and image processing.
- ECE 436. Digital Signal Processing. 3 credits: Topics include finite length transforms (e.g., discrete Fourier transform, discrete sine and cosine transforms) and their fast computation, finite impulse response (FIR) and infinite impulse response (IIR) digital filter design, digital filter structures, finite word length effects on filter performance, and multvariate signal processing fundamentals. Prerequisite: ECE 336.
- AMP536. Modeling of Physical-Biological Interactions. 3 Credit Hours. The course is designed to teach students the basics components for building coupled physical? biological models. Students will be able to understand the processes affecting from low- to high-trophic level organisms in the planktonic environment. Emphasis will be given on numerical simulations of mechanisms involved in: Plankton distribution.

- *Pick 6 of:*
  - Time Series Analysis: Spectral and time analysis methods for multiple inputs systems. Large data sets and multiple regression analysis. Coherency analysis. Dynamic Regression.
  - Coastal Observational Systems: Direct and indirect measurements systems. Radar, satellite and acoustic remote sensing. Lagrangian and Eulearian measurement and instruments. Sampling and experimental design.
  - Applied Ocean Acoustics: Processing of acoustic signals. The Sonar equation. Basics of modelling acoustic propagation in the sea. Arrays and introduction to detection theory. Pulse compression signals. Passive and Active Sonar systems. Acoustic Propagation in time varying oceans.
  - Introduction to remote sensing: Measuring the oceans from space. Orbits, electromagnetic theory, infrared and microwave radiometry, ocean color, radar remote sensing.
  - Geophysical data analysis and visualization: Big Data methods for oceanography data analysis, multiple regression analysis for time and spectral data. Coupled physical/biological/chemical analysis to seek out previously unknown relationships and correlations.

449 – Geophysical fluid modelling: Naturally occurring, large-scale flows in the oceans are
450 modelled beginning with equations of geophysical fluid dynamics. Numerical models
451 seek to solve the GFD equations for rotating, stratified fluid systems in which motions
452 are generated by the action of buoyancy and other forces. Existing models' predictions
453 are compared.

454 – Data Analysis for Ocean Energy Exploration: Propagation of sound in solids and layered
455 media. Petroleum prospecting data analysis. Z-transforms. Pulse compression. Effects
456 of anthropological sounds on marine mammals. Text: Clairbout.

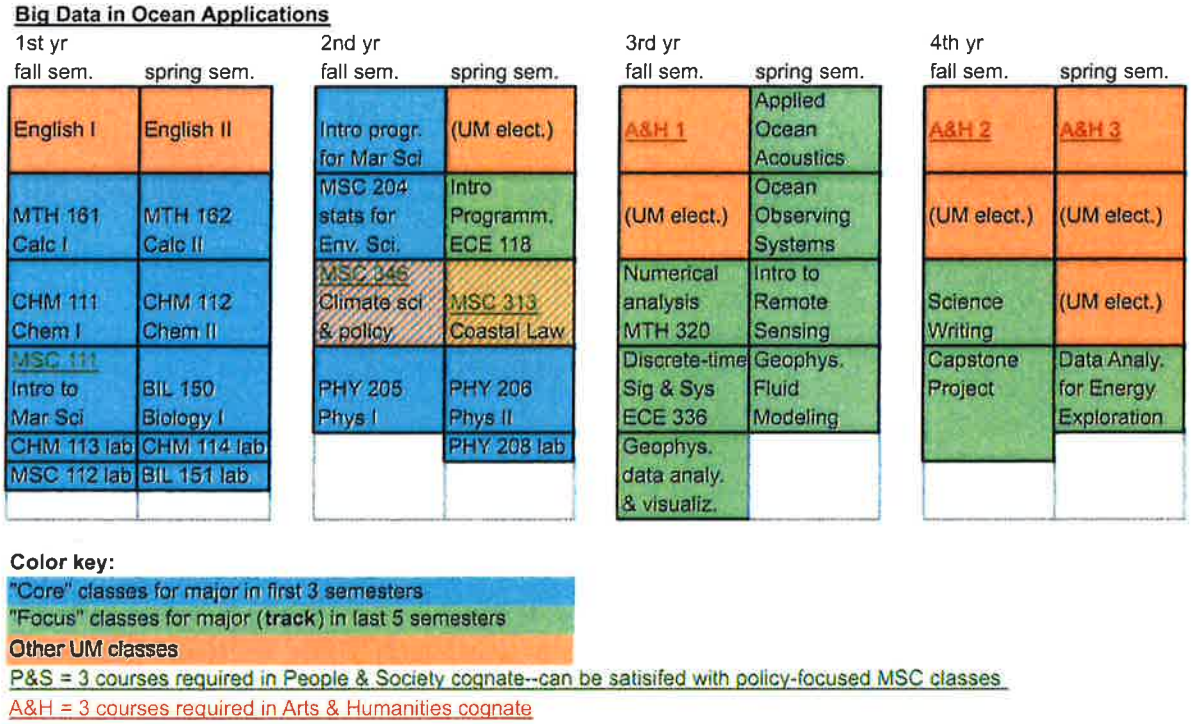


Figure 5: Example course layout for Big Data in Ocean Applications Track.

VI Curriculum of the Climate Science Track

- Science core:
  - Chemistry I, II
  - Physics I, II
  - Calculus I, II
  - Ecology
  - Statistics
  - Computer Science (modeling?)
- Climate core:
  - ATM 103
  - MSC 111/112 Intro to Marine Science
  - MSC 220 Climate and Global Change
  - MSC 417 Marine Biota & Biogeochemical Cycles
  - MSC 301/302 Physical Oceanography
  - MSC 218 Biological Oceanography
  - Polar Science / Ice
  - Hydrology
  - Physics of Climate
  - Thermodynamics
- Climate science electives:
  - Land processes
  - Coastal Processes
  - Paleoclimate
  - Climate Sci/Policy
  - Climate Law
  - GIS
  - Remote Sensing
  - Advanced Statistics / risk analysis
  - Data analysis/visualization

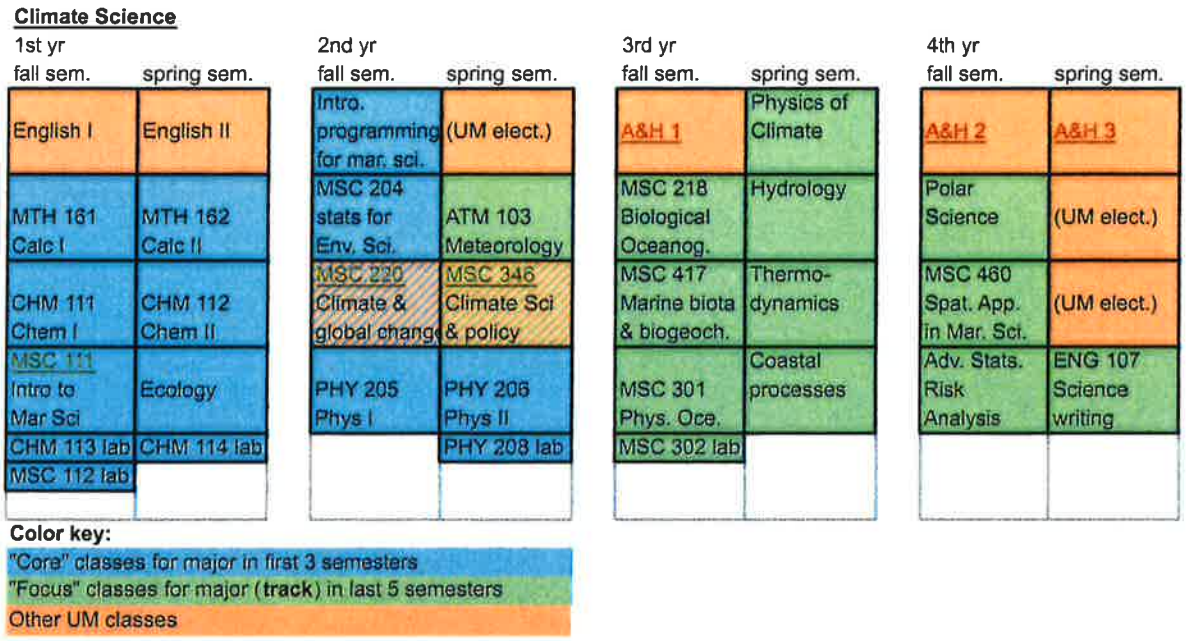


Figure 6: Example course layout for Climate Science Track.

VII Curriculum of Oceanography Track

Instead of following one of the four tracks above, the students will have the opportunity to a define a program of 10 courses drawn from these course tracks, guided by a faculty member, to align with a specific oceanography interest.

6 List of New Courses

* = could be taught during the Marine Semester (RSMAS, or Bermuda?).
Courses shown in green color are common to multiple tracks.

1. Geophysical data analysis and visualization
2. Coastal Oceanography
3. Coastal Hydrology
4. Environmental Fluid Mechanics
5. Geophysical Fluid Modelling
6. Intro to Remote Sensing

7. Time series analysis
8. Applied ocean acoustics
9. Humans and Oceans, including marine pollution
10. Data Analysis for Ocean Energy Exploration
11. *Ocean Hazards (sea-level rise, storm surge/flooding, beach erosion,)
12. *Coastal processes field course (4 credit?)
13. *Environmental assessment field techniques: 4 credit (?), field experience sampling salinity, temp, nutrients, oxygen, microbial abundance; analytical techniques including chromatography; data analysis tools (ODV, matlab)
14. *Marine instrumentation: lab based, 4 credit (?)hands-on project course building analytical instruments using components including sensors, arduino microprocessor, and/or fluidics breadboard
15. *Marine organic geochemistry: concepts behind chromatography & mass spectrometry, intro to isotopes in organic compounds
16. *Marine microbial dynamics & marine microbe lab: with lab as 4 credit (?), the role of microbes in the environment framed in their chemical context: microbial metabolic functions and their energy constraints; major functional microbial groups in the ocean and tools to identify and quantify cells and their chemical fluxes.
17. Science communication: Verbal and graphical skills for communicating science in a compelling way, exposure to communicating in a policy setting, potentially build-in community engagement by presenting at schools, museums, or for local government meetings.