

MIT-WHOI Joint Program in Oceanography/Applied Ocean Science and Engineering

Overview – Fall 2019

The goal of the MIT-WHOI Joint Program is to train and mentor the future leaders of ocean sciences. Attainment of this ambitious goal is enabled by the remarkable resources of the Joint Program: the faculty and staff of MIT, a leading science and engineering university, and the scientists, technical staff, engineers and sea-going facilities and expertise of WHOI, a leading ocean sciences research institution. This overview describes how the Joint Program (JP) brings these resources together, notes some of the accomplishments of the last five years, and describes what we see as important challenges coming in the next five to ten years.

A brief history and description of the governance of the JP

The Joint Program was established in 1968 and, as of September 2019, has awarded 1090 degrees. Of these, 792 have been PhDs or ScDs. Joint Program graduates are leaders in many aspects of research and science administration both nationally and internationally and are the surest evidence of the Joint Program's success.

The Joint Program began with a very brief Memorandum of Agreement (Appendix I) that laid down a single guiding principle: that the faculty and staff at MIT and WHOI would seek consensus on the major decisions that affect the Joint Program and its students. This principle is followed throughout the organization of the Joint Program; every committee includes representatives from the two institutions, and chairs of each Joint Committee alternate between each institution.

The JP is organized around five basic science disciplines: Biological Oceanography, Chemical Oceanography, Physical Oceanography, Marine Geology and Geophysics, and Applied Ocean Science and Engineering. This reflects the organization of ocean sciences at the time the JP was founded in the 1960s, and is in parallel with the research departments at WHOI. This organization does not parallel academic departments at MIT: Physical Oceanography and Marine Geology and Geophysics students and faculty are mainly within Earth, Atmospheric and Planetary Sciences; Chemical Oceanography within the Earth, Atmospheric and Planetary Sciences and Civil and Environmental Engineering Departments; Biological Oceanography within the Biology Department, Civil and Environmental Engineering

Department, and, since 2017, the Earth, Atmospheric and Planetary Sciences Department; and Applied Ocean Science and Engineering students and faculty are within Mechanical Engineering, Electrical Engineering and Computer Science, Civil and Environmental Engineering, and, since 2017, Aeronautics and Astronautics Department. This division by basic sciences is not in all cases the most natural organization for the research problems pursued by JP students who may work with MIT and WHOI staff from several of these disciplines and several MIT Departments.

Students may be admitted into one or more of the five disciplines, but for administrative purposes they must choose a home within one JP discipline. They must also be admitted into and have an affiliation with a department at MIT, and they also reside within a department at WHOI. Presently, JP students are affiliated with Earth Atmospheric and Planetary Sciences, the Biology Department, or one of the Engineering Departments: Mechanical Engineering, Electrical Engineering and Computer Science, Civil and Environmental Engineering, or Aeronautics and Astronautics. JP students are full-fledged MIT graduate students, and are subject to the rules and enjoy the benefits common to all MIT students.

Each of the five disciplines is managed and supervised by a Joint Discipline Committee (hereafter referred to as Joint Committee or JC) that is made up of three or more JP faculty members from each institution, nominated by the Department Head (MIT; or in some MIT departments the JP faculty members are those who volunteer) or Department Chair (WHOI) of participating departments from the partner institutions and approved by the WHOI Dean and the MIT Joint Program Director. The five Joint Committees are for Biological Oceanography (JCBO), Chemical Oceanography (JCCO), Physical Oceanography (JCPO), Marine Geology and Geophysics (JCMGG) and Applied Ocean Science and Engineering (JCAOSE). A list of current members is attached at the end of this report (Appendix II). The Joint Committees enjoy considerable autonomy insofar as they do not report to an academic department at either institution, and these committees establish the rules, guidelines and procedures (e.g., how to operate general exams). They also have the bulk of responsibility for the day-to-day functioning of the JP: they are responsible for the curriculum, for selecting instructors for JP courses, for approving thesis committees, for overseeing general examination procedures, and for conducting an annual review of the progress of each student in their discipline. The importance of the Joint Committees could thus hardly be overstated. It is essential that the home academic departments of the committee members, and especially of the committee chair, appreciate and reward appropriately the level of effort that committee duties require and the vital contribution that the committee members

and committee chairs make to the JP. Each of the Joint Committees has prepared a brief description of the issues that they have chosen to bring to the Review Committee's attention (attached at the back of this report).

The highest level of JP oversight is provided by the Joint Program Committee, which is made up of the Joint Committees Chairs, WHOI Dean, WHOI Associate Dean, and the MIT Joint Program Director. Since 2018, two MIT JP Associate Directors (currently Phil Gschwend from CEE and John Leonard from MechE) serve as ad hoc members of the JP Committee (Figure 1). The Chairs of the Joint Committees are appointed by the Director of the JP at MIT (currently Ed Boyle) and by the Vice President for Academic Programs and Dean at WHOI (currently Meg Tivey). The MIT Director and the WHOI Dean also co-chair the Joint Program Committee.

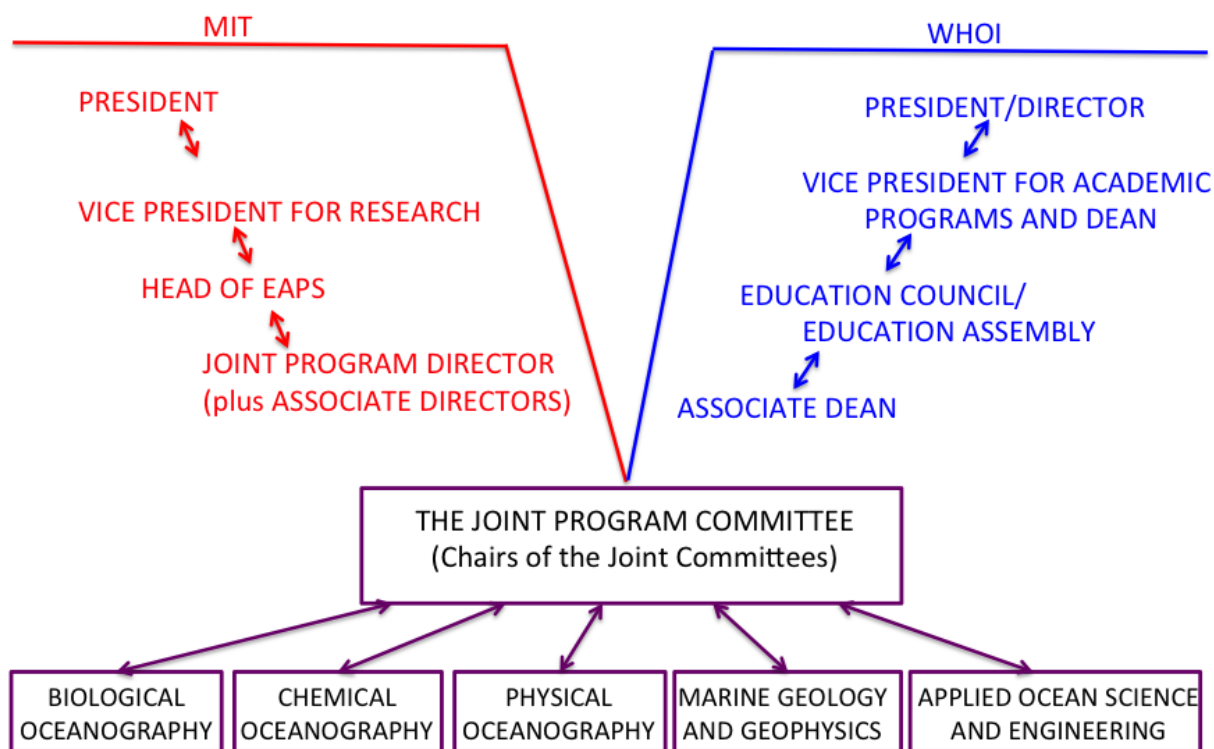


Figure 1. Organization of the MIT-WHOI Joint Program

Admissions and starting out in the JP

Students are admitted by a vote of the Joint Program Committee based upon recommendations from the five Joint Committees and by an Admissions Advisory Committee. The Admissions Advisory Committee is chaired by the WHOI Associate Dean and composed of two WHOI-based JP faculty members from each discipline who first review all applications to their respective disciplines and produce a short-list of top-tier candidates. All ten members of the Admission Advisory Committee then review and rank the top-tier applicants from all of the disciplines. This broad-based holistic review of JP applications takes time, and an effort is made to complete the process so that JP admission offers can be made by mid-February. It is significant that admission is offered on behalf of the entire Joint Program, and not just a single discipline or a major advisor. A commitment of five years of stipend and tuition support is made to admitted students, subject to making reasonable progress toward a degree. Like admission, this commitment of financial support comes from the Joint Program, and not from one department or one potential advisor.

Many entering students have interests and academic backgrounds that fit well within a single discipline, but other students arrive with research interests that span two or more disciplines. Students are admitted to the discipline that they choose (from that or, in some cases those, that the Joint Program Committee gauges to be appropriate for their preparation and stated research interests). This ensures that each student has a well-defined administrative (and scientific) home within the JP. Students are also assigned an initial advisor at the time of admission based on their stated interests and match with faculty interests and available graduate research assistant (GRA) support or other funding. Students are able to change their advisor and their home departments with approval of the relevant Joint Committees. In practice, very few students switch disciplines, but roughly 10% change their advisor at some stage of their careers, although usually not after their second year. The JP commitment of funding makes it possible for JP students to change advisors and disciplines as their research interests develop and change during their first two years in the JP, provided that they find an advisor willing to commit to raising funds to support them.

Degrees and degree requirements

JP students are admitted into a PhD or ScD program (hereafter referred to as Doctoral), with the exception of U.S. Navy Masters (SM) degree students (as noted below). General degree requirements

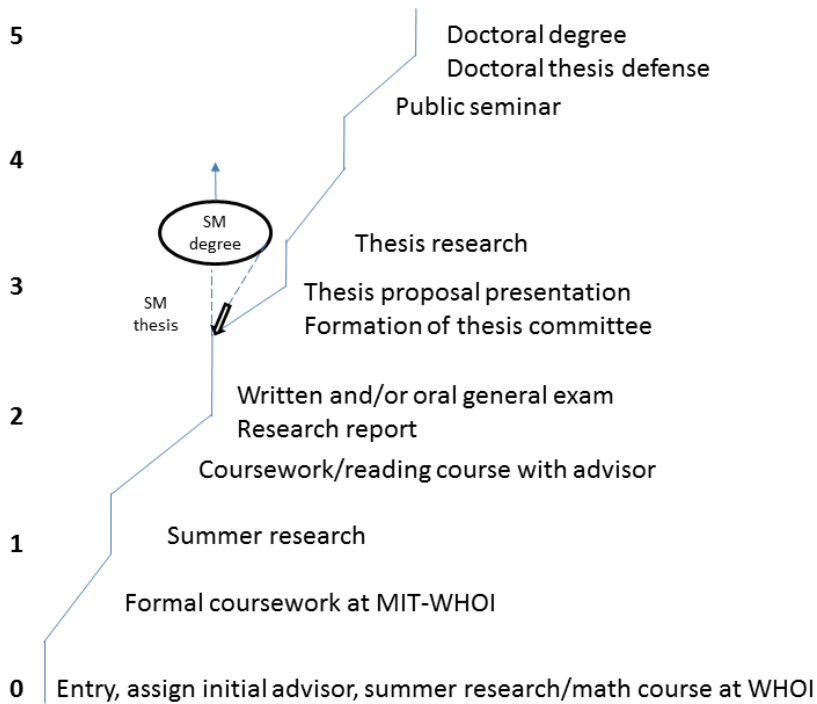
are those specified by the MIT Office of Graduate Education (<https://oge.mit.edu/gpp/degrees/>). There are no core course requirements that hold for the entire JP. Course requirements within each of the disciplines are described in the respective Handbooks (and shown in Table 1) and in all disciplines the requirements are such that there is ample opportunity for JP students to select courses that are tailored to their interests. JP students can take any course that is offered at MIT and cross-registration is available with Harvard. The curriculum of study for each individual student is determined by consultation between the student and their advisor and an Academic Advisory Committee (most disciplines have a pre-thesis advisory committee structure and all pre-generals JP students have at least one advisor that is not their supervisor/advisor).

Table 1. Discipline Course Requirements (non-engineer disciplines)

Discipline	Required Courses
BIO	7.470 Biological Oceanography 7.410 Applied Statistics A total of 36 units of coursework in oceanography or marine science (including 7.470), and no less than 96 units of non-research courses
CO	12.742 Marine Chemistry 12.759 Seminar in Marine Chemistry (twice)
MGG	12.710 Geological Oceanography 12.754 Presenting Scientific Research A data analysis course: (e.g., 1.715, 12.444, 12.714, 12.747, 12.864)
PO	No formal course requirements, but students are expected to know the material covered in the core courses (these are 12.800, 12.808, 12.801, 12.802 for the general physical oceanography track with substitutions allowed for interdisciplinary tracks). Expectation to pass general exam is 9 to 12 courses that include four core courses, one math course, and four to seven elective courses.

Each of the disciplines has a general examination requirement that students must complete in order to advance to Doctoral candidacy. The general exam is taken by most students towards the end of their fourth semester or early in their fifth semester (Figure 2). These are challenging exams, and most JP students see the general exam as the most significant event of their first two years in the program. The scope of the exam is to be consistent with requirements of the student's Joint Committee and sufficiently flexible to recognize the individualized aspects of the course of study followed by each student (see the attached policy statement on Interdisciplinary Studies – Appendix III).

Figure 2. Timeline to Degree



The format of the general examination varies somewhat between the disciplines (the Disciplinary Academic Handbooks provide the details, and an overview is provided in Table 2). In brief, Biological Oceanography, Chemical Oceanography, Marine Geology and Geophysics, and Physical Oceanography general exams each require a report (or two reports in the case of Marine Geology and Geophysics) on the research conducted by the student, and an exam, written and/or oral, that tests both specific and general knowledge. The form of these general exams was reviewed by each discipline (in response to the 2011 JP Strategic Plan – Appendix IV - and recommendations from the 2004 and 2009 JP External Review Committees that these general exams should have a uniform format across all JP disciplines) with significant (Biological Oceanography) and less significant (Chemical and Physical Oceanography) modifications made to all but the MGG general exam structure. The Applied Ocean Science and Engineering (AOSE) general exams are distinct in that they are administered by one of the four MIT Engineering Departments (Electrical, Mechanical, Civil, or Aero-Astro) with which an AOSE student may be affiliated, each of which has a different format. These general exam formats have remained the same as that of the affiliated MIT department recognizing that these large departments are not likely or willing to modify requirements for the relatively small number of JP students that are within these

departments, though it should be noted that the Biological and Chemical Oceanography general exams are distinct from MIT CEE general exams even for students who reside in the MIT CEE Department.

Table 2. General Exams, non-engineer disciplines.

Discipline	Research report	Exam
BO	Research report completed by February of 2 nd year	Oral presentation (~20 minutes) of thesis proposal followed by questions on proposal and then questions on general concepts in BO
CO	Research report completed by end of March of 2 nd year	4-hr closed book written exam on 5 questions/subjects; then oral exam with 12-minute presentation of research followed by questions on research and on written exam
MGG	Two research reports completed by fall of 3 rd year	Oral presentation of each research project and questions on research projects and on general concepts of MGG
PO	Research report completed by early May of 2 nd year	Two-day (8-hr total) open-book written exam; then oral exam with 20-30-minute presentation of research project followed by questions on research, written exam, and general concepts

The next step is the defense (or presentation) of a thesis proposal, usually within three to six months of the general exam. This too is a very significant event, in that it defines the path for the next several years of thesis research, and the likely thesis committee members. Students who successfully complete the general examination and thesis proposal defense or presentation advance to candidacy for the Doctoral degree and form a (or in PO confirm an already formed) Doctoral thesis committee. The major requirement of the Doctoral degree is the completion of a thesis that describes a significant, original, scholarly contribution to ocean science or oceanographic engineering, as judged by a thesis advisory committee composed of MIT and WHOI JP faculty and often additional faculty from other institutions, or MIT departments with no formal connection to the MIT-WHOI JP.

The Joint Committees review the academic progress of each student once per year by requiring reports from the student and advisor(s) and by discussing the progress of each student in their discipline. These reviews are attended by the WHOI Associate Dean (at present, Delia Oppo) and by one or more of the Joint Program Office staff from WHOI and MIT.

As noted above, the JP is committed to providing students with five years of full financial support, assuming reasonable progress toward a Doctoral degree. Few JP students complete a Doctoral degree within five years, but most do finish in less than 5.5 years. The average time to a Doctoral degree in

recent years is 5.4 years (Appendix V). Funding within a sixth year is not guaranteed, but has been provided almost routinely following a formal request by the student and approval by the relevant Joint Committee. Continuing into a seventh year is strongly discouraged, with no guarantee of funding except under exceptional extenuating circumstances (e.g., health or unavoidable technical/logistical problems that may cause the delay of degree completion). The retention rate of those entering the program from 2010 to 2014 to obtain a Doctoral degree is 85% (see Table 3).

Table 3. Retention of students entering into Doctoral program from 2010 through 2014*

Discipline	Doctoral Degree	Engineer Degree	Masters Degree	No Degree	Currently Enrolled	Percent Retention
Biological Oceanography	21	0	0	0	2	100
Chemical Oceanography	24	0	2	1	2	90
Marine Geology & Geophysics	19	0	1	2	1	87
Applied Ocean Science & Engineering**	10	0	5	2	2	63
Physical Oceanography	17	0	4	0	1	82
Total	91	0	12	5	8	85

*Assumes those currently enrolled will successfully complete Doctoral degree

** Excludes one Coast Guard and seven Navy students who entered for and received Masters degrees

A US Navy Masters degree program was started in 1970. Naval officers are admitted into this program with the expectation that they will complete an SM, including a thesis, in two years and three months. Prior to 2017, all of these Navy SM students have been in AOSE; beginning in 2017 it has been possible for Navy SM students to enter into Physical Oceanography. Many of the graduates have gone on to have distinguished naval careers, and they have been strong advocates of the Joint Program and of oceanography within the Navy. The retention rate of those entering the program from 2010 to 2014 to obtain a SM is 88%. The total number of Navy graduates to date is 89. For 2018, 2019, and 2020 the Navy committed to sending six Navy students to the JP, up from two per year in the period prior to 2017.

Teaching and advising effectiveness

Participation in JP teaching and advising is not mandatory for MIT and WHOI staff members. The staff who choose to participate as JP faculty take on these tasks willingly and with genuine enthusiasm for the

opportunity to interact with JP students. Enthusiasm is a good starting point, but not every capable scientist will be a naturally gifted classroom teacher or advisor, and not every pairing of an entering graduate student with an advisor will result in the kind of harmonious, long-term, fruitful collaboration that is so important for a Doctoral student.

We monitor the effectiveness of teaching and advising on a regular basis and by several means. First, students have opportunities and are encouraged to express their opinions and concerns during the annual discipline academic progress meetings, and we also encourage private communication between students and JP faculty and with the WHOI Academic Programs Office and the offices of the MIT JP Administrator and MIT Department graduate officers. Classroom teaching is also monitored by means of anonymous course evaluations that are conducted at the end of every semester. The summaries of evaluations of JP courses taught by WHOI-based JP faculty are public records, and are duly noted by the WHOI Academic Program Office (APO) and MIT senior staff. Quality of teaching is also a discussion topic during post advance-to-candidacy meetings and exit interviews that are held with each JP student as they advance to candidacy and then again as they exit the program. When problems with teaching quality become evident, we make sure that the affected faculty member(s) take some appropriate action toward improvement. One option available for new instructors, and/or those with issues related to teaching quality, is to participate in training at the MIT Teaching and Learning Laboratory (TLL, see <http://tll.mit.edu/>). In serious enough cases where training is not successful, we can suggest that the faculty member be rotated out of a teaching assignment. The course evaluations following the most recent fall and spring semesters (2019) were generally favorable, and without serious problems (available in the APO at WHOI; copies are also sent to MIT JP Director Ed Boyle).

A unique feature to JP classes is the use of a videolink to allow students at either institution to participate in classes if they cannot take the bus to WHOI from MIT or other reimbursed travel options to MIT from WHOI. The videolinked classes are recorded and uploaded for future viewing from the class website (Stellar – MIT's course management system). Issues sometimes arise with there not being enough rooms that allow videolinking; this is being addressed through use of portable units. Another issue that arose two years ago is that the audiovisual group at MIT was dissolved and one of the rooms that had been used for many JP classes was no longer available. This was immediately addressed by the MIT JP Director hiring an audiovisual technician to allow better coordination given the limited physical resources. The hope is that the ability to link classes and the availability of classroom space will be a

consideration during planning for the addition to and renovation of the Green Building (MIT Building 54).

Monitoring advising effectiveness is a much less objective process, since it involves an interaction between only two parties. The most candid feedback that we routinely get comes through post advance-to-candidacy meetings, exit interviews with JP students, annual MGG meetings (because in the MGG format the advisor is not present), and one-on-one confidential meetings of students with one of their committee members, their Education Coordinator, or the Associate Dean, Dean or MIT JP Director. The most variable qualities of JP advisors appear to be research guidance (e.g., frequency of meetings, availability, and content of interactions) and timeliness of feedback. Some advisors are inclined toward fairly close, almost day-to-day supervision, while many other advisors take a much more hands-off approach that can work well with independent students, but can be problematic if/when students are working on novel techniques or are unsure of when and whether they should be bringing concerns to their advisor. The expectations for both students and advisors are outlined in three different documents available on the web site under “Responsibilities” (<http://mit.who.edu/responsibilities>). When assigning advisors to incoming students we consider what we know of advisor tendencies and the probable needs of the incoming student. The latter is, of course, very hard to evaluate and the deciding factor in assigning advisors is more often the matching of research interests with available resources including funding and time.

When problems arise

Most JP students move through the Doctoral program without major delays or complications. However, when problems do arise from personal or academic issues, there are many and varied resources at MIT and at WHOI that JP students may draw upon. WHOI provides quarter-time financial support for an Education Coordinator within each discipline, the J. Seward Johnson Chairs in Oceanography. The Education Coordinators are appointed for three-year terms that may be renewed once with approval of the WHOI Dean. The Education Coordinators are Joint Committee members and provide continuity in the education program within each discipline; they also serve as experienced, on-call consultation resources for JP students. The Department Heads (MIT) and Chairs (WHOI), WHOI Dean, WHOI Associate Dean, MIT JP Director, MIT JP Associate Directors, and the JP office staff at MIT and WHOI are also available to JP students for consultation and advice on any subject affecting student life. Another excellent resource is the MIT Office of Graduate Education. Senior Associate Dean Blanche Staton and

Assistant Dean Suraiya Baluch are available to meet with students and provide personal support (<http://odg.mit.edu/development/gps/>). Professional counseling and other mental health services are available at both institutions (see <http://mit.who.edu/current-students> under Student Resources).

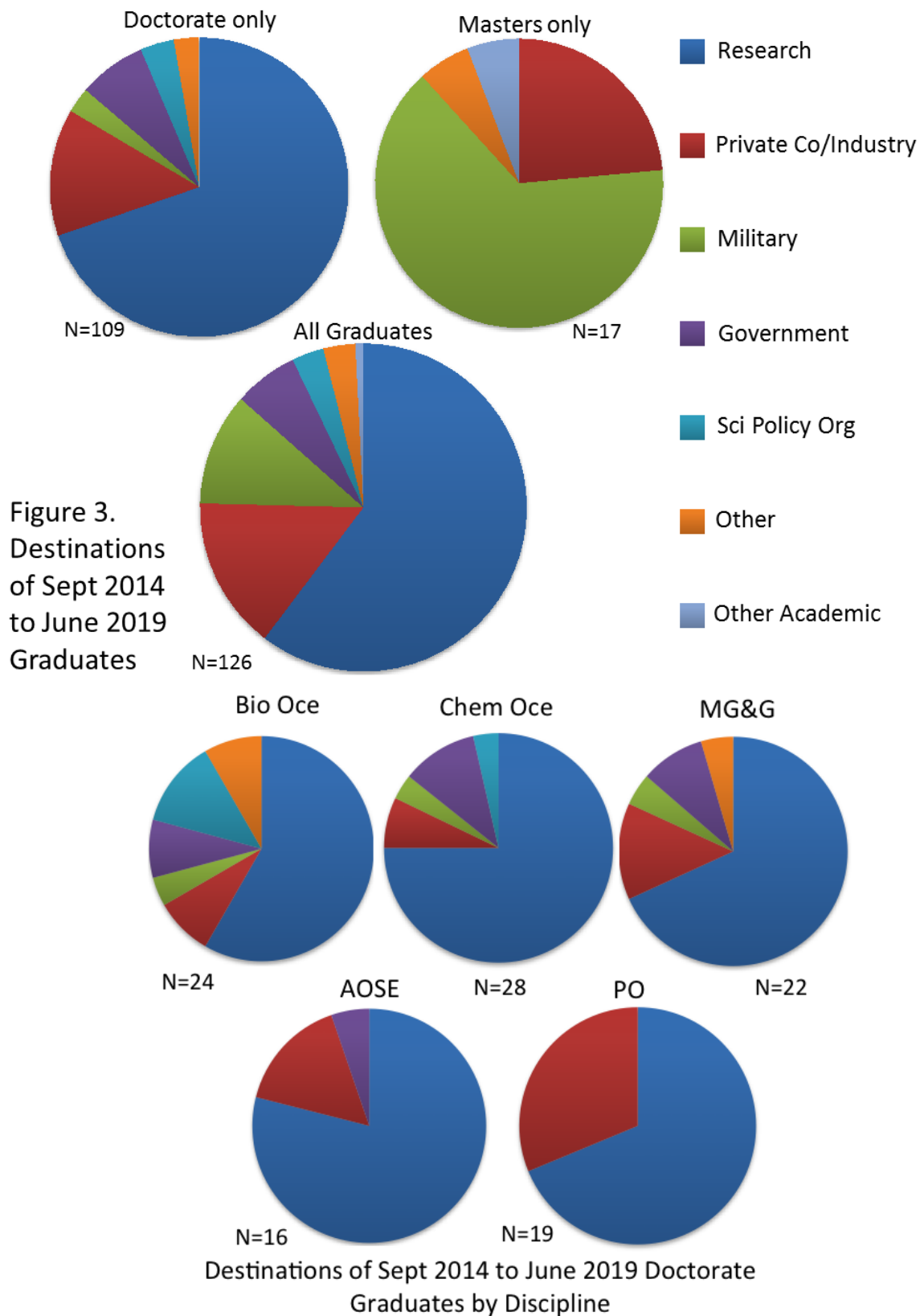
The WHOI (Graduate Admissions and Student Affairs Officer, Registrar, Budget Manager) and MIT (JP Administrator) office staff often know the JP students well since they communicate with them on a regular basis regarding all manner of logistical and administrative tasks. The office staff members are also often the first to learn when problems arise, and will steer students to the assistance they may need. JP students very often express their heartfelt appreciation for this support in the acknowledgments of their thesis.

If a Joint Committee determines that a JP student is struggling unduly with Doctoral degree requirements or if a student performs less than satisfactorily on a general examination, the student may then be directed toward an interim or possibly terminal Masters (SM) degree. Research and writing of a project that could result in an SM thesis are usually completed fairly quickly, e.g. within a year. The Joint Discipline Committee will then decide whether the successful completion of this research and write-up warrants continuation towards a Doctoral degree or whether the best course is to finish with an SM.

Mentoring and extra-academic opportunities

There is much more expected of a recent Doctoral-level scientist than can ever be learned in a classroom, laboratory, or even in a field-intensive program such as the JP. JP students have access to many extra-academic activities and opportunities for learning about the practice of science and science careers at both MIT and WHOI.

Career information and career forums. The expectation had always been that most JP graduates will begin their professional careers as research scientists, either within the academic sector, or within a governmental or industrial research laboratory. While largely true today (see Figure 3), this is less so than in the past (pre-90s) in part because many JP students are drawn to careers that involve science policy and/or communicating science to a broader audience, and in part because the outlook for tenure-track academic research positions in US universities, including oceanographic institutions, has declined significantly since the late 1980s. As a result, Doctoral graduates of the JP increasingly consider and take career paths that do not involve academic research. The pie charts (Figure 3) summarize where JP graduates go after graduation, and details are provided in Appendix VI.



Advising on possible career paths is an essential part of mentoring within the JP and at the MIT Career Development Center. There are frequent MIT career events, and JP students are made aware of them in advance. In addition, to serve those JP students who spend most of their time in Woods Hole, there are specific JP-related career panels and workshops held at WHOI. In 2015, 2017, and 2018, Dr. Jake Livengood, Senior Assistant Director for Graduate Career Services at MIT's Career Development Office, came to WHOI and gave two workshops titled "Non-academic job search: strategies and resources for PhDs" and "Ace the interview: behavioral interviewing strategies and negotiation." There have also been panels with JP alumni where they briefly discuss their career paths followed by a question-and-answer period and general discussion. Each year, a panel discussion and reception, open only to JP students and postdoctoral researchers, is held involving program managers from NSF, NASA and NOAA when they are visiting as part of the summer Ocean Carbon and Biogeochemistry workshop at WHOI. There have also been private meetings for Navy students with the Oceanographer of the Navy during the bi-annual Navy visit to MIT and WHOI.

Science and Policy. Many JP students are interested in science and policy, and several have opted to participate in the MIT Graduate Certificate Program in Science, Technology and Policy (STP) (<http://web.mit.edu/stp/>). Students can apply to this program after they have advanced to candidacy. The program provides a social and policy context to a student's research field. The program requirements of one full STP course, a one-week science policy "bootcamp," one elective course, and a capstone project are designed to fit within the traditional Doctoral degree workload. Students have included faculty with an interest or expertise in policy (e.g., three members of WHOI's Marine Policy Center, which "conducts social scientific research that integrates economics, policy analysis, and law with the Institution's basic research in ocean sciences" <https://www.whoi.edu/what-we-do/understand/departments-centers-labs/mpc/>) to their thesis committees. This interest in policy is reflected in student activities post graduation, with ~10% of graduates formally involved in policy at some level. For example, of those who have completed a doctorate between September 2014 and June 2019, four are employed by science policy organizations, one is a policy advisor, one is a foreign affairs officer, one is co-founder and director of a consulting firm that advises on adaptations to effects of climate change (flooding and rising seas), and three are current Knauss Marine Policy Fellows (see Appendix VI). In the past five years, ten Joint Program alumni have been awarded and accepted Knauss Fellowships to work for a year in the Congress or the Executive Branch; many of these graduates are the ones now in permanent policy positions.

Teaching and communicating ocean science. The JP course ‘Communicating Ocean Science’ aims to provide theory and practice for science teaching at college or secondary school level. The course is open to JP students from all disciplines, is most suitable for post-general exam students, and consistently receives positive reviews.

Quality of life within the JP

Student life at two campuses. The physical separation of the two JP institutions raises a number of challenges for JP students. We do address many of these through videolinks, transportation from MIT to WHOI on Tuesdays and Thursdays, reimbursement for other travel, housing, etc. We also respond to students concerns. An example is that WHOI now provides access to health and fitness services in Falmouth. As MIT students, JP students have access to the MIT student health facility and are covered by MIT health insurance. However, it is very inconvenient for a JP student based at WHOI to travel to MIT when ill or with a minor injury (serious injury or serious illness is considered as emergency care with treatment covered by MIT insurance at the nearest location). A Health Reimbursement Account (HRA) is available for WHOI-based students who are covered by the MIT Student Extended Insurance Plan. The HRA reimburses WHOI-based students for urgent or chronic care close to the WHOI campus without having to travel to MIT. WHOI’s Academic Programs Office offers subsidized access to an exercise facility chosen by the JP students, located on Main Street in Falmouth, for WHOI-based JP students.

MIT has also recognized the difficulties that WHOI-based JP students have accessing student-life benefits offered on the MIT Campus, despite having paid student fees to MIT. To compensate for this, the MIT Office of Graduate Education has provided (since 2013) the MIT-WHOI JP Student Organization with funds to improve student life, hold social events, and increase professional development opportunities in Woods Hole.

Also at the request of the students, there is a student orientation at MIT (now video-linked to WHOI) prior to the beginning of the fall semester, in addition to a welcome meeting held at WHOI in July. This orientation provides an opportunity for the JP students, who reside in six different MIT departments, to get to know one another and learn about JP resources on the MIT campus and at WHOI.

Travel to and from MIT and WHOI is provided by a chartered bus on Tuesdays and Thursdays when classes are in session, and travel costs are reimbursed when the bus is not available. WHOI provides

dormitory rooms in WHOI housing to all JP students who are based at MIT, so that they incur no housing expenses when they need to spend an overnight or longer in Woods Hole visiting co-advisers, committee members, etc. Similarly, MIT provides an apartment in Cambridge for JP students based at WHOI who wish to visit MIT faculty or participate in MIT events.

Diversity. Diversity within the total JP student population mirrors that of other oceanography programs, with there being equal to slightly greater numbers of female vs. male students enrolled during the last five years (48% to 55%), but low numbers of underrepresented minorities enrolled even when including Asian-Americans as minorities (15% to 19%; up from 11 to 15% in the previous five years). There is lower diversity with respect to gender within AOSE, with lower percentages of female vs. male students enrolled from 2014 through 2018 (27 to 41%). As with many other oceanography programs, and as commented on during annual reviews by some of the JP students, for all disciplines the diversity within the faculty, particularly at senior levels, is considerably less than that of the student body. Both MIT and WHOI are taking steps to address equity, diversity, and inclusion. This is discussed in a separate section. An example is the new requirement for incoming JP students (and for all MIT students) to take online Diversity, Equity, and Inclusion training (a two-part module that takes ~ one hour) that goes over resources available at MIT, common terms, and learning to identify unconscious bias <https://oge.mit.edu/graddiversity/dei-online-module/>.

Harassment Prevention Training. JP students must complete harassment prevention training at MIT and at WHOI. At MIT all students (and faculty and staff) are required to complete a two-part online training program on Sexual Assault Prevention <https://titleix.mit.edu/training/haven/StudentsFAQ>. At WHOI all students and staff are required to complete a 35-minute on-line training module and anyone in a supervisory role then completes a second module aimed at supervisors. WHOI's information related to Title IX is at <https://www.whoi.edu/website/HR/title-ix-information>.

Other Short Courses and Opportunities for JP students

Responsible conduct for research workshops are held annually for JP students and postdoctoral researchers to supplement the on-line training they receive through the Collaborative Institutional Training Initiative (CITI) web site: <https://www.citiprogram.org/>. The workshops cover a range of topics including those surrounding authorship and sharing of credit among research collaborators, plagiarism, and web page ethics.

Research proposal writing is the topic of a short course, ‘Writing a Better Science Proposal,’ offered at WHOI twice per year to JP students, postdoctoral students and junior scientific staff members. The participants write or revise an NSF-style proposal during this short course, and many of these proposals are submitted to funding agencies.

Science writing for a lay audience is an informal non-credit course that was developed and offered in 2008, 2010, and 2013 by Chris Reddy (Senior Scientist in the MCG Department at WHOI) and Lonny Lipsett, Editor of WHOI’s publication, *Oceanus*. This course met once per week for two months. Student-authored articles were critiqued by the instructors and the class during each step of the process, with editing of stories for publication in *Oceanus* continuing over the next year. In 2015 and 2017 the course was taught less formally, with students paired with journalists to write articles following a similar format. This activity helps students become adept at communicating their research to a wider audience. Articles can be found at <http://www.whoi.edu/oceanus/series/students-at-work>.

The Steinbach visiting scholar program (named after the first WHOI Dean of Graduate Studies, H. Burr Steinbach) brings distinguished scholars from a wide range of fields to WHOI during the summers for visits of three to four days. These visits give JP students an opportunity to meet with the Steinbach Scholars in an informal, relaxed atmosphere where a free exchange of ideas is promoted. The program is run by JP students who choose the Scholars and then host their visits (see Appendix VII for a list of Steinbach Scholars from 2009-2019).

The Jake Peirson Summer Cruise (named after WHOI Associate Dean A. Lawrence “Jake” Peirson III) is one of the highlights of the first summer for many entering JP students. WHOI charts the Sea Education Association (SEA) research sailing vessel, *SSV Corwith Cramer*, for a 10-day Jake Peirson Summer Cruise to the continental shelf and slope off New England. SEA provides the chief scientist, and the research program is designed in cooperation with WHOI scientists. WHOI scientists have on several occasions gone along to help guide the research. In recent years, the focus of the cruises has been on the shelf-slope front in the vicinity of the NSF-sponsored Oceanographic Observatory Initiative’s Pioneer Array study site. The cruise provides an excellent opportunity for JP students to get to know one another. The *Cramer*, however, was not available in 2014 through 2017. In those years two- to three-day retreats were held (at the University of Rhode Island Conference Center Whispering Pines in 2014, and on Thompson Island as an Outward Bound Program in 2015, 2016, and 2017). The purpose of these retreats was to help the cohort from multiple departments at MIT and WHOI to get to know one

another prior to beginning classes in the fall. Fortunately, the *Cramer* is now available again and a ten-day cruise was carried out in 2018 and in 2019 and is anticipated for 2020. During the years when there was no *Cramer* cruise, a new cruise opportunity was developed: a short (30-hour to 3-day) student-led cruise out of WHOI on the *R/V Armstrong*. Twenty students participated in the 30-hour cruise out to the continental shelf and back in September 2017; a Physical Oceanographer from WHOI was the nominal Chief Scientist, but the students did all of the planning and made all decisions at sea. A second three-day cruise with two faculty mentors was carried out in November 2018 to the edge of the continental shelf, where they discovered signs of water from the Gulf of Maine intruding into the shelfbreak front south of Martha's Vineyard. The third annual student-led *R/V Armstrong* cruise followed a similar track to that traveled in 2018.

Participation in national meetings and workshops is encouraged for all JP students by providing financial support for travel to scientific meetings, conferences, special courses (e.g. during summer at Friday Harbor or at the Marine Biological Laboratory), and to support student research in special circumstances.

Broader Impacts Group (BIG). Joint Program students also take the initiative to enhance their education and training opportunities. An example is the student initiated *Broader Impacts Group (BIG)*. BIG organizes events that generally fall under the NSF category of Broader Impacts. One of the first BIG programs was the Synergy Project (see summary at <http://coseenow.net/blog/2013/02/ocean-stories-a-synergy-of-art-and-science/>). JP graduate students paired eight scientists and eight professional artists to jointly develop art projects with ocean science themes. The project was so successful that an exhibit of the art work was hosted for four months at Boston's Museum of Science. Recent events have included a workshop of over thirty Cape Cod scientists and K-12 teachers to discuss collaborations in the classroom, a bilingual event with twelve presentations that was broadcasted live over Facebook, and a workshop by the Alan Alda Center for Communicating Science in 2018. These and other BIG projects are student organized and student led, although some financial resources are provided by both MIT and WHOI (see <https://web.whoi.edu/big/>).

Progress since the 2014 External Review

The 2014 JP External Review Committee issued its report February 20, 2015 (Appendix VIII), and had several findings (in italics) and recommendations (in bold italics), focusing both on areas of excellence and areas of concern. Progress or plans for addressing recommendations are in regular font. Two major areas of concern were identified: the perennial concern of jointness between the two institutions, and a concern about recruitment and enrollment. Progress has been made in both of these areas.

Concerns from 2014 about JP enrollment:

-In recent years, there has been a troublesome downward trend in enrollment.

-The JP should consider yield more carefully in deciding how many students to be offered admission.

The 2014 External Review of the MIT-WHOI Joint Program in Oceanography/Applied Ocean Science and Engineering recommended growing and then maintaining enrollment at ~125 students, and doing this through more realistic consideration of yield during admissions. We have heeded this advice, offering admission to 45, 47, and 57 students in 2017, 2018, and 2019 and bringing in larger class sizes of 24, 31, and 36 respectively. For students going into the Doctoral degree program, 41 were admitted in 2017 and 2018 with yields of 48.8% (20 new Doctoral students) and 61% (25 new Doctoral students), and 49 were admitted in 2019 for a yield of 59% (29 new Doctoral students) (See Figure 4).

Enrollment is also increasing because the Navy has committed to sending more students to our Navy Masters program. In 2017, at the behest of the Navy, the MIT-WHOI Joint Program began accepting Navy Masters students into Physical Oceanography, and the Navy elected to send four instead of two students (one enrolled in PO, three in AOSE). This increased interest from the Navy represents its concern with impacts of climate change, and the need for future leaders to understand future effects of climate change on the oceans. In 2018, the Navy increased the number of Masters students to six; two were admitted in PO and four in AOSE in 2018, and all six enrolled, and in 2019 three enrolled in PO, three enrolled in AOSE, one deferred to January 2020, and another deferred until June 2020 (Figure 4f). We hope to enroll an additional four Navy Masters students for 2020 as part of this year's admissions cycle.

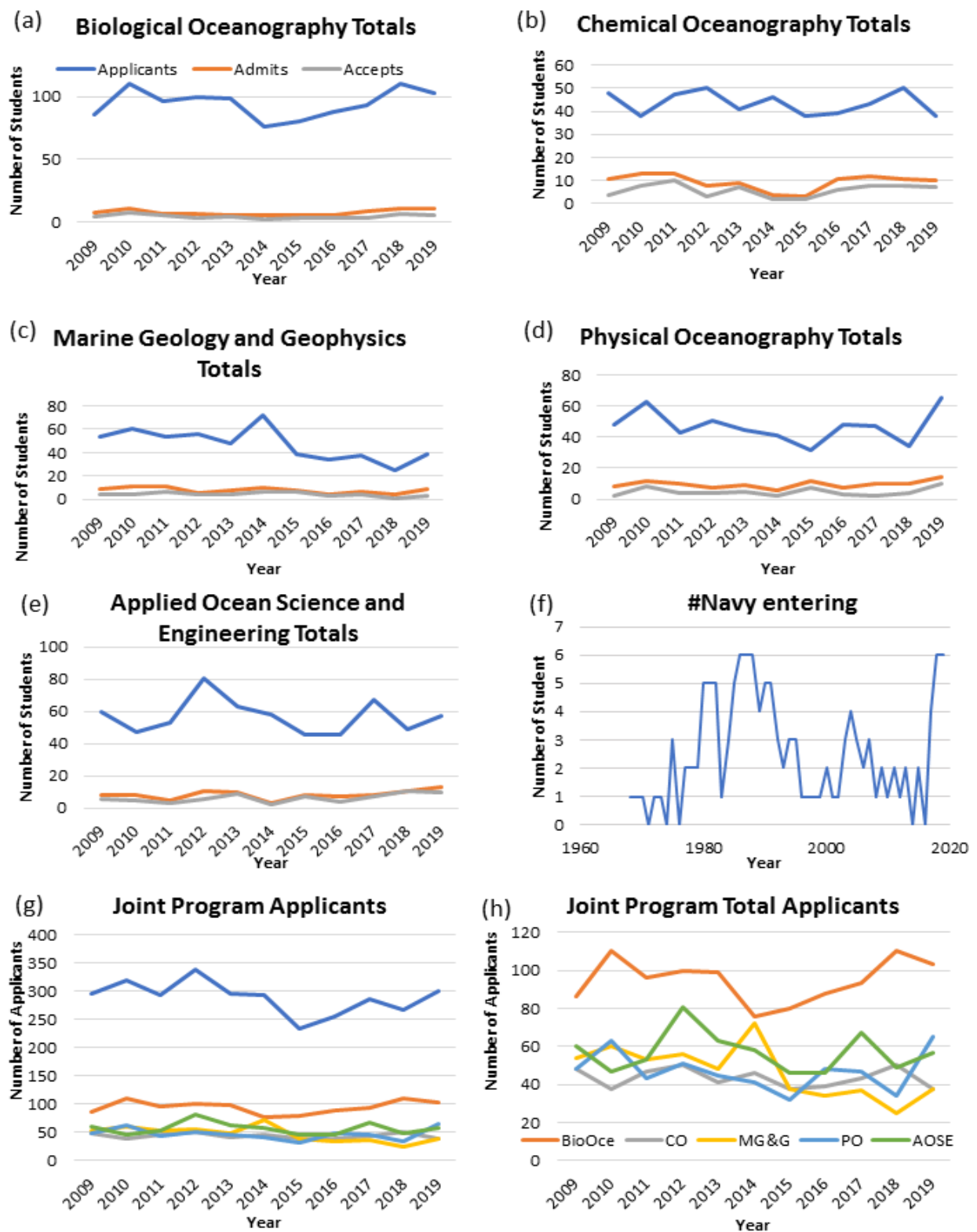
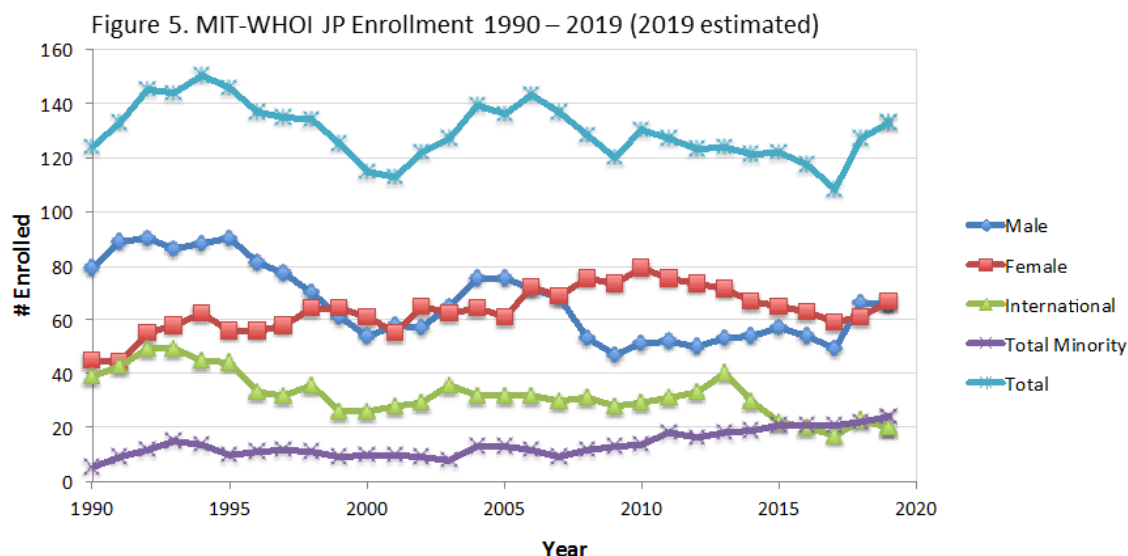


Figure 4. MIT-WHOI Joint Program Applicants, Admits, Accepts 2009-2019.

Due to the combined effects of several students completing their degrees early (in slightly less than five years) and the smaller class sizes from earlier years, JP enrollment hit a low of 108 in fall of 2017. In fall 2018, with the addition of 31 students, overall enrollment was 127, and in fall 2019 enrollment is predicted to be 133 (Figure 5).



As we have focused on increasing enrollment back to ~125 students, we have also focused on growing the numbers of students from groups under-represented in the ocean sciences (this includes Asian Americans as well as other under-represented minorities URM - American Indian or Alaskan Native, Black or African American, Hispanic or Latino, Native Hawaiian or Other Pacific Islander); see Figure 5. A recent review of admissions statistics over the last ten years, done at the behest of a group of interested JP students, documents that the JP admits between 10 and 18% of all of those who apply, between 6 and 24% of URMs (not including Asian-Americans) who apply, and, between 10 and 31% of minorities (including Asian Americans) who apply (Table 4). However, between 2011 and 2018, total numbers of applicants ranged from 234 to 338, while total numbers of minority (including Asian American) applicants was only about 12% (ranged from 26 to 44; Tables 4 and 5), and total numbers of URM applicants was 5 to 6% (ranged from 13 to 23). It is clear from the data that there is a need to increase numbers of minority applicants. The Academic Programs Office is working with interested Joint Program students, MIT, and with leadership of five other research organizations to strategize about methods for recruiting a more diverse pool of applicants.

Table 4. Total Admissions Statistics 2009-2019

Applicant				Admit (Ad)				Accept Offer (Ac)				All											
Male	FM	Intl.	Tot	Male	FM	Intl.	Tot	Male	FM	Intl.	Tot	Min.	%Ad	%Ac	%Ad	Min.	URM	URM	%Ad	%Ac			
As-Am				As-Am				As-Am				URM				URM							
URM				URM				URM				URM				URM							
Min.				Min.				Min.				Min.				Min.							
2009				2010				2011				2012				2013				2014			
All	150	146	110	296	ND	ND	19	18	26	14	44	ND	ND	2	7	13	6	20	ND	ND	0		
BioOce	30	56	12	86	ND	ND	11	4	4	2	8	ND	ND	0	1	3	1	4	ND	ND	0		
CO	17	31	12	48	ND	ND	5	3	8	2	11	ND	ND	2	0	4	1	4	ND	ND	0		
MG&G	29	25	22	54	ND	ND	1	1	8	4	9	ND	ND	0	1	3	2	4	ND	ND	0		
PO	25	23	31	48	ND	ND	1	1	5	5	8	ND	ND	0	0	2	1	2	ND	ND	0		
AOSE	49	11	33	60	ND	ND	1	7	1	1	8	ND	ND	0	5	1	1	6	ND	ND	0		
2010				2011				2012				2013				2014							
All	152	166	106	318	21	17	38	21	34	9	55	6	4	10	13	20	6	33	3	3	6		
BioOce	33	77	19	110	9	7	16	2	9	2	11	2	1	3	2	6	2	8	1	1	2		
CO	20	18	7	38	3	3	6	5	8	0	13	0	2	2	4	4	0	8	0	1	1		
MG&G	27	33	27	60	4	5	9	3	8	1	11	3	1	4	0	4	0	4	1	1	2		
PO	37	26	32	63	3	1	4	5	7	4	12	1	0	1	3	5	2	8	1	0	1		
AOSE	35	12	21	47	2	1	3	6	2	2	8	0	0	0	4	1	2	5	0	0	0		
2011				2012				2013				2014				2015							
All	140	152	107	292	17	15	32	21	25	9	46	4	2	6	15	13	7	28	3	2	5		
BioOce	31	65	17	96	3	10	13	2	5	2	7	0	0	0	2	3	2	5	0	0	0		
CO	19	28	12	47	5	1	6	7	6	2	13	3	1	4	5	5	2	10	2	1	3		
MG&G	26	19	32	53	3	0	3	5	6	2	11	1	0	1	3	3	1	6	1	0	1		
PO	24	19	20	43	1	3	4	3	7	2	10	0	1	1	2	2	1	4	0	1	1		
AOSE	40	13	26	53	5	1	6	4	1	1	5	0	0	0	3	0	1	3	0	0	0		
2012				2013				2014				2015				2016							
All	193	145	141	338	25	17	42	17	21	7	38	3	1	4	9	11	5	20	0	1	1		
BioOce	44	56	24	100	7	9	16	4	3	1	7	2	0	2	2	1	1	3	0	0	0		
CO	22	28	16	50	7	3	10	1	7	0	8	1	0	1	0	3	0	3	0	0	0		
MG&G	38	18	30	56	2	1	3	4	1	2	5	0	0	0	3	1	2	4	0	0	0		
PO	26	25	30	51	2	2	4	3	4	2	7	0	0	0	1	3	1	4	0	0	0		
AOSE	63	18	41	81	7	2	9	5	6	2	11	0	1	1	3	3	1	6	0	1	1		
2013				2014				2015				2016				2017							
All	147	149	97	296	16	23	39	24	17	9	41	3	3	6	18	11	8	29	1	2	3		
BioOce	34	65	24	99	7	7	14	2	4	0	6	1	0	1	2	2	0	4	1	0	1		
CO	14	27	12	41	2	4	6	5	4	2	9	0	1	1	3	4	2	7	0	1	1		
MG&G	24	24	10	48	4	6	10	4	3	0	7	1	1	2	2	2	0	4	0	0	0		
PO	26	19	23	45	2	2	4	5	4	3	9	1	0	1	4	1	2	5	0	0	0		
AOSE	49	14	28	63	1	4	5	8	2	4	10	0	1	1	7	2	4	9	0	1	1		
2014				2015				2016				2017				2018							
All	140	153	107	293	15	20	35	14	15	2	29	3	3	6	6	8	0	14	1	1	2		
BioOce	25	51	20	76	6	5	11	2	4	0	6	3	0	3	0	2	0	2	1	0	1		
CO	16	30	15	46	3	3	6	1	3	0	4	0	0	0	1	1	0	2	0	0	0		
MG&G	34	38	26	72	4	5	9	5	5	1	10	0	2	2	2	4	0	6	0	1	1		
PO	25	16	21	41	2	3	5	4	2	1	6	0	1	1	2	0	0	2	0	0	0		
AOSE	40	18	25	58	0	4	4	2	1	0	3	0	0	0	1	1	0	2	0	0	0		

Table 4. Total Admissions Statistics 2009-2019

	Applicant					Admit (Ad)					Accept Offer (Ac)					All										
	Male	FM	Intl.	Tot	As-Am	Min.	Male	FM	Intl.	Tot	As-Am	Min.	Male	FM	Intl.	Tot	As-Am	Min.	%Ad	%Ac	%Ad	%Ac	%Ad	%Ac	%Ad	%Ac
2015																										
All	111	123	74	234	13	26	15	22	5	37	5	3	8	12	13	4	25	4	2	6	16%	11%	31%	23%	23%	15%
BioOce	35	45	14	80	9	7	1	5	0	6	2	1	3	1	2	0	3	1	1	2						
CO	15	23	14	38	1	0	0	3	1	3	1	0	1	0	1	1	2	1	0	1						
MG&G	13	25	12	38	0	4	3	5	1	8	0	2	2	3	3	1	6	0	1	1						
PO	14	18	13	32	1	1	4	8	3	12	1	0	1	2	5	2	7	1	0	1						
AOSE	34	12	21	46	2	3	7	1	0	8	1	0	1	6	1	0	7	1	0	1						
2016																										
All	106	149	89	255	20	35	15	20	5	35	3	6	9	7	12	1	19	2	3	5	14%	7%	26%	14%	40%	20%
BioOce	23	65	15	88	9	12	3	3	0	6	0	0	0	2	1	0	3	0	0	0						
CO	8	31	9	39	6	4	3	8	2	11	3	2	5	1	5	1	6	2	1	3						
MG&G	17	17	15	34	0	3	2	2	0	4	0	1	1	1	2	0	3	0	1	1						
PO	27	21	28	48	2	4	3	4	3	7	0	1	1	1	2	0	3	0	0	0						
AOSE	31	15	22	46	3	6	4	3	0	7	0	2	2	2	2	0	4	0	1	1						
2017																										
All	129	158	85	287	23	44	19	26	3	45	5	2	7	11	13	3	24	3	2	5	16%	8%	16%	11%	10%	10%
BioOce	26	67	15	93	8	16	3	6	0	9	1	0	1	1	2	0	3	1	0	1						
CO	15	28	9	43	5	8	3	9	1	12	1	0	1	3	5	1	8	1	0	1						
MG&G	18	19	15	37	3	6	1	5	2	6	1	1	2	1	3	1	4	0	1	1						
PO	23	24	23	47	4	6	7	3	0	10	2	0	2	1	1	1	2	1	0	1						
AOSE	47	20	23	67	3	8	5	3	0	8	0	1	1	5	2	0	7	0	1	1						
2018																										
All	128	140	85	268	26	42	30	17	10	47	5	1	6	21	10	7	31	1	1	2	18%	12%	14%	5%	6%	6%
BioOce	36	74	26	110	12	19	4	7	2	11	2	0	2	2	5	1	7	0	0	0						
CO	21	29	9	50	7	11	7	4	0	11	1	0	1	5	3	0	8	0	0	0						
MG&G	11	14	11	25	1	2	3	1	1	4	0	0	0	0	1	0	1	0	0	0						
PO	20	14	16	34	2	3	6	4	3	10	1	0	1	4	0	2	4	0	0	0						
AOSE	40	9	23	49	4	7	10	1	4	11	1	1	2	10	1	4	11	1	1	2						
2019																										
All	151	150	87	301	24	42	25	32	9	57	9	2	11	18	18	6	36	6	1	7	19%	12%	26%	17%	11%	6%
BioOce	40	63	23	103	8	15	4	7	2	11	3	0	3	1	5	1	6	1	0	1						
CO	12	26	8	38	3	5	1	9	1	10	1	0	1	1	6	1	7	0	0	0						
MG&G	19	19	10	38	3	6	1	8	0	9	1	2	3	1	2	0	3	1	1	2						
PO	34	31	31	65	4	6	10	4	5	14	2	0	2	8	2	3	10	2	0	2						
AOSE	46	11	15	57	6	10	9	4	1	13	2	0	2	7	3	1	10	2	0	2						
2014	1 Spring Enroll, BioOce, white male, citizen, counted in stats																									
2015	1 Spring Enroll, MG&G, white male, citizen, not counted in stats																									
2015	1 MIT transfer into AOSE, white male, citizen, not counted																									
2016	1 off-cycle admit into CO (Feb), female, international,																									
2019	1 MIT transfer into AOSE, white male, citizen, counted																									

Table 5: MIT-WHOI Joint Program Applicants 2009-2019

		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Biological Oceanography	Applicants	86	110	96	100	99	76	80	88	93	110	103
	Admits	8	11	7	7	6	6	6	6	9	11	11
	Accepts	4	8	5	3	4	2	3	3	3	7	6
Chemical Oceanography	Applicants	48	38	47	50	41	46	38	39	43	50	38
	Admits	11	13	13	8	9	4	3	11	12	11	10
	Accepts	4	8	10	3	7	2	2	6	8	8	7
Marine Geology and Geophysics	Applicants	54	60	53	56	48	72	38	34	37	25	38
	Admits	9	11	11	5	7	10	8	4	6	4	9
	Accepts	4	4	6	4	4	6	6	3	4	1	3
Physical Oceanography	Applicants	48	63	43	51	45	41	32	48	47	34	65
	Admits	8	12	10	7	9	6	12	7	10	10	14
	Accepts	2	8	4	4	5	2	7	3	2	4	10
Applied Ocean Science and Engineering	Applicants	60	47	53	81	63	58	46	46	67	49	57
	Admits	8	8	5	11	10	3	8	7	8	11	13
	Accepts	6	5	3	6	9	2	7	4	7	11	10
Total		296	318	292	338	296	293	234	255	287	268	301
Female		146	166	152	145	149	153	123	149	158	140	150
Male		150	152	140	193	147	140	111	106	129	128	151
Minorities		19	38	32	42	39	35	26	35	44	42	42
International		110	106	107	141	97	107	74	89	85	85	87
Percentages												
Female		49%	52%	52%	43%	50%	52%	53%	58%	55%	52%	50%
Male		51%	48%	48%	57%	50%	48%	47%	42%	45%	48%	50%
Minorities		6%	12%	11%	12%	13%	12%	11%	14%	15%	16%	14%
International		37%	33%	37%	42%	33%	37%	32%	35%	30%	32%	29%

2014	1 Spring Enroll, BIO, white male, citizen, counted in stats
2015	1 Spring Enroll, MG&G, white male, citizen, not counted in stats
2015	1 MIT transfer into AOSE, white male, citizen, not counted
2016	1 off-cycle admit into CO (Feb), female, international,
2019	1 MIT transfer into AOSE, white male, citizen, counted

Additional enrollment-related concerns raised by the 2014 External Review Team focused on funding:

-The budget of the WHOI Academic Programs Office should be structured so that higher enrollment is incentivized.

While technically true that it is slightly more expensive to have greater numbers of students within the Joint Program at WHOI, the effect is so small that it has never influenced Academic Programs Office (APO) decisions. The major issue is whether those enrolled are covered by external fellowships or GRAs. The WHOI Academic Programs and MIT Joint Program Offices picks up funding of students who fall off grant or external fellowship support, and it is important for the APO budget to maintain the number of students requiring APO support at a manageable number. Experience has shown that total enrollments on the order 125 students, or 25 per discipline (and ~five incoming students per discipline) are manageable. Experience also confirms that small class sizes lead to difficulties in providing students with needed courses (JP courses taught at WHOI require enrollment of at least three JP students; courses taught at MIT require enrollment of at least five to seven MIT, including JP, students).

-Fellowship funding at MIT should be structured, as much as possible, not to disadvantage the JP.

The MIT EAPS Department Head, beginning in 2015, allowed EAPS first-year fellowships to be awarded to incoming Joint Program students provided that they would be advised by an MIT EAPS JP faculty member. This policy is still in place.

-First-year fellowships for graduate students should be made a priority for development efforts.

This suggestion has the support of the new President of WHOI and the new WHOI Vice President for Advancement, with the latter (and the VP for Academic Programs) favoring unrestricted fellowships.

Concerns from 2014 about jointness between WHOI and MIT within the JP include the following:

-The decreasing “jointness” of the JP threatens the very existence of the program.

--- the Committee believes that both institutions must take steps immediately to ensure the continued existence of the JP.

-Issues of jointness exist in all disciplines, although these issues vary in type and severity.

-It is incumbent upon WHOI to improve relations with MIT with regards to the JP. As the future of the JP at MIT depends on a rejuvenation of personnel, WHOI should work to develop productive relationships with young MIT faculty.

WHOI initiated a new program in 2016 offering \$20K to WHOI scientists to encourage collaborations with MIT faculty that include graduate students. So far, two WHOI scientists have taken advantage of this program, and an additional proposal is pending.

Thirteen MIT faculty members have joined the JP faculty since 2014, six from EAPS, four from Aero-Astro, one from MechE, and two from CEE. All but two of these faculty have already been involved in advising JP students, as primary advisors, thesis committee members, or academic advisors.

-The JP should make special efforts to be involved in MIT initiatives.

MIT is in the process of planning an addition to the Green Building (building 54), and is including the MIT-WHOI JP in planning discussions. The plan is to have an Earth and Environment Pavilion located in line with the MIT “infinite corridor” that showcases synergies among the Earth, Atmospheric and Planetary Sciences Department, the Environmental Solutions Initiative <http://catalog.mit.edu/mit/research/environmental-solutions-initiative/>, and the MIT-WHOI Joint Program in Oceanography/Applied Ocean Science and Engineering.

-MIT and WHOI should develop reciprocal efforts in hiring.

MIT and WHOI have emphasized the MIT-WHOI Joint Program in some faculty position advertisements and some WHOI departments have sought to engage MIT colleagues in WHOI candidate interviews. However, there is a need to revisit and remind departments at both institutions to do this.

-The JP should focus on improving communications and interactions between MIT and WHOI faculty and students.

WHOI and MIT have continued to work on strengthening their commitments to the MIT-WHOI Joint Program (JP). We are pleased to report several very positive advances. These include:

1. The MIT Department of Aeronautics and Astronautics (Aero-Astro) decided in July 2017 to partner with the Joint Program within the discipline of Applied Ocean Science and Engineering, joining MIT Departments of Mechanical Engineering (MechE), Electrical Engineering and Computer Science (EECS), and Civil and Environmental Engineering (CEE). There are already four Joint Program Students within this department and WHOI’s Applied Ocean Physics and Engineering Department, three of whom are jointly advised by MIT and WHOI faculty.
2. Effective September 2017, the MIT Department of Earth, Atmospheric, and Planetary Sciences (EAPS) is able to award degrees in Biological Oceanography to JP students. This addition was driven by MIT EAPS faculty who work in biological fields of study, and was strongly supported by the JP Biological Oceanography students. This addresses a concern of both students and faculty, and also helped in recruiting Biological Oceanography students this spring.

3. A joint meeting of MIT and WHOI faculty was held on September 25, 2017 at MIT, and was well attended by both established and new faculty. The meeting provided opportunities for new faculty from each institution to give brief (10 minute) scientific presentations, and for all faculty and students to discuss Joint Program business.
4. In fall 2018, 28 of 124 JP students were advised by MIT faculty, and seven JP students were jointly advised by MIT and WHOI faculty. This represents a slightly greater percentage (23%) than the historical average of ~20% of JP students being advised by MIT faculty, and supports MIT's continued interest and commitment to the MIT-WHOI Joint Program (Figure 6). Sources of support for JP students, whether from WHOI or MIT or External Fellowships, is shown in Figure 7.

Figure 6. Primary Advisors. Red=MIT; Blue=WHOI

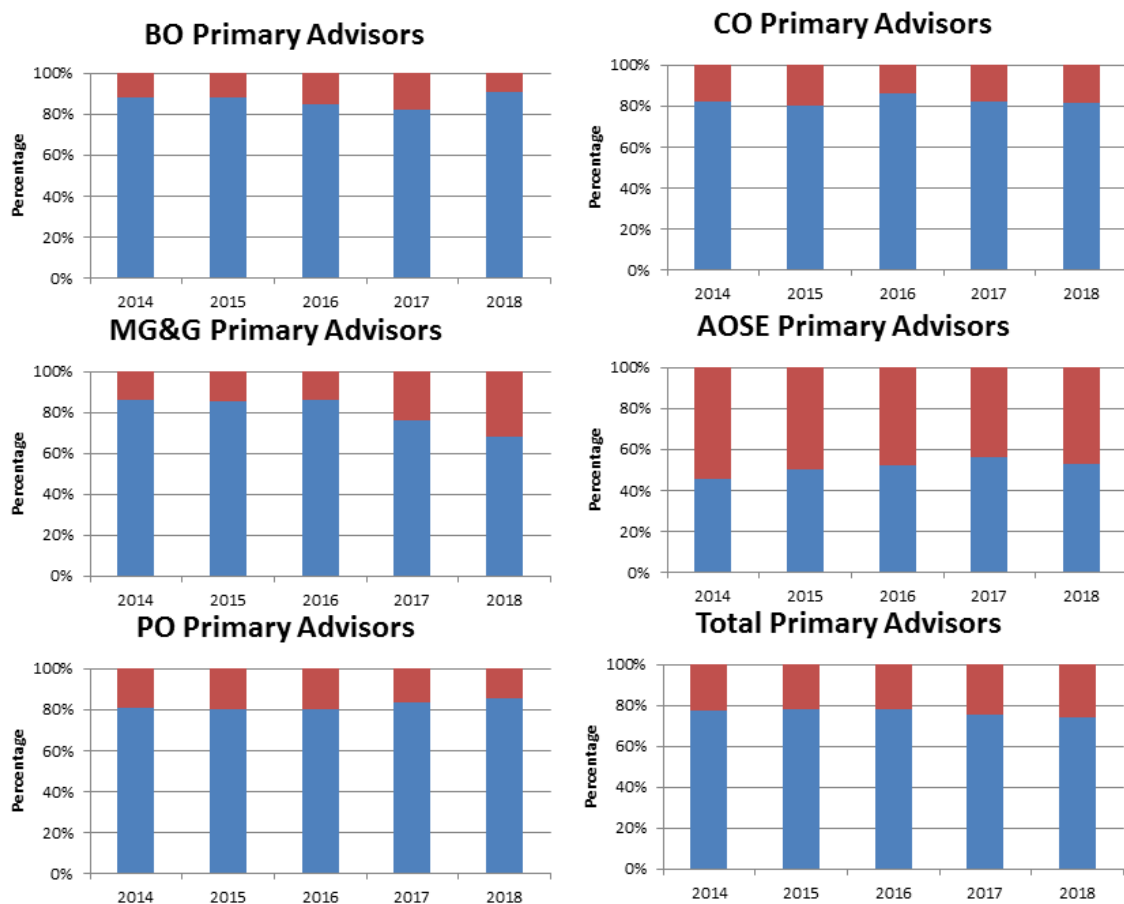
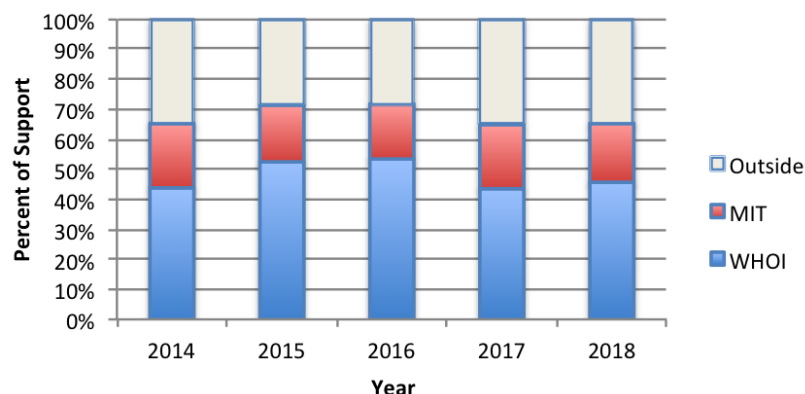


Figure 7. Support Source (Entire Program)



The 50th Anniversary of the MIT-WHOI Joint Program was celebrated in 2018. On July 21, 2018 there was a reunion at WHOI that was attended by ~100 JP alumni. Formal celebrations of the anniversary were held September 27, 2018 at MIT (including a symposium, reception, and dinner) and September 28, 2018 at WHOI (including lab and dock tours and a poster session plus a reception and dinner). Highlights can be found at <http://mit.who.edu/50th-anniversary>.

Other areas of excellence and recommendations from the 2014 External Review Committee

-The JP continues to be recognized as one of the strongest programs in the country and the world.

-Efforts to encourage interdisciplinary research by JP students have been successful.

-We recommend that the JP enhance its website to provide more examples of interdisciplinary opportunities and encourage the JP to emphasize its offerings in marine policy and marine resource management to its students and applicants.

The web site <https://mit.who.edu> is currently being migrated and updated. Content related to coastal research and biophysical interactions and other topics, and relevant links (e.g., to the WHOI Coastal Systems Group <https://web.who.edu/coastal-group/> and to the MIT Perron Surface Processes Group <https://web.mit.edu/perron/www/>), will be added. Opportunities related to climate variability and impacts are at <http://mit.who.edu/climate-variability-and-impacts> and in Appendix IX.

-The JP has taken several steps toward improving student life.

-The JP has paid close attention to the professional development of its students, including tracking them

as they proceed in their careers.

-In order to improve preparation for careers in education, a recommendation is to provide more opportunities for students to teach, perhaps through TAing undergraduate classes. As part of the efforts to keep the JP at the forefront of the field, we recommend that the JP poll its alumni regarding the adequacy of their training and potential ways to improve it.

There are possibilities of TAing undergraduate courses within the six MIT departments. Unfortunately, as at many institutions, these opportunities are limited. JP students with MIT-based advisors do sometimes have opportunities to TA, and on occasion JP students with WHOI-based advisors have been able to TA MIT undergraduate courses. The JP students do take advantage of the MIT Teaching and Learning Lab, and we make an effort to spread the limited numbers of JP course TA opportunities to as many students as we can. In recent years we have had difficulty finding JP students willing to TA, which we take as an indication that they are having success in obtaining the training they desire.

-The JP has made changes to the general exams to create a more uniform format across the disciplines. On the whole these changes have been for the good.

-Our recommendation is to proceed carefully with the new general exams, with due consideration for the effects of new requirements on students.

Each year following the general exams, outcomes are reviewed at the annual meeting of that discipline's Joint Committee. Pros and cons of the new general exams have been discussed within each of the JCs where general exams were modified (JCBO, JCCO, and JCPO). Details are provided in the discipline reports (see below).

-The academic training of the JP remains excellent.

-In an effort to maintain academic excellence, we recommend that faculty be encouraged to participate in mentoring programs, and that the JP provide support for faculty to improve their teaching skills.

Several steps have been taken to address this concern. The web site has been updated to provide information on student and faculty resources and responsibilities (e.g., <http://mit.whoi.edu/faculty>). Mentoring sessions for students and faculty have been developed that use the 2006 Burroughs

Wellcome Fund, Howard Hughes Medical Institute publication “Making the Right Moves: A Practical Guide to Scientific Management” (<http://www.hhmi.org/labmanagement>) as a guide.

Advising/mentoring workshop for JP students were held in April 2016 and December 2016 and one for JP faculty in November 2016. The purposes of the workshop are 1) to make sure that JP students and faculty are aware of the full range of available resources, and 2) to have an hour-long dialog that allows students or advisors to bring up examples of advising and mentoring issues that they have either experienced, seen others experience, or anticipate. The MIT EAPS Department is currently holding training sessions (five to six hours in total) on graduate student mentoring that all of their faculty are strongly encouraged to attend. To improve teaching skills, an option now available for new instructors, and/or those with issues related to teaching quality, is to participate in training at the MIT Teaching and Learning Laboratory (TLL, see <http://tll.mit.edu/>). The quality of teaching and education involvement is explicitly considered in promotion discussion at both institutions.

-WHOI scientific staff greatly value the JP and are committed to its success. [MIT] EAPS leadership cares about the JP, and is committed to its continued success.

-We recommend that the [MIT] EAPS chair be given some measure of authority commensurate with the responsibility of running a JP that spans several departments at MIT.

Department Heads at MIT have a lot of authority and control significant resources. As of 2013 the MIT EAPS department head is the principal MIT point of contact for the Joint Program (instead of the MIT Vice President for Research). This change has proven to be a positive development for the WHOI and MIT partnership of the Joint Program, though with some concerns from JPAOSE. Recently, in response to the 2014 External Review, an informal agreement was made to involve a JP faculty member from within the MIT Mechanical Engineering Department and a JP faculty member from within the MIT Civil and Environmental Engineering Department in the JP administration. In 2018 this was formalized: Professor John Leonard from Mechanical Engineering and Professor Phil Gschwend from Civil and Environmental Engineering were appointed as Associate Directors of the MIT-WHOI Joint Program in Oceanography/Applied Ocean Science and Engineering at MIT effective April 1, 2018 through June 30, 2019, and they were recently reappointed through June 30, 2020. Their roles are to help advance and support the mission and the activities of the MIT-WHOI Joint Program working closely with the JP Director, Professor Ed Boyle. This includes communicating with WHOI on academic matters relevant to JP students within their schools and departments, playing a role in JP admissions and Open House

activities, encouraging new faculty participation in the JP, and helping organize inter-institutional program-building events.

Challenges facing the MIT-WHOI Joint Program

Major challenges facing the JP include: faculty turnover due to retirements and faculty leaving (particularly at MIT); difficulties, particularly in some disciplines, in being awarded grants that include GRA funds; and difficulties in attracting and enrolling graduate students. These concerns are discussed more fully within the disciplinary reports below.

The good news is that there has been progress on each of these issues. With respect to concerns about faculty turnover, there is considerable interest in EAPS in maintaining a healthy MIT-WHOI Joint Program, the Head of EAPS, Rob van der Hilst, is keeping the JP informed about all faculty hire decisions, and the MIT-WHOI JP is being actively involved in the process of planning the addition to MIT's Green Building (Building 54). The addition of EAPS as a department able to award degrees in Biological Oceanography to JP students is another very positive move toward increasing jointness between the two institutions and across the program. Faculty turnover concerns have also been addressed through the addition of Aero-Astro to the JP, and the addition of MIT JP Associate Directors from the CEE and Mech E Departments, providing better communication within the MIT School of Engineering.

Significant progress has been made on student recruitment since the last external review. The overall size of the JP student body is currently healthy. However, there is still a concern with the enrollment in the MGG discipline, and some of that concern likely is related to funding issues. There has been success in both MIT EAPS and WHOI recognizing the need for more fellowship support for graduate students, both in the first year or two, but also to cover students who fall off grant funding. This issue is one that we are well aware of, and are actively working on with Development Offices at both institutions.

A final concern related to enrollment, and a major concern of students in general, and of some prospective students, is the lack of ethnic and racial diversity within the JP (both student body and faculty), that mirrors other oceanographic programs. A compounding issue for students wanting to be advised by JP faculty at WHOI, however, is the lack of ethnic and racial diversity on Cape Cod. This is a topic that WHOI and Woods Hole are now actively engaged in addressing, through the Woods Hole Diversity Initiative <https://www.woodsholediversity.org/about/memorandum-of-understanding/> and the WHOI Committee on Diversity and Inclusion <https://web.whoi.edu/cdi/>. To supplement these

committees and address concerns of both students and postdocs at WHOI, an additional less formal and open-to-all WHOI Academic Programs Office committee on diversity, equity and inclusion is being established; this committee will meet in open sessions quarterly, and will identify goals and metrics. This group will take advantage of expertise at MIT.

In Closing

The MIT-WHOI Joint Program celebrated its 50th anniversary last year, and it is still healthy and vibrant. This is particularly remarkable given that its success relies on voluntary participation of faculty from six different departments at MIT and five different departments and the Marine Policy Center at WHOI. Neither MIT nor WHOI hire faculty or scientists specifically to teach and/or advise within the MIT-WHOI Joint Program. Nonetheless, the MIT-WHOI Joint Program continues to train the next generation of ocean scientists and engineers and produce national and international leaders in these fields. It has been and continues to be a remarkably successful experiment. At this time there are no anticipated plans for significant changes to the structure and organization of the program, although there is a recognition that national trends do shift. In particular, we are aware of the need to make sure that the MIT-WHOI Joint Program remains at the forefront of many cross-disciplinary topics, including climate variability, coastal processes, and biogeochemistry. For example, modifications to the general exams (as advised by the 2009 JP External Review Committee) were carried out in part to balance needs for disciplinary depth while at the same time providing students with sufficient flexibility to pursue a range of topics. Unsurprisingly, jointness of the two very independent institutions has, is, and will continue to be a challenge, but it is one that we are aware of and that we know needs to be continually addressed. The five-year external evaluations are extremely valuable in providing feedback and suggestions to help with these efforts.

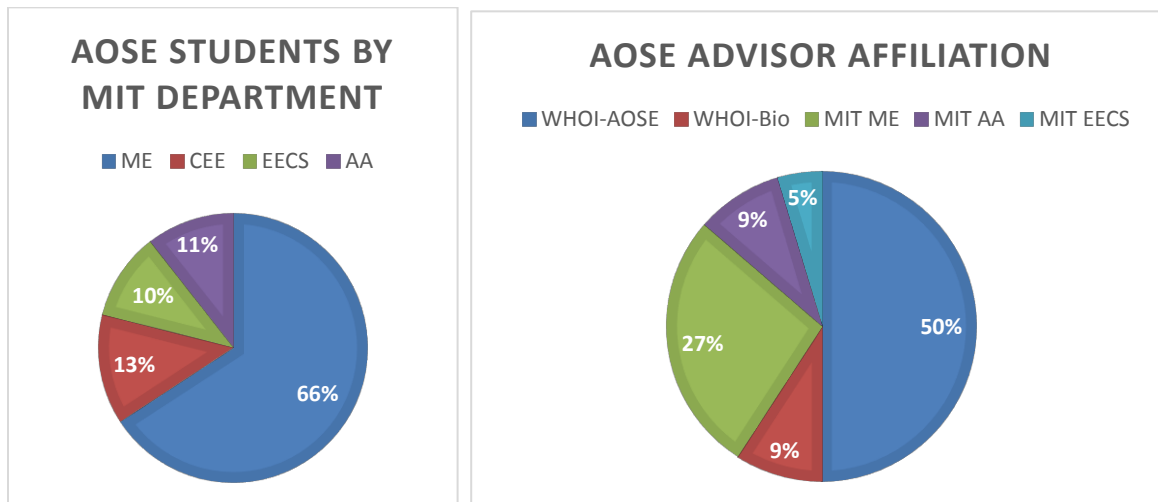
Applied Ocean Science and Engineering

Students admitted into the Applied Ocean Science and Engineering (AOSE) discipline within the MIT-WHOI Joint program are associated with the Department of Applied Ocean Physics and Engineering (AOPE) at WHOI and one of four engineering departments at MIT: Civil and Environmental Engineering (CEE), Mechanical Engineering (ME), Electrical Engineering and Computer Science (EECS), and Aeronautics and Astronautics (AeroAstro or AA). Participation of AeroAstro in the Joint Program is new since the 2014 JP review, and was driven in large part to student interest in autonomy. Oversight of the AOSE JP students is provided by the AOSE Joint Committee (JCAOSE). The current members of JCAOSE include representatives from AOPE and from all four engineering departments at MIT. The main activities of the Joint Committee on Applied Ocean Science and Engineering (JCAOSE) involve the student admissions process, continuously tracking and evaluating the progress of AOSE JP students, monitoring the overall health of the AOSE program, and facilitating changes that resolve problems and insure the longevity and continued high quality of the program. Overall, the health of the program has been strong, with steady growth since 2014: There are currently 36 students enrolled within AOSE, with five new Ph.D. and four new Navy Masters admissions in 2019. There has been particularly strong growth in the Joint Program Navy Masters program over the last three years, with participation comparable to that in the 1980s, and quality applicants. Within the Navy Master program, students show a particularly strong interest in marine robotics, autonomy, and machine learning.

Unlike the other four disciplines that make up the Joint Program, students admitted through the AOSE program must satisfy the regular degree program requirements of the MIT department they are affiliated to, which can be found on-line in the corresponding MIT Engineering Department web pages. The only other requirements within the AOSE program include an oceanography breadth class, a course on the fundamentals of oceanographic instrumentation (MIT course catalog 2.688), and a one-semester WHOI research requirement. Once students have successfully presented their thesis proposal, they must form a thesis committee with representation from both AOPE and their home MIT department. The number of faculty in the MIT engineering departments involved in the JP has remained approximately constant since 2014, while the number of WHOI faculty participating in the JP has increased since 2014. There remain common interests between a core group of MIT faculty and WHOI scientific staff which serve as a basis for representation by both institutions in terms of advising, serving on thesis committees, and the PhD qualifying exams process. With the addition of the MIT AeroAstro Department in the AOSE JP, there have been a number of new MIT faculty participating in the JP. A remaining concern is that there continues to be relatively little flexibility in these programs regarding the qualifying exam compared to other disciplines in the JP.

While the AOSE JP is generally doing very well, there are still concerns about the breadth of faculty participation at MIT. Generally, a few committed MIT faculty members have multiple JP students, but the number of participating faculty is lower than desirable and visibility of the JP within the engineering departments at MIT is low. While there were concerns leading into 2014 with the MIT JP Director reporting to the EAPS Department Head instead of the Provost's office, the addition of two MIT JP

Associate Directors (including John Leonard in Mechanical Engineering) to serve as ad hoc members of the JP Committee seems to be addressing some of these concerns.



The AOSE program has maintained a strong balance from the perspective of number of students with a primary advisor at MIT (16) versus at WHOI (19), and three students co-advised by a WHOI and MIT advisor. As has been historically the case, the majority of currently enrolled students in the AOSE program are affiliated to the MIT ME department. Likewise, the majority of MIT-based advisors are affiliated to ME, with only 1 MIT-based advisor in EECS, and none in CEE. Within ME, many of the faculty that participate in the Joint Program are affiliated to the Center for Ocean Engineering. *Ocean acoustics is one of the three main research areas in AOSE, and there had been a drastic decrease in number of students in ocean acoustics prior to the 2014 review. While that number has grown, the majority of acoustic students are advised at WHOI. There is only one faculty member remaining in acoustics at MIT, and there is some concern that this trend will negatively impact the AOSE program.*

The number of students within AOSE affiliated to EECS has stabilized since 2014, but many of these students do not have primary advisors in EECS. Though there have been efforts to improve the visibility of the JP in EECS, key MIT faculty and WHOI staff losses in the last decade have had a severe impact on this part of the program. The AOSE students in EECS typically perform research in underwater acoustic communications and imaging from underwater vehicles, and have generally performed very well and have secured challenging, diverse, and often lucrative employment upon completion of their degrees. It will be important to continue to build bridges between AOSE and EECS for JP students to continue to thrive in these areas, and to recruit new talent. The number of JP AOSE students affiliated with the CEE department has also remained fairly stable, though no JPAOSE students have primary advisors in CEE. Some scientific staff in AOSE have chosen to advise students affiliated with the MIT Department of Earth and Planetary Sciences (EAPS) working through the Joint Committee on Physical Oceanography (JCPO) instead of JCAOSE. The number of JCAOSE students with primary advisors in the WHOI Biology Department is small (currently, two) and appropriate arrangements for handling interdisciplinary issues are made as they arise.

Biological Oceanography

The Biological Oceanography component of the MIT/WHOI Joint Program in Oceanography/Applied Ocean Science and Engineering provides students with an educational experience that combines the relevant faculty and facilities of the two institutions. The Joint Committee for Biological Oceanography (JCBO) believes that the program continues to provide an educational experience that is at the cutting edge. During our last review, we noted that the number of applicants had recently declined. Over the past five years, this number has rebounded, and we have averaged 95 applicants per year. We have admitted 9% of applicants, and 51% of admitted students have enrolled. Overall, we continue to attract exceptional applicants to the program. We have effectively leveraged institutional fellowships to recruit highly qualified students; however, financial constraints mean that we must still decline a number of highly qualified and motivated applicants every year. Our students are finishing their degrees in a timely fashion, with a mean time-to-degree of 5.5 years (9/22 students finished in less than 5.5 years and 6/22 in 5.5 years). We have had a 100% retention rate of students entering the program from 2010-2014, with the two remaining students on schedule to graduate this year. Graduates from our program are found in academia, government and non-governmental organizations throughout the world.

At the time of our last review, we had recently conducted a major revision of our curriculum and exam structure, and it was too soon to assess the effectiveness of these major changes. Each student's curriculum is now guided by the student's primary advisor and members of an Academic Advisory Committee (AAC; includes a total of at least three faculty, at least one from MIT). Curricular plans of incoming students are reviewed and approved by JCBO prior to the start of the fall semester. Since the last review, an ad hoc committee was convened to evaluate effectiveness of the new curriculum and make recommendations to the faculty and JCBO. From these efforts, we have implemented several "tweaks" to our curriculum. Specifically, we added a minimum requirement of oceanography and marine science courses (36 units), reduced the minimum number of course units from 120 to 96, and developed three recommended curricular tracks. The tracks were developed to provide guidance to students in customizing a curriculum and a starting point for JCBO to evaluate curricula. Also, since our last review, we have added additional oversight of our "Topics Courses." These are advanced courses in specific areas of biological oceanography that are taught by WHOI faculty, with different topics offered each year. In the new process, there is an open call for faculty to submit course proposals. The proposals are evaluated by the faculty based on their perceived relevance, rigor and potential for student enrollment. JCBO selects the courses to be offered each year from these proposals and sometimes requests adjustments to the scope or structure of the course.

The comprehensive exam consists of a Research Report and Thesis Proposal defense. The report is due after 18 months in the program, and the Thesis Proposal defense must be completed by the end of the 25th month in the program (usually the end of June in the second year). The Research Report is evaluated by the AAC, with the comments and results collated by an exam chair chosen by the student and advisor. This report is based upon research conducted by the student in their first 1.5 years, and the advisor's input to the report is limited. While some of these reports may result in publications, the primary goal is to evaluate the student's ability to assess, synthesize and explain research data. The Thesis Proposal defense portion of the exam includes a written thesis proposal and a short presentation of the proposed research by the student, followed by questions from the student's thesis committee. The thesis committee is composed of at least four members, including the advisor and one faculty member from MIT, and will serve to guide the student's thesis research. In the exam, the committee

asks questions that probe the student's depth and breadth of knowledge in general oceanography as well as the chosen course of study. This new exam structure was initially implemented late in 2012. The exam has evolved since the last review. Most notably, more guidance has been given to the committee regarding the structure of the exam. This appears to have achieved the desired effect of ensuring that students are asked questions that test their ability to explain and synthesize fundamental concepts in biological oceanography. An ad hoc committee has recently been formed to formally evaluate the effectiveness of the current exam structure.

A primary concern raised in the 2014 review was the lack of jointness between MIT and WHOI. At the time, JPBO students were admitted primarily through the MIT Biology Department. Beginning in 2017, JPBO students were able to be admitted into MIT's Earth Atmospheric and Planetary Science (EAPS) department. This change has been beneficial to the program, and very popular among the students. Joint Program students have access to desk space within the Green Building at MIT. Many JPBO students switched from Biology to EAPS and most incoming JPBO students now start in the EAPS program. The composition of JCBO also reflects this new association with EAPS. Three members of JCBO have primary appointments at MIT EAPS and one has a primary appointment in MIT CEE (Civil and Environmental Engineering). Most JPBO students (22) have primary advisors at WHOI, two have a primary advisor at MIT, and one is co-advised (very similar to the numbers from our last review). The number of MIT-advised JPBO students remains small; however, the overall level of MIT faculty engagement with and enthusiasm for the Joint Program feels much stronger than it was at the time of the previous review.

There is still progress to be made regarding connections between Cambridge and Woods Hole. Recruiting Joint Program students into the labs of MIT faculty remains challenging, in part because they must compete for positions with graduate students admitted through other MIT programs, where fellowship funding may be more accessible. JPBO students sometimes report feeling isolated while being based in Cambridge for coursework or in research labs. During the Admissions Open House, several admitted students commented that they perceived a disconnect between the two campuses. We see the Open House as a discrete opportunity for improvement and will seek to work together more closely and to highlight examples of collaboration and synergy between the two institutions.

We would like to highlight two new courses within the JP. The first is a new Microbial Oceanography Field Course (not credit-based) that is being taught jointly by WHOI and MIT faculty. Students will spend 10 days at the Bermuda Institute of Ocean Sciences Station in Bermuda and receive hands-on training in microbial sample collection, cultivation, nutrient analysis, respiration rates, DNA sequencing and bioinformatics. The second is an Environmental Bioinformatics course that is being taught by three new faculty members within the WHOI Biology Department. In its first year, this course has received high enrollment by JP students, and even by MIT students outside the JP. These efforts both have the potential to increase the "jointness" of the program and to provide innovative training opportunities to our students.

Overall, the JPBO program has evolved since the last review, responding with flexibility and seeking to maximize strengths. It continues to attract and train talented students in diverse fields of study related to oceanography. These students are assets to both institutions, and we are fortunate to have the opportunity to work with them.

Chemical Oceanography

Students: The MIT/WHOI JP in Chemical Oceanography (CO) continues to attract and train talented students interested in pursuing diverse and often interdisciplinary research on topics related to the chemistry of the oceans. Current enrollment in the CO Program is 34, consisting of 25 legally female and 9 legally male students, although not all identify as either female or male. The relatively high number of students reflects the successful recruitment of six or more students to the program in each of the past four years. Larger class sizes have been facilitated by relaxing the amount of student support required for WHOI JP faculty from 18 to 12 months and the ability of CO faculty to access external funding for student support, especially from philanthropic foundations. Our overall recruitment rate since 2014 is 65%, up slightly from 59% during the previous five years. Of the 27 JP students that have entered the CO program between 2010 and 2014, 22 were awarded Doctoral degrees, two were awarded Masters degrees, one left without a degree, and the remaining two will be defending their Doctoral thesis this fall. Except for one student who left with a Masters degree, all of the students who entered the program since 2014 are currently enrolled yielding an overall retention rate since 2010 of 90% at the Doctoral level. On average, CO students required 5.4 years to earn their Doctoral degrees over this period. Interdisciplinary topics continue to be a prominent feature of student research with participation of faculty members from other disciplines at WHOI and MIT regularly serving as thesis committee members from other universities and research organizations.

Institutional Participation: A key strength of the CO program is the dedication of participating faculty at both MIT and WHOI. The previous review commented on the fact that many of the participating faculty at MIT were in the later stages of their careers and eventual retirement could impact the level of MIT participation. The recent hiring of Andrew Babbin (EAPS), Kristin Bergmann (EAPS), and Desiree Plata (CEE) at MIT has gone a long way towards addressing this potential issue. Five of the students who earned their degree since 2010 and four current students were/are advised by MIT Faculty (Boyle, Summons, Fournier, Babbin, Bosak, Ono). A significantly greater number of MIT faculty participate through serving on thesis committees (Bowring, Heimbach, Delong, Hemond, Gschwend, Follows, Rothman, Dutkiewicz, Kocar, McGee, Bergmann, White, Laub, Chisholm, Perron, Woosley).

At WHOI there is widespread faculty participation in the JP with 22 of the 35 individuals who have been members of the WHOI CO faculty since 2010 having served as primary advisors to JP students. The rest participate through various activities such as teaching, serving on pre-generals advising committees and thesis committees, and participation in oral general exams and thesis proposal defenses, both of which are open to all CO faculty from both WHOI and MIT. Two MC&G faculty (Klein & Apprill) currently advise students in the MGG and BO disciplines and one CO student is currently advised by Sam Laney in the Biology Department. The departure of seven faculty members from MC&G since 2014 has been balanced by the hiring of Matt Long, Tristan Horner, Julie Huber, Collin Ward, Peter Barry, Adam Subhas, Hyewon Kim, and Ann Dunlea.

General Exam: The format of the CO General Exam was changed in 2013 to provide JP students with sufficient flexibility to design their course of study and research programs. Students define five subject areas that are relevant to their research and course of study, with guidance from their advisors and instructors. These subject areas form the basis of five questions posed in a four-hour written exam. Now that the exam has been implemented over seven years, there is general consensus that the new exam format has succeeded in preparing students for their individual research programs and facilitating

interdisciplinary research. Introduction of mandatory pre-generals research and an associated paper are viewed by many as a particularly valuable part of the exam format change since it exposes the students to independent research and writing early in their time at WHOI. The positive aspect of the new exam format, notwithstanding, there is some dissatisfaction among the faculty with the current structure due to substantial amount of time required to administer the exam and the amount of time the students devote to studying, considered by some to be unproductive. The topic has been the focus of significant discussion among the faculty, with no clear consensus of how we might implement change. The students have not expressed dissatisfaction with the exam and appear to value being required to synthesize the enormous amount of diverse information that they are exposed to during their first two years of course work. Although only two JP courses are mandatory for CO students (Marine Chemistry and participation in the Seminar in Chemical Oceanography in years 1 and 2), the new General Exam structure has resulted in students typically taking 7-8 classes during their first two years from which they select their five exam topics.

Challenges: The unique challenge of the JP is the geographic separation between the MIT campus and WHOI. This separation poses challenges to students and faculty alike. While modern communication equipment helps to bridge the gap, particularly with smaller meetings (thesis committee meetings, thesis proposal defenses), the capabilities are limited for the two largest venues at WHOI – Clark 507 and the Redfield Auditorium – that are used for thesis defenses and many seminars.

The relatively small number of MIT faculty participating in the JP and the requirement to have at least one MIT faculty member on every thesis committee and three MIT faculty members on JCCO places a heavy burden on those MIT faculty members who are most engaged in the JP.

The challenge of acquiring extramural funding (both current and projected) has a significant negative impact on all aspects of the JP. Despite large CO class sizes in recent years, a significant number of those students are concentrated in relatively few labs. The high cost of supporting a student (~100K/year or more) continues to represent a significant barrier to acquiring students, especially for new faculty members spinning up a lab who are particularly vulnerable to the risks associated with advising students. An obvious solution to this problem would be fundraising efforts to increase the number of fellowships dedicated to the support of MIT-WHOI JP students.

Due to the small size of the JP, opportunities for WHOI faculty to engage in teaching are limited. The recent departures of faculty at WHOI involved in teaching have created new opportunities for early career faculty to get involved. Due to the significant time commitment involved with teaching, early career scientists at WHOI are advised to carefully consider the impact that a significant teaching load may have on their research productivity. The small number of JP courses also limits opportunities for JP students to gain direct experience in teaching.

If members of the review committee have any questions, please contact us: Colleen Hansel (chansel@whoi.edu) JCCO Chair, Jeff Seewald (jseewald@whoi.edu) Education Coordinator.

Marine Geology and Geophysics

The graduate program in Marine Geology and Geophysics remains strong. We are successfully training and mentoring our graduate students as they define cutting-edge research projects and carry them to completion. We remain committed to a research-based General Examination structure, which enables our students to engage in independent research early in their graduate school careers. Our students leave the Joint Program ready to become leaders in their field, many with a strong record of cross-departmental / interdisciplinary education and research. In part, of course, their success reflects their high caliber upon entering the program, but the faculty at both MIT and WHOI devote considerable effort to the Joint Program – classroom instruction, research advising, and general mentoring. The close interaction of students and faculty, which is much like that of colleagues by the final Ph.D. year, provides training in both disciplinary expertise and the art of doing science.

Despite these strengths, the Joint Program in Marine Geology and Geophysics (MGG) currently faces an enrollment challenge. The MGG program has never been large, averaging 23 ± 1.7 total students since 1999, or four to five students per class. This is a good number for the program, but it is at the small end of what is sustainable, since successive low-admission years can result in anemic class sizes, which may negatively impact our ability to attract new students. We may be in such a situation soon. Since 2009, ~four students per year have enrolled in MGG. This includes six students in both 2014 and 2015, but only 11 students in the four subsequent years, including only one in 2018 and three in 2019. There are 17 students in the program now, and a better-than-average admissions year in 2020 is needed to keep that number from shrinking significantly when the 2015 class graduates next year.

The decrease in MGG admissions over the last four years correlates with several factors including a decreasing number of individual faculty at WHOI seeking students for grant-supported work due to a lack of GRA support within funded proposals, and a decreasing number of proposals written (that correlates with the shift to a ‘no-deadline’ proposal policy for the NSF OCE-MGG program). In addition there has been an increase in numbers of highly qualified applicants interested in climate-related topics and decreases in those interested in other marine geology and geophysics topics. There are reasons to be optimistic that recruitment of students in MGG topic areas will soon improve. The pause in hiring at WHOI, which produced a demographic skew toward more senior scientists with perhaps less enthusiasm for taking on new students, ended several years ago. New hires in the G&G Department at WHOI over the last few years, including a geochemist, a climate modeler, a fluid dynamicist, and a geomechanicist interested in both the mantle and ice, are eager to advise new students and are actively writing proposals; the lull in proposal writing that occurred with the loss of motivating deadlines seems to be ending; and new hires at both WHOI and MIT in climate-related areas (across the entire Joint Program) add to what now represents a broad and attractive climate-science program, though it could perhaps be more effectively branded as such. We are thus cautiously optimistic about the upcoming admissions year.

‘Jointness’ between MIT and WHOI in the MGG program was noted as a concern in the 2014 review. Jointness must be continuously nurtured, and it is currently quite positive, with seven of the seventeen MGG students having a primary advisor at MIT and with robust involvement of MIT faculty on thesis committees. It is particularly positive that new hires within MIT EAPS – including a geophysicist focusing on ice dynamics, a sedimentologist studying environmental conditions of the ancient earth, and a structural geologist focused on mantle processes, have chosen to engage substantially in the joint program. The complimentary scientific interests and existing interactions between these recent hires and recent and anticipated (offers pending) hires in the WHOI G&G department should drive even

greater jointness. Assessing the state of ‘jointness’ remains difficult, however, since the concept is largely subjective and few objective metrics of jointness exist. Establishing common metrics would help to better define the term ‘jointness’ and assess its state, identify barriers to greater jointness, and highlight steps that can be taken to enhance it.

The inability to consistently offer disciplinary courses remains a concern. Partly in response to this concern, we introduced a requirement in 2015 that all MGG students take Geological Oceanography, a reasonably high level introductory course that covers foundational material within geochemistry, geophysics, sedimentology/coastal processes, and climate. The course provides students with core knowledge needed to pass the General Exam, and the requirement ensures that the course is taught regularly. Few courses within MGG are taught regularly beyond this course. This is a shame because, while MIT courses provide the bulk of disciplinary classroom instruction, at least six geochemistry and geophysics courses offered at WHOI provide unique material that would greatly benefit students in those disciplines – and students are frustrated that these courses cannot be offered. A focus for the next few years will be to combine aspects of these geochemistry and geophysics courses into a single course that would be beneficial to both subdisciplines and which could be regularly offered. In addition, we will explore combining existing seismology courses into a new one that would be attractive to EAPS as well as JP MGG students. The loss of three successive seismologists at MIT has left gaps in MIT, and JP MGG, course offerings. In addition to benefiting MGG students, designing and offering courses with EAPS interests in mind is a mechanism that may enhance jointness.

We hope we have adequately highlighted progress since the last review and existing challenges. We want to maintain a program that continues to attract excellent students, that provides them with a top-quality education, and prepares them for their selected careers. We feel that to do this, we must continue to attract enough students in each MGG subdiscipline so that essential classes can be offered, and so that students have peers in their subdiscipline and a vibrant graduate-school experience. The ability to take courses and conduct research at both WHOI and MIT provides an exceptionally rich experience to our students and is very attractive to prospective students. This aspect of jointness is thus central to the vibrancy and sustainability of the Joint Program, and we must continue to nurture jointness broadly by constantly observing the evolving factors that influence it and seeking new elements that can be added to enhance it. We would appreciate suggestions on how we can achieve these goals, as well as any other advice on how we may improve the program.

Joint Committee for Marine Geology and Geophysics:

Oliver Jagoutz (chair), David McGee, Veronique Le Roux, Taylor Perron, Daniel Lizarralde

Physical Oceanography

The Joint Program in Physical Oceanography (JPPO) has continued to evolve and broaden the program into the areas where ocean physics is an important element, but not the only one. This reflects the increasingly broader interests of the faculty at both institutions and the growing diverse foci of the student applicants. The faculty of the MIT-WHOI Joint Program in Physical Oceanography has taken the suggestions of the previous 2014 visiting committee seriously. We acknowledge the major concerns and have taken steps to address them, which have resulted in changes in procedures as codified in the JP-PO Student Handbook. We have been successful at increasing the communication between the students and JCPO by revising the Handbook and having more frequent meetings with the students. Another concern raised was the divergence in faculty interest between the two institutions. Progress on this front has been slow and we are aware that the jointness of the two institutions remains a problem that needs to be addressed and continued efforts will be needed to maintain a healthy and vibrant program. Below, the major changes since the 2014 review are briefly summarized.

i) Divergence of faculty at the two Institutions

Although research projects involving both MIT and WHOI scientists are still occurring, they are less connected to the educational programs. Joint discussions of the full MIT-WHOI group on education need to be more frequent and improved to increase jointness between the two groups. However, the main problem is the fact that the number of physical oceanographers in EAPS has decreased over the past years with the retirement of Carl Wunsch and Paola Rizzoli. The EAPS Department at MIT has been actively searching for candidates with physical oceanography expertise since the last review, but a new hire has not happened yet. The EAPS Head, Robert van der Hilst, has been aware of the critical situation in PO at MIT and has been supportive for the search for new faculty. There is now an active search. A new hire in EAPS would help the situation by alleviating the burden on MIT faculty on advising and participating in committees.

The need of available advisors and committee members at MIT remains an issue. Traditionally, 25-30% of the students have been advised by MIT faculty but this number has decreased somewhat since the last review (19% not including the six Navy students, all advised at WHOI) reflecting the reduced number of faculty in PO at MIT. To alleviate this issue, JCPO has also tried to engage faculty from other departments in our program. Prof. Pierre Lermusiaux from the Mechanical Engineering Department currently sits on JCPO, though he has many educational responsibilities within his department. Tom Peacock from the same department is also engaged and sits on some JP thesis committees. In addition, students can presently pick committee members from a wide variety of departments and other institutions.

An overarching problem that impacts this and other issues raised by the 2014 visiting committee is the split between the JPPO and PAOC. Each program has its own somewhat different requirements, with separate governance and separate committees. In particular, being the Director of PAOC has prevented Prof. Ferrari (one of the few faculty members in PO at MIT) from sitting on JCPO. Discussions have begun within a small group of WHOI and MIT faculty on ways of bringing JPPO and PAOC closer together, one of the main goals being recruitment. In particular, we are discussing whether to revise the JPPO general exam format to make it more aligned with PAOC's.

Finally, appointments to JCPO have been discussed in advance by both institutions. The November 2018 change of JCPO chairmanship was preceded by substantial discussion between

WHOI (Pratt, Mahadevan, Cenedese, Bower and Tivey) and MIT (Flierl, Ferrari and Ed Boyle). There was also consultation between WHOI JCPO members and Flierl regarding Jake Gebbie as JCPO replacement for Pratt. It should be noted, however, that Flierl (EAPS-MIT) remains the only fully engaged MIT member of JCPO.

In summary, we are aware that the jointness of the two institutions remains a problem that needs to be addressed but we have been actively and consciously working on it by engaging MIT faculty in research conducted at WHOI (e.g. Rypina (WHOI) and Peacock (MIT)) and including both institutions in appointment decisions in JCPO.

ii) General exam

To address the concern about the lack of guidance for the written paper requirements we have rewritten the Handbook with language intended to make the general exam and other procedures as clear as possible. For example, under Section 3.5.1: “The advisor can give advice on the outline and general organization, but the primary writing and research must be the student’s. The degree of input from the advisor will be discussed at the oral exam.” The goal of the written paper is “to demonstrate the ability to document and communicate research” as stated in the Handbook.

We have also explicitly indicated in the updated Handbook (Section 3.2) that the number of classes recommended is 9-12 to make sure that the students do not feel compelled to take 12 courses as previously recommended. At the same time, we obviously do not want to discourage students who want to take 12 classes.

During the past four years (2015-2018) the chair of JCPO rotated to WHOI and during that period the organizational issues indicated by the previous visiting committee have been dealt with. We are aware that the future members and chairs of the committee need to remain vigilant and revisit all issues annually through regular meetings, many of which should be open to other faculty. Finally, following a discussion with the JPPO students, we are considering changing the format of the student’s annual review by having short meetings (15 min) between each student and a group of faculty (possibly not including their advisor) to discuss their progress.

iii) Recruitment and Retention

The number of applicants, offers, acceptances to JPPO have ranged between 32-65, 6-14, 2-10, respectively over the last ten years. These numbers fluctuate but show no significant trends. Similarly, the number of students enrolled in PO has remained steady at around 22. Since the last review we had two years (2016-2017) of low numbers of incoming students (two per year) but last year we were successful at recruiting 11 students (of which three are Navy students). At present, there is no evidence of a sustained decrease in applications or recruitment. Small class sizes within these fluctuating numbers, however, do pose a problem both for teaching courses and for camaraderie/collaboration amongst students.

The APO has been fundamental in increasing our ability to recruit student by allowing us to admit more students than there are GRAs, to compensate for rejections and increase the class size. Of those students who entered in 2010 through 2014, 82% completed or will complete a PhD (average time to degree is 5.6 years), while the remaining students left the program with a Masters. This attrition rate is within the range of other JP disciplines.