School of Oceanography
2022 Self-Study

University of Washington, Seattle WA 98195-5351

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Degree Programs

Undergraduate

- Bachelor of Science
- Bachelor of Arts (non-thesis option)
- Minor in Oceanography
- Major in Marine Biology (joint with Aquatic & Fishery Sciences)
- Minor in Marine Biology (joint with Aquatic and Fishery Sciences)
- Minor in Climate Science (joint with Atmospheric Sciences & Earth and Space Sciences)

Graduate

- Master of Science
- Doctor of Philosophy
- Graduate Certificate in Astrobiology
- Graduate Certificate in Climate Science
- Graduate Certificate in Interdisciplinary & Policy Dimensions of Earth Sciences (joint with multiple other units on campus)

Background

Section I: Overview of Organization

Introduction

The oceans serve as our planet's memory; storing vast quantities of heat, genomic information, chemical inventories, and of course, water. Marine sediments contain records of past lives and events, and the geologic processes occurring beneath the sea shape and impact the earth on a daily basis. The oceans help regulate earth's climate, provide food and oxygen for earth's inhabitants, serve as shipping lanes to connect regions, and drive weather patterns. Submarine volcanism accounts for >60% of the volcanism on the planet supporting some of the most extreme organisms on Earth. The oceans and the seafloor are repositories of natural resources and the source of devastating natural hazards. The field of oceanography provides access to, and interpretation of, this vast repository of information.

The ocean is changing at an accelerating and alarming rate. With nearly 40% of the world's population living within 100 km of the coastal zone, the number of people directly impacted by the oceans is also increasing. Given the ocean's importance in governing weather and climate, it is not a stretch to say that the ocean and its health impacts every person on the planet either directly or indirectly.

The societal demand to train oceanographers and to study the ocean is vast. The need to make informed predictions of future conditions on our planet far outstrips the available infrastructure, both human and physical, that is currently available. Employment of oceanographers, environmental scientists and marine biologists is projected to increase by 7-10% percent between now and 2030, a rate that is 125% higher than that for all occupations (US Department of Labor). Much of that labor force will be focused in the state of Washington, which trails only California in predicted need for water-related scientists (US Bureau of Labor Statistics).

Over the next decade, oceanography departments (and other environmentally-focused sciences) must develop ways to amplify their research and instructional capabilities to meet the growing needs and planetary environmental pressures. In the state of Washington this has manifest itself in multiple ways - here at UW the School of Oceanography has worked to expand its reach and to train all its students in "big data" and environmental technology such that they are prepared to enter the workforce in a variety of areas (see later discussion), and our neighbors at Western Washington University have established a Marine and Coastal Science major to

complement and augment offerings at UW (many of the Western faculty are UW alumni). We applaud and support their growth.

The field of oceanography is changing rapidly, and UW is among the leaders forging new paths. Autonomous instrumentation and computational modeling now fully complements seagoing expeditions, providing a broader and more detailed view of the ocean environment. The UW School of Oceanography plays a commanding role in this transition by:

- Implementing and managing NSF's Ocean Observatories Initiative Regional Cabled Observatory (OOI-RCO),
- Developing and using profiling floats and robotic gliders (GO-BGC "Global Ocean Biogeochemistry Array") to understand ocean biogeochemistry,
- Creating widely used tools to simplify data collection and analysis (e.g. Simons-CMAP),
- Leading the genomic and data revolution by releasing open source software for analysis of large genomic datasets,
- Acquiring patents and seeking solutions to ocean acidification.

The University of Washington's Oceanography program has been ranked #1 or #2 in the world for the past five years. Each year approximately $30-60M in research money passes directly through the School of Oceanography, making it the fourth largest research unit on campus (exclusive of the medical school). In collaboration with our partners in the Applied Physics Laboratory and the Cooperative Institute for Climate, Ocean and Ecosystem Studies (CICOES) the UW is funded for an additional $140M in annual research, making marine-related research one of the largest and most important research focuses on campus. Marine-related work (research and education) employs more than 500 people across campus. The School of Oceanography employs more than 200 of these folk. The School of Oceanography is also one of only three schools in the country operating more than one UNOLS research vessel, and our global-class ship the *R/V Thomas G Thompson* has completed the greatest number of at-sea days in the fleet every year since 2019.

Oceanography is housed within the College of the Environment, which is unified by an Earth-system focus with strong affiliations to disciplines that incorporate human dimensions. The University of Washington (UW), a large Research I state university with excellence in a wide variety of disciplines. The UW is located within the city of Seattle, where the School of Oceanography has links to local NOAA laboratories, high-tech businesses, diverse maritime industries, and information technology industries, all of which help to expand our breadth.

The success of the School is built upon the synergy between our research and teaching programs. Our research opportunities attract some of the best graduate students in the country and produce future leaders in the field. Our research activities provide the framework for a distinctive undergraduate oceanography majors program that highlights experiential learning and couples field and laboratory research with scripting and coding for data analysis, research and formal classroom learning. Such a close interaction between marine research and campus-wide education is unique in the oceanography community. This synergy uniquely positions the School to continue expanding and amplifying our scientific and educational reach.

Mission & Organizational Structure

The mission of the School of Oceanography is to advance the science of the ocean, educate students in the field, work toward solutions to problems stemming from climate change, and to increase the public's awareness of the ocean. The School has a focus on scientific discovery through observation, experimentation, theory, modeling, and technological innovation. We are a national leader in undergraduate oceanography, unique in incorporating "blue water" research cruises as a major component of our curriculum. We graduate master and doctoral students (90% of whom stay in the field) who will be future leaders of scientific discovery, teaching and public service.

Degree Programs

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- Master of Science
- Doctor of Philosophy
- Graduate Certificate in Astrobiology
- Graduate Certificate in Climate Science
- Graduate Certificate in Interdisciplinary and Policy Dimensions of Earth Sciences (graduate certificates are joint with multiple other units on campus)

We have no fee-based programs. Enrollment trends are depicted in Appendix B.

Academic Services and Support

The School has one *student services coordinator* who handles all course-related services for graduate and undergraduate students This is unusual in our college, where most teaching units have more than one person providing student services. The position is the main point of contact on a team that consists of an Associate Director for Education and the Academic Affairs committee. The student services coordinator receives support from the Assistant to the Director (Appendix A for the organizational chart).

Formal mentoring of graduate students is performed exclusively by the faculty, including affiliate faculty. Substantial responsibility is vested in curricular groups based on the four traditional divisions of oceanography: biological oceanography, chemical oceanography, marine geology & geophysics, and physical oceanography. The curricular groups set specific academic requirements, review graduate applications, vet teaching assignments, and put forth hiring needs based on educational and research goals.

There are currently *two teaching faculty* in the School. Historically three teaching faculty were employed, one on a part-time basis. Retirements in the last decade reduced the numbers, but current plans include growing the number of teaching faculty to four full time members. Teaching faculty receive mentoring support mostly from the college level, where the cohort of teaching faculty is larger. The teaching faculty have been a critical team in leading the School and college through the pandemic, and these faculty are highly regarded within the School. One, Mikelle Nuwer, holds a distinguished professorship and was UW's distinguished instructor for 2022.

School Structure and Governance

The School of Oceanography is large (200+ people on payroll plus students), has a substantial research portfolio ($30M per year), is the home to major national facilities (UNOLS, OOI-RCO, has robust undergraduate and graduate programs, and manages two ocean-going research vessels. We possess all the administrative intricacies that come with these multiple operations. Despite the complexity, the School has a strikingly lean administrative structure that relies heavily on shared governance by faculty and the heavy workload of two administrative positions - the School's Lead Administrator (Kittie Tucker) and its Manager of Marine Operations (Commander Robert Kamphaus).

Organizationally, the School of Oceanography can be thought of as having four parts, but there is great overlap between them. In the organization chart (Appendix A), the blue components denote the faculty/academic/research portions. Numerically this is the largest part of the School. These are the little fiefdoms each faculty member maintains for their research. In a mix of blue and tan are the student services component, which overlap strongly with the faculty component. The main administrative component is in tan. Its focus is on personnel, fiscal and grant management. The fourth component is ship operations (also in tan color), which acts as a largely independent arm of the School with no fiscal intermingling.

The School of Oceanography is led by a **Director** who serves a five-year term. The director has traditionally been selected by the dean from internal candidates after soliciting input from the School. Our last search for an external director occurred in the late 1970's. The Director, in consultation with the faculty, is ultimately responsible for administrative affairs of the School, including personnel, budget, space allocation, and educational programs and serves as the primary conduit between the faculty and the Dean. The directorship is currently paid as a 9-month position with the expectation that the director will continue to teach and perform research. Thus,

the position is effectively part-time. In reality, and as currently implemented, the directorship is more than a full time position.

There are two **Associate Directors**, one for Education (who also acts as the Graduate Program Coordinator and liaison to the UW Graduate School), and one for Facilities and Ship Operations. The two Associate Director positions come with financial support equivalent to three months of salary per year plus a department-paid administrative supplement of $600 per month. The financial support is typically in the form of a teaching buyout.

There are four standing committees; the **Faculty Council** (voted by the faculty, only faculty on this committee), the **Hiring Committee** (a mix of faculty and graduate students, selected by the director), the **DEI Committee** (a mix of voluntary members from across the School), and the **Academic Affairs Committee** (faculty members only, selected by the Associate Director of Education, assisted by the Student Services Coordinator). None of the committee chairs are compensated for their extra workloads.

The **Faculty Council** is an elected component of the School, chaired by an elected member. Traditionally it is given a set of issues for evaluation each year. It is also charged with making recommendations on improvements in operations, leading long-term planning efforts and providing advice to the administration. The Faculty Council is composed of four members elected by each of the curricular groups, two members elected at-large and two members appointed by the Director, in consultation with the council. The Associate Directors are members ex officio. Traditionally the Director does not attend these meetings unless asked.

The **DEI Committee** is a task force composed of volunteer members from all components of the School; undergraduates, graduate students, postdocs, research staff, administrative staff, ship operations crew or staff, and faculty. The committee is always chaired by a faculty member and always contains a minimum of two faculty. This committee is task-oriented and works on one or two ideas at a time, after which it turns management of DEI issues over to the entire School. An example of this is how the DEI committee scoped out and helped implement a complete revamping of our graduate student recruitment process such that it eliminated identified systemic biases. After the first iteration, the management of recruitment was handed back to the Academic Affairs committee and the Associate Director of Education.

The **Hiring Committee** is composed of one faculty member from each option (biological, chemical, marine geology and physical). Members are selected by the director. The committee seeks input from the full faculty and scopes out the hiring needs of the School for all faculty types including teaching, research, tenure lines and research positions. When positions are available, the Director in consultation with the Hiring Committee establishes **Search Committees** to perform the necessary tasks of advertising, evaluating candidates, and recommending persons to the full faculty for hiring. Search committees consist of faculty (one from each option) and one graduate student.

The **Academic Affairs Committee** is populated with faculty selected by the Associate Director of Education in consultation with the Director. This committee evaluates new course proposals, processes and manages undergraduate scholarships.

A special committee is formed for annual reviews and faculty raises. This committee typically consists of one full professor from each option and they meet only a few times in order to handle the task at hand.

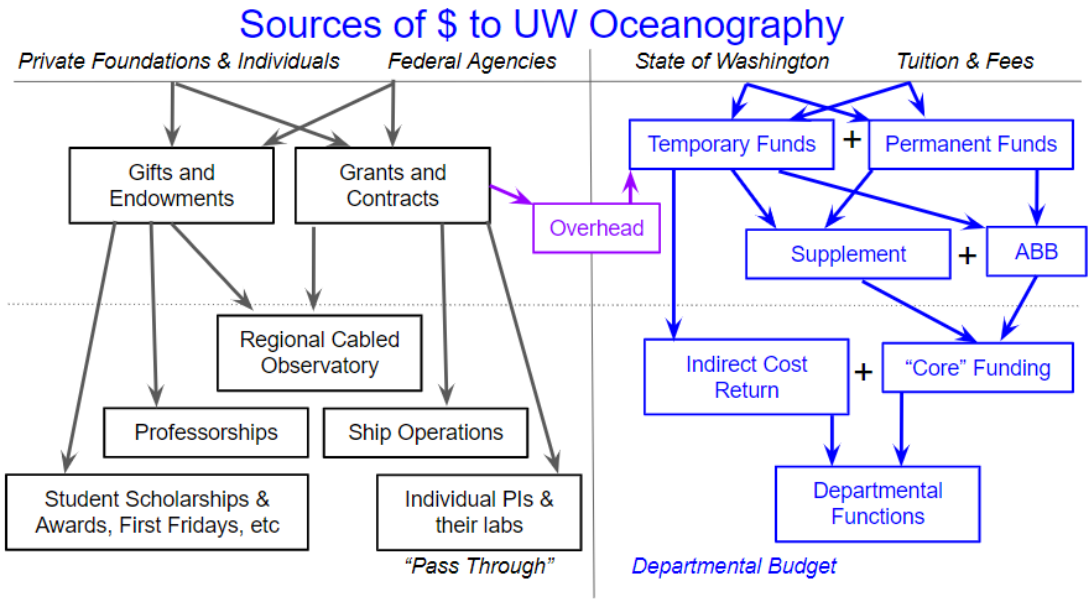
The faculty meet monthly during the academic year. Faculty meetings are open to all, follow state guidelines, and adhere to Robert's rules of Order. The School provides official meeting minutes on our website, and the undergraduate students, graduate students and postdocs report directly to their cohorts via student representatives. All faculty, regardless of rank, are encouraged to attend promotion meetings, unless conflicted. An open and visible promotion process allows assistant and associate professors to gain personal knowledge of the criteria applied, and the emphasis placed on each of the criteria. Ballots concerning faculty appointments and promotion and tenure are conducted electronically after discussion in one or more meetings.

The School interacts with other faculty across the College of the Environment and the UW mainly in three ways; shared teaching, shared research grants, and through our adjunct faculty (of which we have 6 individuals from four units in Seattle, one at UW Bothell and one international adjunct). Currently the School shares six courses with other units and the faculty share more than 35 grants with others at UW.

The School of Oceanography does not have an advisory board.

Budget & Resources

The School of Oceanography has four basic fiscal sources; gifts and endowments (~$250k distributed annually), grants and contracts (~$30M awarded annually), 'permanent' state funds (~$3M annually) and 'temporary' state funds (~$2.5M annually). The operating budget for our ships is held separate (~$18M annually).



Gifts and Endowments

The School's endowment is a shade under $7M and distributes approximately $250k each year. Much of this money is specifically directed by donors via their endowment agreements. The majority is distributed to undergraduates in the form of scholarships and stipends ($70% or $175k). Scholarship applications are due each spring after UW announced freshman admits. All current majors and minors, as well as admitted prospective undergraduates who identified Oceanography as an interest in their application, are contacted and invited to apply for scholarships. Scholarships are awarded by the Academic Affairs committee and distributed the following fall.

The vast majority of donors to the School give small amounts of 'current spending' money (<$2500) to one of our discretionary budgets. This money is used to support core activities including graduate student recruitment and monthly social events.

Grants and Contracts

Researchers within the School are awarded an average of $30M in new awards each year, making the School of Oceanography one of the largest research entities on campus. If the medical school is excluded, Oceanography ranks third on campus in research dollar generation. It is interesting to note that of the top four research units on campus, three focus extensively on the ocean; the Applied Physics Laboratory, the School of Oceanography, and the Cooperative Institute for Climate, Ocean and Ecosystem Studies (CICOES). Parenthetically, School of Oceanography researchers contribute nearly $14M to the APL and CICOES grantsmanship via partnerships and shared grants. If those numbers were added to our tally, we would surpass Computer Sciences and be the second-largest research unit on the main campus.

Unit	Grants	Amount ($M)	% non-med research*	% overall
APL	238	63.3	10.03	4.01
Computer Sciences	133	38.7	6.13	2.45
Oceanography	66	31.3	4.95	1.98
CICOES	58	29.1	4.60	1.84
Chemistry	95	25.6	4.05	1.62
Physics	165	21.7	3.45	1.38
Electrical Eng	98	21.1	3.33	1.33
Civil & Environmental Eng	111	19.7	3.13	1.25
Education	39	18.9	3.00	1.2
Biology	54	8.5	1.35	0.54

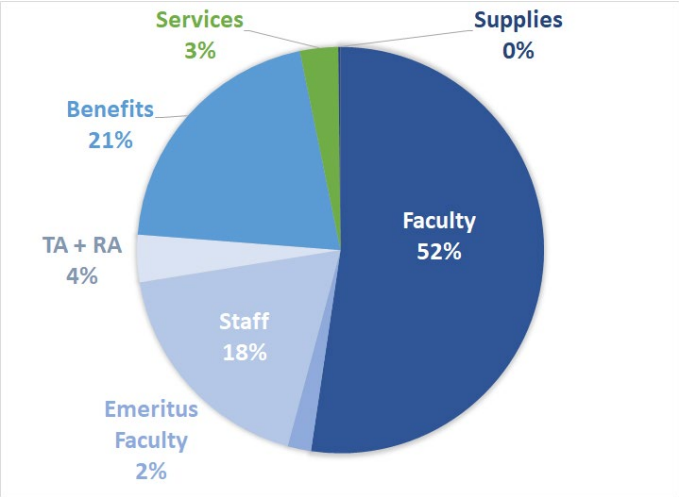
* excludes Medicine and Public Health

Within the School, Grants and Contracts are colloquially called “pass through” because administration does not manage the grants or determine spending. That responsibility, and the money, is “passed through” to the PI. The School, however, does employ administrative staff who handle payroll and who liaise with the university and agencies in order to assure that established rules and processes are followed. The School does not track grant spending in detail, but on average, grant money is used for salaries and tuition (65%), general expendable supplies ($30%) and permanent equipment (5%).

Salary expenditures within this category approach $20M per year and the School employs more than two hundred researchers (including graduate students, research faculty, etc).

Permanent and Temporary State Funds

State funding and tuition revenues that come to the School of Oceanography total to $6M annually, including the commitment to the ship (see next section). This amounts to 7% of our total monetary flow each year. These ‘state’ monies are nearly exclusively used to pay salaries and benefits for faculty and staff.



A consistent source of confusion and stress within Oceanography is that university-supplied resources (state support plus tuition) exceed those earned within the ABB model via generation of student credit hours (SCH). On average, Oceanography delivers approximately 7000 SCH (5000 to undergraduates and 2000 to graduate students), generating ~$1.4M in tuition revenue. In this simple sense, the School only "earns" ~30% of its $5M annual state support and the remainder is termed "supplement." Often, members of the School of Oceanography feel sensitive because our teaching revenue does not cover our total costs to the state. However, this simple calculation ignores the State of Washington's contribution to the university (currently equal to 60% of the tuition revenue). If state support were distributed similarly to tuition (ABB) revenue (it is not), the School would receive ~$0.8M in additional money. The School's overhead on research generates ~$3.25M in income to the university. Thus, the School contributes ~$4.75M to the university each year and receives ~$5M; we are roughly revenue-neutral while simultaneously employing and educating hundreds of people. This is an area where we hope to improve both in internal performance (ABB generation) as well as in institutional awareness about how we contribute to the university.

Marine Operations

On behalf of the University of Washington, the School maintains and operates two ocean-going research vessels, the R/V Thomas G Thompson and the R/V Rachel Carson. Both are UNOLS vessels, meaning that we are part of the University National Oceanographic Laboratory System. Each ship receives federal support for science-based days, and the University of Washington supports educational days aboard the ships as part of our charter Party Agreement with the Office of Naval Research. The total annual operating budgets for the two ships and associated costs is approximately $18M, of which $16M comes from grants and contracts. The ships are used to educate students widely across the college and university, and support learning opportunities for more than 100 undergraduate and graduate students each year. The finances of the School and of Ship Operations are kept completely separate.

Financial and Resource Planning

Fiscal planning is shared by the director and the lead administrator. The primary concern in the last half decade has been to save money for new faculty startup packages and to pay off fiscal debts. Our cost centers within Oceanography had fallen nearly $2.3M in arrears. With the help of the Associate Dean for Administration we have been able to retire nearly $2M of debt and are closing cost centers that continue to lose money.

Strategies for Growth

We are interested in four types of growth; a) number of faculty, b) number of students, c) fiscal resources (all types) and 4) space.

A) Faculty numbers have steadily fallen in the last decade. If the School is to remain at the forefront of our field, this reduction in faculty count needs to be reversed. There are several reasons for this decline; tenure line retirements who have not yet been replaced, a decision in the early 2000's to stop hiring WOT faculty, and disagreement with the dean's office over funding for our 6-month tenured faculty who converted to 9-month appointments. This is an active area of discussion for the school and we seek the committee's input and advice.

B) Our 'core' student body is stable and we are generally happy to have ~110 undergraduates and 60 graduate students. We, as partners in the Marine Biology degree, are experiencing a surge in students enrolled in that major and in those classes. The 300+ marine biology majors are taxing our ability to teach and mentor. The one area where we wish to grow is in generation of student credit hours ("butts in seats"). Our strategy there is to diversify the types of professors we have and increase the quantity of teaching faculty. We will implement a new model for teaching faculty, one that is being spearheaded by the college, where teaching faculty are fully engaged in our School's mission.

C) While our research income continues to grow, funding from the state is stagnant. This adds additional strain to an already strained academic system.

D) The School is functionally out of usable research space, despite having an abundance of physical space. Much of our infrastructure is too old to be easily revitalized (e.g. Marine Sciences Building, Old Ocean Building). Thus, our greatest area for growth is in the renovation of existing space or the construction of new ones.

Diversity, Equity, and Inclusion

The School of Oceanography's DEI action plan is in the second draft phase, and will be voted on by the faculty in spring 2023. Much of the plan is already being implemented. There are five categories, each with identified actions and *metrics*.

Category 1: Cultivate and support an inclusive departmental culture
Category 2: Attract and recruit students, postdocs, faculty and staff
Category 3: Retain and Advance diverse members within the School
Category 4: Incorporate DEI into all of our educational activities
Category 5: DEI and Ship Operations

Category 1: Cultivate and support an inclusive departmental culture

This category includes some simple things such as creation of a code of conduct (complete), creation of a DEI award (complete), a conflict resolution webpage with links (complete), maintaining our existing anonymous email tool, and regularly updating the DEI webpage. In addition, the School seeks to cultivate participation from underrepresented groups. We do this in several different ways, including our annual Banse Early Career seminar series, in which we highlight the scientific work of underrepresented scientists (many of whom are still

graduate students. We also have ambitions to interact with local communities more. Finally, this category includes annual faculty trainings in anti-bias and DEI related themes.

Category 2: Attract and recruit students, postdocs, faculty and staff

The work in this space is already ongoing and includes creation of (or use of existing) 'best practice' documents for all types of hiring within the school. Category 2 efforts dovetail with the Banse seminar series, allowing us to meet some of the best and brightest young diverse scientists in the hopes of attracting them to UW for graduate or post-graduate work. We successfully revised our graduate student recruitment, resulting in increases in the number of diverse students who apply and enter the program. This year we are employing best practices for our faculty searches, and a DEI subcommittee is scoping out best practices for staff hiring within the school.

Category 3: Retain and Advance diverse members within the School

This category of activities leverages actions within the College of the Environment (e.g. career fairs, optional trainings, etc), asks for career networking and resource development for all students with emphasis on creating opportunities for students from diverse backgrounds, and specifically requests that DEI activities of faculty be reported to the School and used as part of the merit and promotion process. This had been occurring for the past few years, but the role has been highlighted and enhanced. We are creating mentoring committees for all junior faculty and postdocs, creating annual or semi-annual networking and community events for postdocs, and evaluating demographic data for where our postdocs come from, their gender and identity, etc, with an aim of diversifying the pool of applicants for postdoctoral positions and then encouraging growth once new postdocs are within our community.

Category 4: Incorporate DEI into all of our educational activities

We are adding diversity statements to all our courses, beginning with undergraduate courses. Our long-term goal is to provide resources and training (with the college's help) to all our instructors and TAs so that they can create and maintain welcoming and inclusive classrooms and labs. We also aim to modify several of our undergraduate courses to include environmental justice and/or diversity components. Identified courses include our 100-level general ed courses as well as some 400-level advanced courses (e.g. Marine Pollution).

Category 5: DEI and Ship Operations

Ship Operations are unique on the UW campus in at least three respects; 1) crew spend extended time away from their home and family and work in a relatively small space that also is their leisure space, 2) virtually every crew position aboard the ship requires some sort of federal-level certification (or multiple certifications) and 3) a substantial portion of our hiring is in the form of temporary hires. These three things pose immense challenges in-and-of themselves. Additionally, the pandemic has resulted in a severe shortage of sea-going personnel and those who are available are highly coveted by the maritime, luxury cruise, and oil-and-gas industries. As our ship operation unit moves forward, we are trying to learn and incorporate best practices into our hiring, both permanent and temporary, so that diverse crew are invited to sail on our ships.

Role of the DEI Committee

The DEI committee is a voluntary, task-oriented, effort. The committee reforms annually as it takes on new tasks. Generally, the committee has one task it is finishing and one it is starting up. Past efforts include revising our graduate admissions process to be more open and friendly toward applicants who don't have 'insider knowledge' about the process. The result of this has been a 2-fold increase in the number of applicants from ethnically diverse backgrounds, and a significant change in the demographics of our graduate students including more students with diverse backgrounds, 2SLGBTQIA+ identifications, and international students. Current efforts focus on revising hiring throughout the department (last year's emphasis was on faculty hiring but the new focus is on staff hiring), and on creating guidelines and opportunities for excellence in mentoring.

The committee has a minimum of six core members serving one- to two-year terms with additional members added for term lengths based upon the current task of the committee. The core committee membership includes a minimum of one faculty, staff, and graduate student. Since inception the committee has always had one or more postdocs and undergraduates. The School attempts to keep the number of representatives to two or three (interest in being on this committee is strong). Currently, we try to balance the committee by accepting volunteers such that the committee has two faculty members, two staff members (one from the administrative staff, one from the research or ship staff), two graduate students, two undergraduate students and one post-doc. A faculty member always serves as chair of the committee.

The DEI Committee maintains its own set of web pages.

Diversity in our School

Faculty in Oceanography (meaning that of those whose appointments are at least partially in the School) are relatively non diverse. However, changes are occurring. The faculty are now gender-equivalent (see Appendix C). In addition, three of our five most recent hires have been female persons of color.

Our departmental strategy for young faculty of all types is to provide one quarter of teaching buyout for the addition of a child to a family, to provide reduced teaching loads as faculty prepare their tenure packets, and each junior faculty member has a mentoring committee and a career development plan.

Our graduate students are also relatively non diverse compared to the population of the USA. However, since our DEI committee worked with the School to change graduate admissions to a holistic model, the number of applicants from diverse backgrounds has risen to be 35% of our applicant pool (from average values in single digits) and the number of acceptances has also risen by a similar amount. Currently the School has 59 graduate students, of which 39 are female (66%), 3 are from "federally-recognized" diverse backgrounds (e.g. hispanic, black, native etc; 5%) and 11 are international (19%). These are the highest percentages in departmental records back to the 1990's.

Our undergraduate population is our most diverse. Currently we have 109 declared majors, and their diversity matches that of the State of Washington fairly well except that we under-recruit Hispanic students. Over the last decade we have made significant progress in educating a more diverse student population. Our student diversity index in 2010 was 0.37 and now it is 0.54 (the diversity index for the entire USA is 0.54 and for Washington State it is 0.56).

Table: Percentage of different ethnic communities in undergraduate majors in the School of Oceanography and for the State of Washington.

	SoO	WA State
White/caucasian	66%	64%
Asian	15%	11%
Hispanic	7%	15%
Afro-Amer	2%	5%
Amer-Ind	2%	3%
Hawaii/Pac	1%	2%

Initiatives and Partnerships

We rely heavily on the college in this regard, but have a small number of steady programs.

- We partner annually with SACNAS students here at UW (Society for the Advancement of Chicano and Native Americans in Science) to staff a booth promoting the ocean sciences at the annual SACNAS meeting (our graduate students manage this).
- We have a GEODUC (Marine Geoscience Education, Oceanographic Discovery, Undergraduate Collaboration) grant to work with low income and diverse community college students (Nuwer and Thompson PIs)
- We have long-term collaborations with the ALVA (Alliances for Learning and Vision for Underrepresented Americans program that is run through engineering (Rocap manages our portion).
- We run a summer internship for low income high school students (Keil lab manage)
- And we offer a biennial international field trip for underserved students who wish to learn about ocean technology (Rupan manages)

The School of Oceanography does not have specific outreach strategies for students with disabilities or for our LGBTQ community. We have gender-neutral bathrooms in each of our buildings and a no-tolerance policy for harassment.

Section II: Teaching & Learning

The typical college student of today, like their predecessors, possesses a great curiosity about the environment and an urgent desire to make a positive contribution to its preservation and restoration. Jobs in the environmental sciences continue to expand and employment rates are projected to grow at ~3x the national average during the next decade.

Oceanography offers a unique open-ocean focused undergraduate major leading to a BS in Oceanography that emphasizes a solid basic science training and interdisciplinary approach and provides ample opportunities for field and research experience. We also offer a BA degree that does not require a written thesis and is more tailored to students interested in teaching or non-research related post-baccalaureate work. We currently have 108 undergraduate oceanography majors, a steady number over the last decade and a half. We track approximately 85% of our graduates into and through their first or second positions post-graduation. More than 50% obtain science staff positions within the federal, state or private sectors, and about 20% attend graduate school in the environmental sciences. Our marine technology program, and the python coding classes that we teach, have opened new job opportunities and a growing number of our alumni enter into the data sciences.

Oceanography partners with Fishery Sciences in the Marine Biology BS degree, which contains more than 300 undergraduate majors. The program is young, but one thing is clear - we expected a drop in oceanography majors because of the marine biology major, but that did not happen. Nor did we accumulate a large number of double-majors (about 20% of oceanography majors are doubling but many other degrees are sought; dance, earth and space, biology, etc). In many respects the two degrees have started to be managed independently and the anticipated need to merge academic services has not come to pass. We believe that the expected drop in oceanography majors did not occur because the two degrees are actually very different; oceanography being very open-ocean focused and quantitative with emphasis on large data collection and analysis while marine biology tends to be more organismal, observational and coastal in its implementation.

Our graduate education program consistently produces graduates who are hired at the top institutions and become leaders in the field. We currently have 59 graduate students divided into four options. There are 22 physical oceanography graduate students, 14 chemical oceanography, 13 biological oceanography and 10 marine geology students. The gender distribution is roughly ⅔ female in each option. The average time to PhD is six years and one month, and 80% of our incoming graduate students achieve this highest degree. On average, our students graduate with two published papers and two submitted or near submission, and more than 35% of our graduate students earn themselves some sort of federal or regional fellowship.

Our alumni are asked to fill out an exit interview so that we can improve our program, and we try to keep in touch through their first couple jobs or postdocs. Eighty percent of our PhD graduates attain teaching or research positions at leading oceanographic institutions across the country and another 15% become consultants, program managers, or educators outside the university setting. This large number (95%) of our graduates remaining in the field of oceanography is a strong indicator of the quality and success of our graduate teaching program.

Student Learning Goals and Outcomes

Undergraduate Program in Oceanography

Our undergraduate student learning goals fall into four categories: analytical (including technical and data manipulation), intellectual, communication and interpersonal. Oceanography majors are expected to apply scientific methods to solve problems in oceanography (and environmental sciences), locate scientific information needed for background understanding, write and speak effectively, be aware of key interactions between society and the ocean, apply technological methods to problems, and work as part of a team.

Evaluation of undergraduate student learning relies on several metrics. In the classroom, student performance is evaluated through exams, problem sets, written papers, presentations and discussion of primary literature. In our two field courses, additional metrics are used. The sophomore oceanography field course (Ocean220) includes evaluation of the creation and execution of an experimental plan by a team, individual meetings to discuss data analysis and scientific writing, multiple revision cycles of a final paper and an oral presentation. The senior capstone courses (Ocean443 and 444) includes weekly student meetings to discuss formulation of a thesis topic, analysis of data and scientific writing, team planning of cruise operations, multiple revision cycles of thesis proposal, a final paper and final oral presentation. The senior theses produced are archived in the Research Works Archive through UW Libraries, and oral presentations are via a public symposium.

We evaluate student satisfaction through use of standardized teaching evaluation forms and student feedback coordinated through the Office of Educational Assessment (OEA). We also maintain an electronic feedback form and host regular open meetings for students to bring ideas and issues forward.

Approximately a decade ago this information was used to kick-start a major reimagining of our undergraduate program. Changes included:

A. a freshman orientation course (ocean 100) that introduce students to the SoO and encourage them to participate in research during their UW career,
B. a data analysis course (ocean 215) which uses the coding program *python*,
C. infusion of data science into our entire curriculum,
D. establishing our ocean technology program,
E. teaching more applied oceanography content while reimagining the upper-division core courses,
F. expanding the senior thesis course sequence to include individual study options and blue-water cruise opportunities (most years), and
G. Creation of an early fall start course for transfer students and students who declare the major late in their time at UW

We currently have no plans for any further major revision of the undergraduate curriculum. Instead, we are focusing on growing our marine biology course offerings.

Graduate Program

Our graduate program emphasizes doctoral study, though we believe that a masters degree is an important milestone along the way. We admit students with a promise of full financial support for six years as long as the student is making satisfactory academic progress. Financial backing for this promise limits the size of the program and we are stable over the last decade at about 60 students.

The goal of our graduate program is to develop deep-thinking individuals who are capable of independent research, who can lead but also excel as part of a team, and who have excellent communication skills in both written and oral formats. Students are expected to gain sufficient depth of knowledge in their research specialization, to develop independent research capabilities, and to graduate with sufficient breadth of knowledge to work effectively within the interdisciplinary field of oceanography. This is primarily accomplished via required courses both inside (6-8 courses) and outside (3 courses) their discipline. All students must serve as a TA at least once, and a second TA opportunity to expand a graduate student's teaching experiences is strongly recommended.

Evaluation of graduate student progress uses several metrics including mandatory semi-annual meetings with the advisory committees where students describe progress and achievements from the past six months and plans for the next six months. A brief summary of the committee's recommendation, written by the student and approved by the advisor, is placed in the academic file. The results of these semi-annual committee meetings are presented to the graduate faculty within each student's curricular group and a written report from this meeting is placed in the student's file. The first formal evaluation point is the master's (MS) presentation, which is expected to occur in the third year. The supervisory committee evaluates the student's potential and recommends whether the student should continue towards the general examination, a requirement to become a PhD candidate. The general examination is expected to occur 6-12 months after the MS and consists of an oral examination by the supervisory committee of the student's ability to present the proposed dissertation research and to understand the oceanographic concepts relevant to their research. At the completion of the thesis research and write-up of the dissertation, the student must successfully defend their research in a public seminar.

Graduate student satisfaction is evaluated throughout their time in our program. Quarterly open meetings are held, students have an anonymous feedback form they can use, school administration works with the graduate student club ARGO, student leadership meets regularly with the director, and beginning this year students have biannual opportunities to provide critical and constructive feedback to their mentors. We also have two exit surveys, one administered locally and one by the graduate school.

Feedback from students has led to substantial changes in our program over the last decade. We now have an undergraduate course (Ocean 215; data analysis) that is completely taught by graduate students. This gives graduate students an opportunity to lead a course and develop teaching skills. Since the pandemic we have taken great effort to try and assure student well-being. We now offer individual mentoring for students who are writing their first or second

research papers. Additionally we offer a highly successful course geared at helping students win fellowships, and we have been operating in a more transparent manner when it comes to scholarships, top off awards, student pay and other departmental operations.

Undergraduate Courses for non-majors

The School of Oceanography teaches a host of courses at all undergraduate levels with the expressed audience of non-majors. They include:

- Ocean 102: The Changing Ocean (e.g. ocean and climate change)
- Ocean 121: Deep Sea Exploration: Submarine Volcanoes and Novel Life Forms (e.g. hydrothermal vents)
- Ocean 161: Introduction to Environmental Monitoring and Technology
- Ocean 230: Rivers and Beaches
- Ocean 235: Arctic Change (e.g. humans, climate change and the Arctic)
- Ocean 355: From Big Bang to the Blue Planet (e.g. the history of the oceans)
- Ocean 409: Marine Pollution
- Ocean 450: Climatic Extremes (e.g. extinctions, ice ages & the oceans)
- Ocean 480: Global Ocean - Human Culture (e.g. an exploration of oceans and human health)

Each of these courses has been highly popular and has the general goal of 'educating voters' such that they will live responsible adult lives, acting and voting to protect our planet.

Instructional Effectiveness

Oceanography conforms to the UW norm; we encourage all junior faculty to participate in the Faculty Fellows program, we engage in college and UW educational programs (primarily led by our teaching faculty), we use the OEA forms, and we use peer teaching evaluations with all our assistant and associate professors.

Graduate students are provided with both UW and Oceanography-specific TA training sessions. We have two school awards for excellence in graduate teaching and mentoring, and winners of these awards are voted upon by undergraduates and graduate students.

Teaching and Mentoring Outside the Classroom

A defining aspect of our educational program is incorporation of our research ships *R/V Thomas G. Thompson* and *R/V Rachel Carson* into instructional activities. The State of Washington supports use of these ships through an agreement with the Office of Naval Research (owner of the *R/V Thompson*). Students can get out to sea via a number of our courses. Dedicated educational cruises are central to our required undergraduate field courses. The senior capstone course uses the *R/V Thompson* for 10-14 days per year on average. Student-centered research expeditions within the last decade include trips to the Hawaiian Islands, Japan and the Kuroshio Current, the outer fjords of Vancouver Island, the Eastern Tropical North Pacific, the Great Pacific Garbage Patch, and this year's trip is from Hawaii to Fiji across the equatorial

Pacific. The result has been extraordinary research experiences for the students, mentoring opportunities for graduate students, and several peer-reviewed papers.

The *Thompson* is also used each summer to support educational efforts of the RCA; Regional Cabled Array component of the Oceans Observing Initiative. *R/V Carson* is used for local expeditions in the 200-level and 300-level courses for both Oceanography and Fishery Sciences. Since our last program review more than one thousand students have sailed on our ships, with most undergraduates sailing for 10-16 days as part of their education.

In addition to fieldwork, approximately half our students become involved in research with a faculty member (in addition to course-required research) during their undergraduate career. These independent projects expose undergraduates to cutting edge research topics and provide mentoring experiences for our graduate students and postdocs. We are particularly proud of this synergy between our education and research programs.

Section III: Scholarly Impact & Future Directions

Despite the rather drastic decline in our total faculty count (see Appendix C), the faculty of the School of Oceanography remain leaders within the international oceanographic community. This is perhaps best illustrated by the Shanghai Rankings, the only international ranking of research at educational units (this excludes WHOI from the ranking). Shanghai Rankings evaluate the total number of papers in “first-quality” journals, the frequency with which papers are referenced, the number of papers that include international authors, and the number of papers published in six selected marine journals. In almost all these metrics UW has ranked #1 or #2 since 2018 (15 of the 16 metrics).

Among our faculty are members of the National Academy of Science, the State of Washington Academy of Sciences, the Brazilian Academy of Sciences, numerous AGU Fellows, and ALSO career and paper award winners. Amazingly, all our assistant professors since 2005 have been awarded Career development awards from either NSF Geosciences, the Simons Foundation, or the Microsoft Foundation. We have been awarded four patents in the last ten years despite that being a minor component of our effort, and last year one of our teaching faculty won UW’s distinguished teaching award.

Our excellent standing within the oceanographic community is equally evident in our funding success. Oceanography faculty currently raise on average $30M each year in new funding and the average research portfolio of a faculty member in our school exceeds $1M per year in expenditures (of course there is a wide range here).

New faculty hires over the past several years reflect our desire to maintain disciplinary strength while simultaneously building cross-disciplinary bridges. Our assistant professors are not only wonderful people, but they are establishing respected programs in ocean biogeochemistry and micronutrients (Bundy), Arctic and Antarctic plankton ecology (Young), machine learning for

fluid dynamics and climate studies (Manucharyan), *in situ* sensors for evaluating climate and ocean circulation (Gray), and blue carbon studies of coastal environments (Valentine).

Our newest hires promise to bring expertise in electromagnetic geophysics (Chesley), chemical oceanography and climate evolution (Pavia), and astrobiology and agnostic biosignatures (Weiss).

SoO faculty members are responsible for key discoveries in varied areas including geophysical fluid dynamics, turbulence, environmental genomics, microbiology of extremophiles, carbon cycling, sedimentary processes, paleoclimate, mid-ocean ridge dynamics, biogeochemistry of large rivers, and seafloor venting.

Part B Self Reflection & Unit Defined Questions

The School of Oceanography's foundational attribute, first articulated in the 1940's, is to promote the synergy of research and education such that it leads to new discoveries and trains future leaders. We reaffirm this goal while recognizing that the School needs to be nimble amidst changing times. In particular, the School of Oceanography faces three immediate and immense challenges:

1. Poor physical infrastructure and decaying laboratory spaces.
2. Declining faculty numbers compounded by an increased urgency and necessity to teach and educate undergraduates and graduate students.
3. Low faculty salary and a lack of incentives; we have recently lost two faculty to competitive recruitments.

Infrastructure

1. How can the School of Oceanography improve its infrastructure? Much of our infrastructure is old, inadequate for modern research, and increasingly unusable.

The School of Oceanography is spread across several buildings: the Ocean Sciences Building (OSB; est. 2000), the Marine Sciences Building and pier (1967), the Ocean Teaching Building (1965), Old Oceanography (1934), a few out buildings, and we have rental space in Ben Hall (2005). Only OSB and Ben Hall are adequate for modern research, and even OSB has major building issues. Also, OSB is at capacity and cannot hold more than one more new professor and their research teams.

It is important that the University of Washington begin in earnest to plan for the replacement of, or reconstruction of our space. The southeast campus plan (covering our spaces) expands the hospital and eliminates several of our buildings without apparent replacement. While the School of Oceanography can certainly consolidate, we cannot operate without a dock, and without more high-quality lab and engineering space. Here is an incomplete list of issues we face:

- The electrical, heating and cooling systems in MSB are unreliable. Each summer we lose valuable samples when the building overheats (office temperatures routinely exceed 90 degrees), and in the winter the building is often unheated due mechanical failures.
- MSB is also an asbestos-laden building with inadequate lab spaces for modern science. Much of the second floor is contaminated with low (but legal) levels of carbon and hydrogen radiation that prevent modern oceanographic chemistry from being pursued there.
- The MSB dock has a recurring issue where potholes and slumps threaten our ship operations.
- The elevators and heating on OSB remain problematic after twenty two years of repeated repair (they were installed incorrectly - the litany of issues with our newest and ‘best’ building would be longer than this document if fully laid out).
- The Old Ocean building houses our wet labs for teaching, but infrastructure such as the Puget Sound model remain vulnerable because of sagging concrete floors and inadequate maintenance.
- The Ocean Teaching Building is in reasonably good shape but it is slated to be torn down in the first phase of the hospital expansion and no new location has yet been identified (the timeline for this remains unclear).
- We do not have adequate lab space to hire new faculty.

Faculty Numbers and Composition

2. How do we maintain a robust research and teaching program in the face of budget cuts and declining faculty populations?

Over the last decade the number of Oceanography faculty has shrunk by more than 40% due to retirements from tenure lines, competitive recruitments from other institutions, and our decision to retire our WOT lines while simultaneously moving all our appointments to a 9-month basis. Prior to 2010, our School hired faculty into tenure-line positions with a six (6) month State of Washington commitment, and we also paid our research "without tenure (WOT)" faculty three (3) months of salary. Full professors received nine (9) months support, but most focused on research and "bought out" their additional three months, freeing it up for our WOT faculty. That model helped our school grow throughout the 1980's until approximately 2010, when changing external factors and the desire of the dean led the School to pledge not to hire any new WOT faculty and to move all the professors to nine (9) month appointments regardless of their rank. In order to achieve this, an infusion of money was given to the School by the college with a pledge from us that when tenured faculty retired their FTE would be counted against the infusion of money, to pay it back. In essence, we were given a loan to move faculty to 9 month appointments at the cost of future hires. The reckoning is occurring now. The number of voting faculty in the School has fallen from a high of 49 in 2010 to only 29 today. This has been a massive attrition and we need to develop new strategies to respond.

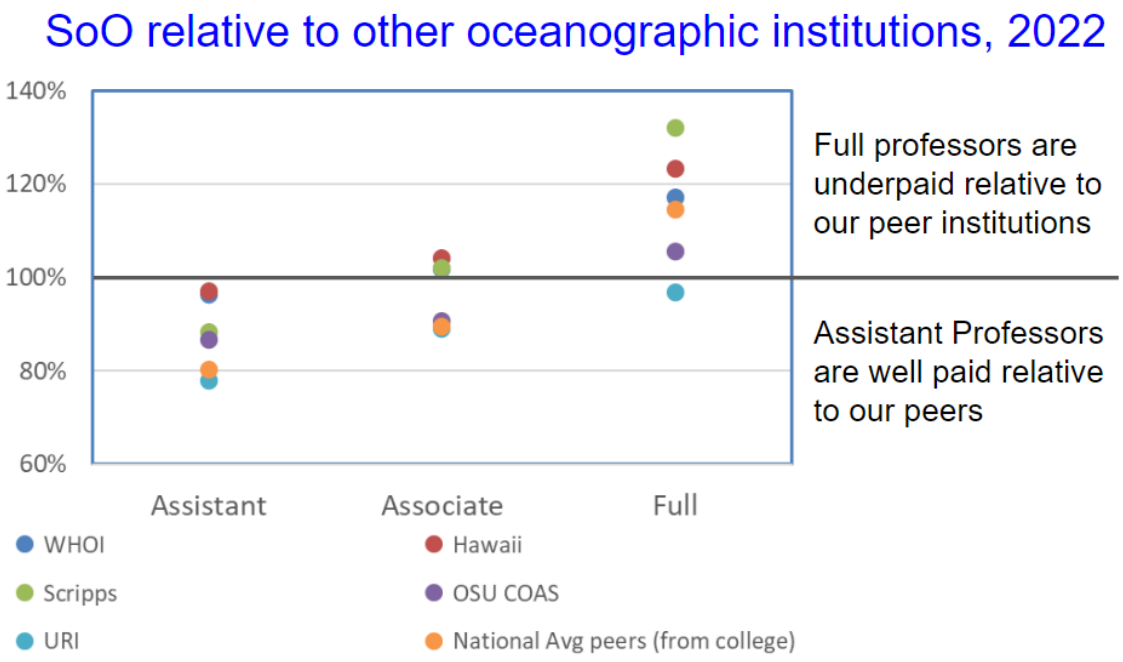
We have thought of two paths forward. One is to hire more teaching faculty. We currently only have one permanent full time teaching faculty member but we are actively recruiting a second now (and have a 3-year commitment in hand to a person serving in the role) and have plans to bring in a third. Teaching faculty "pay for themselves" via the internal monies they generate through teaching. They also relieve other faculty of some teaching duties, freeing up time for research. Finally, teaching faculty give us an opportunity to have needed teaching specialization that is not reflected in our research portfolio.

The second idea is to revitalize our WOT program, particularly with our colleagues in the Applied Physics Lab. This nascent idea is to create 3-6 year WOT positions for researchers at APL such that they are given opportunities to teach, grow their graduate student mentoring abilities, and flesh out their portfolios. After a 3 or 6 year rotation the WOT monies would be free give to a different researcher. We would value the review committee's thoughts on these ideas and value new ideas as well.

Departmental Salaries

3. How should the school recruit and maintain excellence in light of poor salaries relative to our peers and increased poaching of faculty by private institutions?

The School of Oceanography recently reached out to directors at four institutions we consider near-peers; Scripps-UCSD, WHOI, Oregon State, URI, and U Hawaii. Directors at these schools graciously shared data. We also compared ourselves to the national averages in the geosciences (data compiled by our college). As illustrated in the graph below, the UW School of Oceanography is hiring new professors at salaries that are above the going rate (by as much as 25%), but our full professor salaries are 5-35% under that of our peers (15% below the national average). Our two most highly cited associate professors (both of whom will soon be promoted hopefully) are also 3-8% behind their peers. Given that Seattle has become one of the most expensive cities to live in, the region-adjusted differential in spending power is 7-55% lower for our full professors than their peers at other institutions. This is a major concern, as we have recently lost two professors to competitive offers and have one negotiating right now. Given the School's current excellence in research and teaching, we need help getting the university to recognize the need to pay suitable wages.



It is worth mentioning that the only two communities on campus that are paid uniformly at the national rate are our graduate students and postdocs, both unionized. All other communities including research staff (very recently unionized), ship personnel and academic staff are paid at average salaries below market.

Additional Issues

The School of Oceanography recognizes that there are two other issues we need to address.

Graduate Curriculum

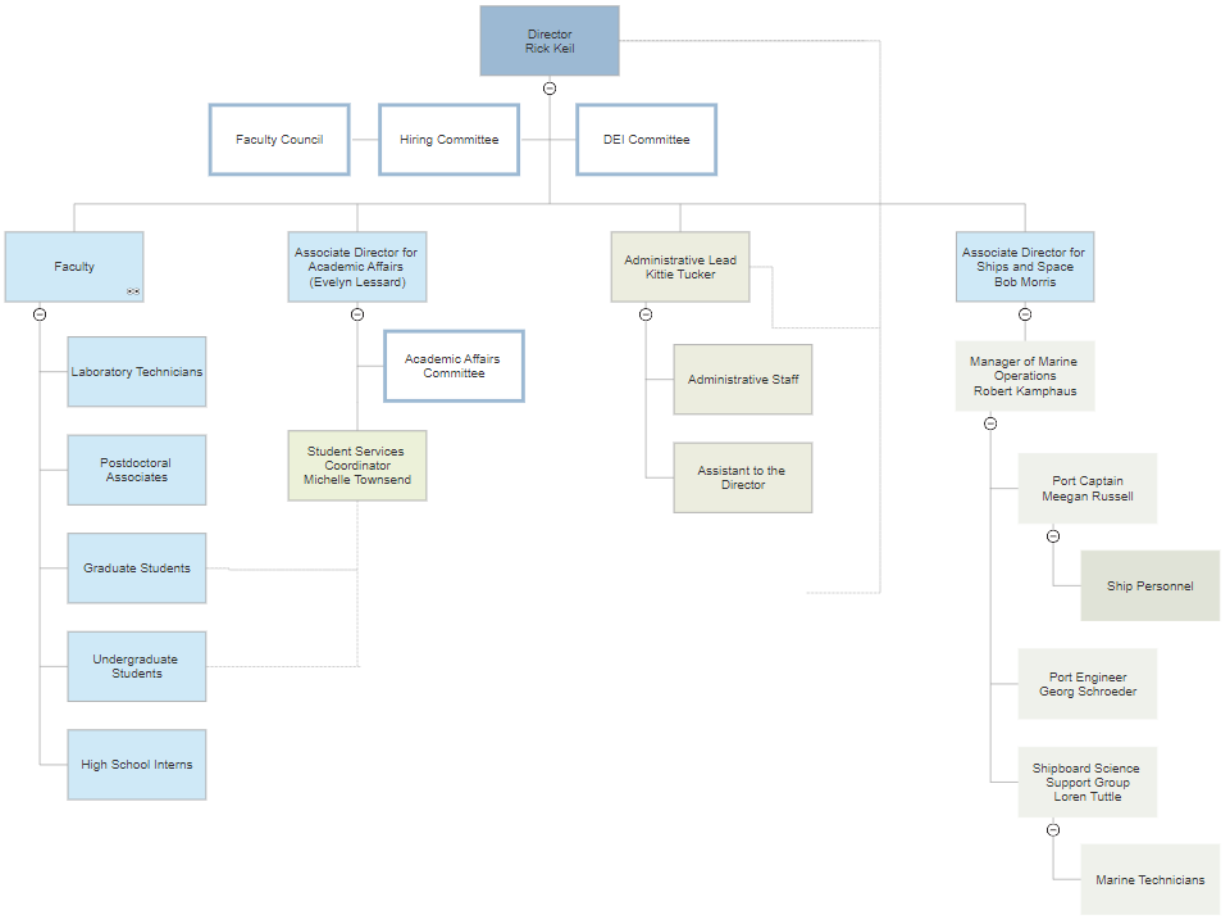
Many of the exciting areas of current and future research across disciplines, yet we have few interdisciplinary graduate courses currently being offered. How should the graduate curriculum be realistically revised? The graduate students provided some excellent suggestions in their letter. Does our curriculum provide the knowledge/tools for graduate students to succeed in careers both inside and outside of academia? Do we have the faculty expertise, and time to develop and teach it?

Organizational Structure

The conclusion of the review committee of the last decadal review was that the disciplinary organization of the school was a barrier to progress, yet the disciplinary perspective is still utilized in our school and graduate student research has become more interdisciplinary. Is our disciplinary organization a benefit or burden? Should we keep or dissolve the disciplinary structure? If we do move away from the option structure, what do we replace it with as our faculty is too large to operate without sub-structure.

Part C: Appendices

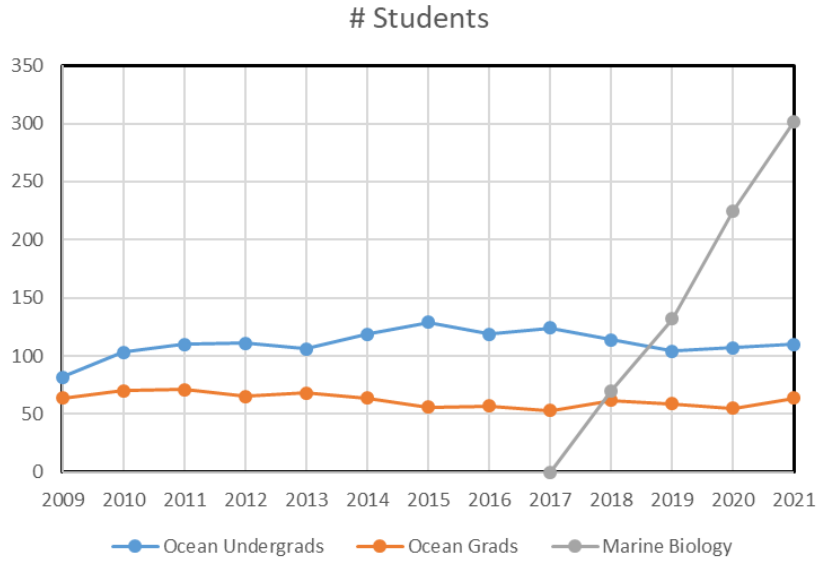
Appendix A: Organizational Chart



Appendix B: Undergraduate and Graduate student numbers

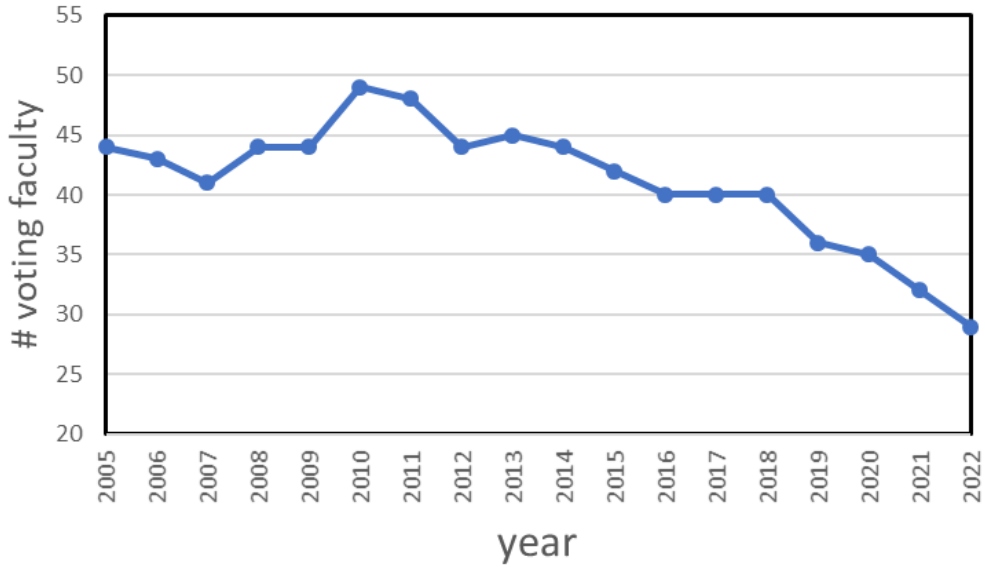
Table 1. Matriculation and graduation data for the past decade.

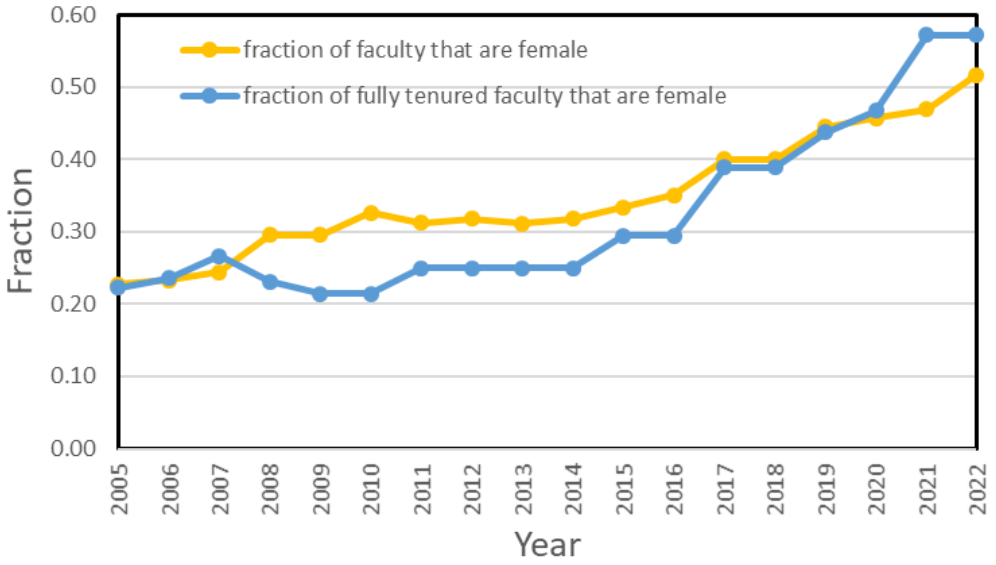
year	Marine Biology	Ocean Undergrads	Ocean Grads	PhDs awarded	MS awarded	BS awarded	BA awarded
2010		103	70	6	12	21	
2011		110	71	6	15	16	
2012		111	65	9	15	19	
2013		106	68	9	11	34	1
2014		119	64	8	9	27	
2015		129	56	12	5	31	
2016		119	57	16	10	30	
2017	0	124	53	4	8	48	
2018	70	114	62	8	9	32	
2019	132	104	59	9	13	37	2
2020	225	107	55	6	6	29	3
2021	302	110	64	9	8	31	1



Enrollment numbers for the Oceanography undergraduate (blue) and graduate programs (orange) have been steady over the last decade. The new Marine Biology undergraduate major (shared with the School of Aquatic and Fishery Sciences) has grown dramatically in its first four years, but not at the expense of the Oceanography major.

Appendix C: Faculty Demographics





Faculty in the School of Oceanography, December 2022

This list includes only faculty drawing salaries in the School. Not included are affiliate and adjunct faculty, and emeritus faculty. A full list of faculty and links to their resumes can be found on our web page.

Name	Title	Emphasis	Notes
Bundy, Randie	Assistant Professor	Biogeochemistry	Simons Foundation Young Investigator
Gray, Alison	Assistant Professor	Circulation and Dynamics	Microsoft Youn Investigator
Manucharyan, Georgy	Assistant Professor	Fluid and climate dynamics	
Valentine, Kendall	Assistant Professor	Coastal processes and blue carbon	
Young, Jodi	Assistant Professor	Arctic and Antarctic phytoplankton	NSF Career award winner
Michael, Susanna	Temporary Assistant Teaching Professor	Chemical Oceanography	
Seroy, Sasha	Temporary Assistant Teaching Professor	Ocean technology	
Chesley, Christine	Assistant Professor*	Marine electromagnetics	arrives January 2023
Pavia, Frankie	Assistant Professor*	Biogeochemistry	arrives January 2023
Weiss, Gabriella	Acting Assistant Professor*	Paleo and Astrobiology	arrives June 2023
Armour, Kyle	Associate Professor	Climate Dynamics	Grabaud Professor
Gagnon, Alex	Associate Professor	Ocean Acidification	on leave, starting a company to fight climate change
Morris, Bob	Associate Professor	Marine bacteriology	
Hautala, Susan	Associate Professor	Deep sea circulation	
Solomon, Evan	Associate Professor	Fluids, gas hydrates and hydrogeochemistry	
Abadi, Shima	Associate Professor	Marine Acoustics	main appointment is in Engineering, UW Bothell
Warner, Mark	Asssociate Professor WOT	Gases and climate	

Nuwer, Mikelle	Associate Teaching Professor	Zooplankton ecology	Fleming Professor, UW 2022 Teacher of the year
Armbrust, Ginger	Professor	Mirobial Ecology	Banse Professor, AGU Fellow
Ingalls, Anitra	Professor	Biogeochemistry and metabolomics	Grabaud Professor
Keil, Rick	Professor	Biological pump, pollution and proteomics	Wakefield Professor, School Director
Keister, Julie	Professor	Zooplankton ecology	on leave, moved to NOAA
Kelley, Deb	Professor	Hydrothermal geology	director, RCO-OOI
Lee, Craig	Professor WOT	Integrated Observational Platforms	primary appointment at APL
Lessard, Evelyn	Professor WOT	Microzooplankton ecology and physiology	
MacCready, Parker	Research Professor	Bio-physical coastal and estuarine modeling	*recently retired from his WOT to focus on research
Nowell, Authur	Professor	Environmental philosophy and engineering	
Ogston, Andrea	Professor	Coastal geological processes	Grabaud Professor
Riser, Steve	Professor	Circulation and climate	
Rocap, Gabrielle	Professor	Microbial ecology of picoplankton	
Sachs, Julian	Professor	Paleooceanography	on leave, starting a company to fight climate change
Thompson, LuAnne	Professor	Observational ocean and climate modeling	Fleming Professor
Wilcock, William	Professor	Ocean seismic networks	Paros Endowed Chair in Sensor Networks
Williams, Kevin	Professor WOT	Biophysical Acoustics	Director of APL, where his primary appointment is held
Woodgate, Rebecca	Professor WOT	Arctic Ocean Circulation	primary appointment in APL
D'Asaro, Eric	Professor WOT	Internal waves and air-sea interactions	primary appointment in APL
Deming, Jody	Professor	extreme condition microbiology, astrobiology	National Academy of Sciences, Banse Professor

Appendix D: Budget Summary

Provide a summary of the unit's three most recent biennia. Prepare this summary in any way that makes most sense for your unit while providing a comprehensive overview for the review committee.

The manner in which the School of Oceanography spends departmental money does not change significantly from biennium to biennium. The table below, for the 2019-2021 biennium, illustrates our major expenditures. In the "incoming" column the black numbers come from UW resources (State monies and tuition). The green numbers are from gifts or from return on research overhead (indirect cost return). In the "Outgoing" column the red numbers denote where we spend more money that we are given by the university.

2019-2021 Simplified Budget

	INCOMING	OUTGOING	% of Expendatures
Faculty salary	$ 6,150,000	$ 6,775,000	56%
Staff salary	$ 1,425,000	$ 2,225,000	18%
TA & RA Salary	$ -	$ 475,000	4%
Benefits	$ 1,900,000	$ 2,500,000	21%
Misc Income/Services	$ 500,000	$ 100,000	1%
Indirect Cost Return	$ 2,100,000		
TOTALS	$ 12,075,000	$ 12,075,000	

The vast majority of our resources are spent on salaries and benefits (99%). The School could not operate at its present effectiveness without our indirect cost return. In comparing our current budgets to those from our last program review in 2010, we currently spend more on faculty salary than is provided to us by the university. This is partly because we have teaching faculty without guaranteed salary lines, and because we still have WOT faculty with a 3-month salary guarantee from the department.

If the dollars provided by the university are compared to our salary obligations to tenure lines, the current values are: $8.1M dedicated to faculty salary + benefits, and $9.4M in income per biennium. After adding in teaching faculty and WOT faculty obligations, the dollar matches are almost equal.

Appendix E: Undergraduate and Graduate degree flow and course catalogs

The following is a possible sequence of courses for the Oceanography B. Sc. degree for a typical STEM student, starting in freshman year. There is flexibility in the balance of the introductory science/math courses and electives between Year 1 and Year 2 - just one possible sequence is shown below. Similarly, the way the upper division electives are scheduled are representative only. However, Oceanography courses tend to occur only once per year, so attention to their scheduling is important.

YEAR 1

AUTUMN (16 credits)	WINTER (15 credits)	SPRING (15 credits)
Math 124 (5)	Math 125 (5)	Math 126 (5)
Phys 121 (5)	Phys 122 (5)	Phys 123 (5)
Chem 120 (5)	English Composition (5)	Ocean 200/201 (5)
Ocean 100 (C/NC, 1 credit)		

YEAR 2

AUTUMN (13 credits)	WINTER (15 credits)	SPRING (15 credits)
Ocean 210 (4)	ESS 210 or 211 (5)	Ocean 220 (3)
Ocean 285 (3)	Biology 180 (5)	Ocean 295 (5)
Electives (6)	Electives (5)	Biology 200 (5)

YEAR 3

AUTUMN (15 credits)	WINTER (15 credits)	SPRING (15 credits)
Ocean 310 (5)	Ocean 320 (5)	Ocean 330 (5)
Ocean 215 (4)	Ocean 351 (3)	Elective Upper Div Sci (3-5)
Electives (5)	Electives (7)	Elective Upper Div Ocean (3)
Ocean 300 (C/NC, 1 credit)		Electives (2-5)

YEAR 4

AUTUMN (15 credits)	WINTER (15 credits)	SPRING (15 credits)
Ocean 443 (3)	Ocean 444 (2)	Ocean 445 (3)
Elective Upper Div Ocean (3)	Elective Upper Div Ocean (3)	Elective Upper Div Science (3)
Electives (9)	Elective Upper Div Science (5)	Electives (9)
	Electives (5)	

For students that transfer to UW (or just to the Ocean major) without a full basic science and math (aka "STEM") preparation, we suggest you consider a plan that allows you to complete the Ocean B. Sc. degree in two years + one extra Fall Quarter for a Senior Thesis Intensive course. The sample plan shown below assumes, for example, that you have only taken a full year of introductory biology (along with all your other non-science general education requirements). It does assume that you have taken an introductory oceanography course equivalent to Oceanography 200/201 - contact the Oceanography student advisor to discuss available options for the summer prior to your junior year, or during the Fall Early Start window.

YEAR 1 (Junior Year)

AUTUMN (15 credits)	**WINTER (15 credits)**	**SPRING (15 credits)**
Ocean 210 (4)	Math 124 (5)	Elective Basic Sci/Math (5)
Chem 120 (5)	Phys 121 (5)	Ocean 220 (3)
ESS 210 or 211 (5)	Ocean 295 (5)	Elective Upper Div Sci (5)
Ocean 100 (C/NC, 1 credit)		

YEAR 2 (Senior Year)

AUTUMN (15 credits)	**WINTER (15 credits)**	**SPRING (15 credits)**
Ocean 215 (4)	Ocean 320 (5)	Ocean 330 (5)
Ocean 285/286 (5)	Ocean 351 (3)	Elective Upper Div Sci (5)
Ocean 310 (5)	Elective Upper Div Sci (4)	Elective Upper Div Ocean (3)
Ocean 300 (C/NC, 1 credit)	Elective Upper Div Ocean (3)	Elective Upper Div Ocean (3)

Undergraduate course catalog for Oceanography

OCEAN 100 Explore Oceanography at UW (1) Explores the research and experiences of the Oceanography school's faculty, graduate students, and undergraduate students. Intended for freshmen, new transfer students, and other considering oceanography as a major. Credit/no-credit only. Offered: A.

OCEAN 101 Oceanography of the Pacific Northwest (5) NSc Introduces the fundamental principles of oceanography by focusing on the waters that surround us - the Washington coast and Puget Sound. Investigates the geologic history of the Pacific Northwest, and the physics, chemistry, and biology of coastal waters using case studies. Intended for nonmajors. Offered: A.

OCEAN 102 The Changing Oceans (5) SSc/NSc Explores case studies on how the ocean drives our planet's climate system and how humans have altered marine and coastal environments. Students consider societal factors affecting progress in marine science, changing popular attitudes toward the oceans, and key current policy implications of marine science. Offered: WS.

OCEAN 115 Astrobiology: Life in the Universe (5) NW Introduction to the new science of astrobiology, study of the origin and evolution of life on Earth, and the search for microbial and intelligent life elsewhere in the Universe. Designed for non-science, liberal arts majors. Offered: jointly with ASTBIO 115/ASTR 115/BIOL 114/ESS 115.

OCEAN 121 Deep Sea Exploration: Submarine Volcanoes and Novel Life Forms (2) NSc Examines the dynamic marine processes that shape the planet and cutting-edge oceanographic technologies used to explore the deepest oceans. Includes imagery of rarely seen submarine volcanic eruptions, hot springs, and novel life forms highlighting the interconnected geological-biological processes creating the most extreme environments on Earth. Offered: W.

OCEAN 161 Introduction to Environmental Monitoring and Technology (5) NSc Introduces a range of environmental monitoring technologies in the context of their scientific application and case studies spanning ocean, atmosphere, and land examples. Includes hands-on experience with sensors and working with data from various technologies and monitoring techniques. Integrates knowledge across environmental science, technology, and engineering. Offered: A.

OCEAN 200 Introduction to Oceanography (3) NSc Focuses on importance of ocean processes for the functioning of our planet. Interdisciplinary case studies are used to examine relationships and interactions at macro-, meso-, and microscales in the ocean. Case studies build upon previous topics and examines human influence on these systems. Intended for science majors. Offered: Sp.

OCEAN 201 Introduction to Oceanography Lab (2) NSc Provides opportunities to experiment with oceanographic concepts through laboratory and field experiences. Students apply the scientific method of inquiry as it applies to the study of geology, physics, chemistry, and biology of the ocean. Emphasizes topics that explore current challenges faced by the ocean and its ecosystem. Co-requisite: OCEAN 200. I Offered: Sp.
View course details in MyPlan: OCEAN 201

OCEAN 210 Integrative Oceans (4) NSc Presents fundamentals of ocean science through regional case studies that illustrate the relationship between interdependent physical, chemical, biological, and geological process. Students apply tools from these scientific disciplines to understand major changes predicted for future oceanic environments. Prerequisite: either OCEAN 200, or OCEAN 250/BIOL 250/FISH 250. Offered: A.

OCEAN 215 Methods of Oceanographic Data Analysis (4) Statistics, graphical representations, and analysis methods for oceanographic datasets using the PYTHON programming language. Prerequisite: MATH 125. Offered: A.

OCEAN 220 Introduction to Field Oceanography (3) NSc Design and conduct a field study in oceanography. Focuses on active learning, deployment of instruments, data collection, interpretation, and presentation. Required field trip during spring break. Prerequisite: OCEAN 200 and OCEAN 215 Offered: Sp.

OCEAN 230 Rivers and Beaches (3/5) NW Introduction to Earth surface environments, the processes that shape them, how humans affect them and are affected by them. Field trips examine mountains, rivers, deltas/estuaries, beaches, and environments beyond. Focuses on linkages between these environments to illustrate coupling between landscapes and seascapes. Offered: jointly with ESS 230.

OCEAN 235 Arctic Change (2/3) SSc/NSc Investigates the Arctic system of ocean, ice, atmosphere, and sea-floor; how human interact with it, and what the future of the Arctic means to the world. Includes sea-ice loss, climate impacts, & Arctic resource exploitation. Offered: Sp.

OCEAN 240 Special Topics in Oceanography (1-5, max. 9) NSc Selected topics of contemporary interest in oceanography such as hydrothermal vents, planetary volcanism, biogeochemical cycling, the ecology of Puget Sound, and the ocean's role in climate.

OCEAN 250 Marine Biology (3/5) NW Lecture-laboratory course in marine biology focusing on physical, biological, and social aspects of the marine environment. Topics include oceanography, ecology, physiology, behavior, conservation, fisheries, exploration, and activism. Weekend field trip. Honors section research project. Offered: jointly with BIOL 250/FISH 250

OCEAN 261 Introduction to Ocean Technology (2) NSc Introduces ocean science and technology in observational ocean science. Covers the basics of underwater sensor design,

power, and data communication, and introduces the design and build process and the operational scope of the ERIS cabled observatory. Offered: S.

OCEAN 270 Aquatic Ecophysiology (5) NW Focuses on fundamental physiology, with an emphasis on processes relevant to living in a variety of aquatic environments. Includes a broad survey of taxa, from prokaryotes to mammals, and a variety of aquatic habitats. Prerequisite: BIOL 200. Offered: jointly with FISH 270/MARBIO 270.

OCEAN 285 Physics Across Oceanography: Fluid Mechanics and Waves (3) NSc In the context of oceanography applications, explores fluid mechanics, waves, light, acoustics, and heat transfer. Prerequisite: either MATH 125 or Q SCI 292, which may be taken concurrently; either PHYS 114 or PHYS 121; recommended: OCEAN 210 concurrently. Offered: A.

OCEAN 286 Physics Across Oceanography: Fluid Mechanics and Waves Laboratory (2) NSc Laboratory and tutorial further exploring the oceanography applications of fluid mechanics, waves, light, acoustics, and heat transfer. Prerequisite: OCEAN 285, which must be taken concurrently; either MATH 125 or Q SCI 292, either of which may be taken concurrently; either PHYS 114 or PHYS 121. Offered: A.

OCEAN 295 Chemistry of Marine Organic Carbon (5) NSc Explores the movement of organic carbon through the global carbon cycle, in the context of earth sciences and marine biogeochemical cycles. Prerequisite: either CHEM 152 or CHEM 120. Offered: W.

OCEAN 300 Exploring Opportunities in Marine Science (1) Explores academic, research, and career opportunities in the field of marine science and helps prepare students for graduation. Intended for junior and transfer students studying marine science. Credit/no-credit only. Offered: jointly with FISH 300/MARBIO 300; W.

OCEAN 310 Marine Geology and Geochemistry (5) NSc This course focuses on marine geologic processes including the formation and evolution of the ocean crust; marine sedimentation and diagenesis; subduction zone dynamics; the role of marine geology in seawater composition and sustaining the deep biosphere; and the relationship between marine geological processes and climate. Prerequisite: OCEAN 200; and either ESS 211 or ESS 212; and OCEAN 285, which may be taken concurrently. Offered: A.

OCEAN 320 Coastal Oceanography (5) NSc The formation of, and processes within, coastal ocean systems emphasizing the geological evolution of coastal and estuarine environments and the physical dynamics within them, including waves, currents, river plumes, and sedimentary processes. Influences of physical processes on marine chemical cycling and biological productivity in the coastal ocean. Prerequisite: OCEAN 285; ESS 210. Offered: W.

OCEAN 330 Marine Biogeochemical Cycles (5) NSc Covers the distribution of life and chemical elements in the ocean; the relationship between them; and the physical processes affecting these patterns. Emphasizes how marine organisms and the structure of marine ecosystems influence

the fate of carbon and other elements in the ocean. Prerequisite: OCEAN 210; BIOL 200; and either OCEAN 295, CHEM 220, CHEM 223, or CHEM 237. Offered: Sp.

OCEAN 340 Interdisciplinary Topics in Oceanography (1-5) NSc Special topics of an interdisciplinary nature setting ocean into a broader context.

OCEAN 351 Foundations of Ocean Sensors (3) NSc, RSN Experiential learning, foundational knowledge of methods used to observe key quantities that characterize marine environments. Includes theory and application of sensor design and construction principles, in the context of inferences and hypothesis-testing about key physical, biological, chemical, and geological dynamics in the oceans. Prerequisite: OCEAN 215; OCEAN 285. Offered: W.

OCEAN 355 From Big Bang to the Blue Planet (3) NSc Explores the origin and evolution of the Earth, ocean, atmosphere, and life, with an emphasis on climate as the integrator of changes in the biosphere, cryosphere, hydrosphere, atmosphere, and lithosphere. Prerequisite: either CHEM 120 or CHEM 142; either PHYS 114 or PHYS 121; either BIOL 161, or BIOL 180.

OCEAN 361 Ocean Technology I: Introduction to Underwater Observational Sensor Design and Build (2) NSc Combines ocean science and technology in a design and build course utilizing the ERIS cabled observatory at the UW Oceanography dock. Students apply the basics of sensor design, power, and data communication to individual underwater observatory projects. Prerequisite: OCEAN 261, which may be taken concurrently. Offered: S.

OCEAN 370 Marine Evolutionary Biology (5) NW Emphasizes geobiological patterns of marine evolutionary biology environment; processes of evolution; marine prokaryote and eukaryote diversity; and applications of evolutionary principles to ocean change, and conservation and management of marine biodiversity. Prerequisite: either FISH 270/OCEAN 270/MARBIO 270 or BIOL 220. Offered: jointly with FISH 370/MARBIO 370; Sp.

OCEAN 401 Special Topics in Chemical Oceanography (3) NSc

OCEAN 402 Advanced Marine Biogeochemical Processes (3) NSc Current research in chemical oceanography. Marine biogeochemical cycles and explores more deeply how marine organisms and humans impact the chemistry of the ocean. Prerequisite: OCEAN 330; recommended: OCEAN 210; OCEAN 295; and BIOL 200. Offered: W.

OCEAN 409 Marine Pollution (3) SSc/NSc Explores anthropogenic impacts on the oceans and marine organisms. Examines how scientific understanding informs environmental management, thereby linking science and society. Students develop a detailed understanding of the major categories of anthropogenic pollutants on marine systems, how they impact the environment, their sources, and fates. Prerequisite: OCEAN 101, OCEAN 102, OCEAN 200, OCEAN 250/BIOL 250/FISH 250, or permission of instructor Offered: A.

OCEAN 410 Marine Geology and Geophysics (4) NSc Explores the geological and geophysical processes that form and shape the ocean basins and continental margins. Prerequisite: either OCEAN 310 or ESS 211 Offered: jointly with ESS 410; A.

OCEAN 411 Special Topics in Marine Geology and Geophysics (3) NSc

OCEAN 412 Seismic Exploration (3) NW Introduction to theory and practice of seismic exploration. Application of refraction and reflection techniques to geologic investigations, tectonics and mineral exploration. Practice in the interpretation of subsurface structure. Prerequisite: ESS 311 or ESS 314, or OCEAN 285 and OCEAN 310. Joint with ESS 467; Sp.

OCEAN 421 Special Topics in Physical Oceanography (3) NSc

OCEAN 423 Ocean Circulation and Climate (3) NSc Quantitative treatment of ocean basin to global scale ocean circulation systems and their interaction with climate variability. Prerequisite: MATH 125; and PHYS 123 or OCEAN 285.

OCEAN 431 Special Topics in Biological Oceanography (3) NSc Reviews current research. Topics include global change effects on marine organisms, marine pathogens and emerging diseases, introduced species, marine viruses, astrobiology, hydrothermal vents, symbiosis, animal physiology, larval forms and dispersal, biogeography, and environmental ethics.

OCEAN 432 Microbes in a Changing Ocean (3) NSc Covers the major groups of marine bacteria and archaea, and their viruses, and the range of activities and interactions that enable microbes to thrive in a changing ocean. Prerequisite: OCEAN 330; recommended: introductory college-level coursework in all three of, or advanced college-level coursework in two of, biology, oceanography, or microbiology. Offered: W.

OCEAN 443 Undergraduate Thesis: Proposal (3) NSc Work closely with faculty mentors to conceptualize and write a proposal for independent thesis research. Prerequisite: OCEAN 220, OCEAN 310, OCEAN 320, or OCEAN 330 Offered: W.

OCEAN 444 Undergraduate Thesis: Research (2) Work closely with faculty mentors to conduct thesis research as designed in OCEAN 443 in a field, laboratory, or other guided research setting. Prerequisite: OCEAN 443.

OCEAN 445 Undergraduate Thesis: Data Analysis and Writing (3) NSc Analyze results from senior thesis experiments and present results in a series of drafts and a final paper. Results are presented at a two-day long public research symposium and on the students; individual websites. Prerequisite: OCEAN 444.

OCEAN 450 Climatic Extremes (4) NSc Course examines Earth history for extreme climatic conditions to predict future climate changes. Numerical climate models use PC-based computer programs to identify processes and feedbacks that control climate. Offered: W.

OCEAN 452 Marine Geospatial Information Science (3) NSc Introduces the use of Geographic Information Systems (GIS), seafloor mapping, hydrographic surveying, and spatial analysis in ocean science. Emphasizes sampling and analysis of spatially-referenced data about the coastal and marine environments, integrating these technologies in an applied research setting. Offered: jointly with FISH 452; A.

OCEAN 454 Hydrothermal Systems: An Interdisciplinary View (3) NSc Provides a general, interdisciplinary overview of seafloor hydrothermal systems including important geological, chemical, and biological processes. Topics include tectonic and volcanic controls on hydrothermal systems, water/rock reactions, phase separation, temporal variability, fluxes to the deep sea, micro- and macro biology. Offered: W.

OCEAN 461 Advanced Ocean Technology - Project Design and Management (2) NSc Practicum in the design, build, operations, and management of observational ocean science technology. Students oversee and mentor ongoing design and build projects, with attention to design criteria and deployment timelines. Prerequisite: OCEAN 361. Offered: S.

OCEAN 462 Ocean Technology Studio (1-5, max. 15) NSc Hands-on experience to build technical, science, and management skills in ocean technology through small group projects. Projects may include instrument design and building, data analysis, and/or participation in an on-going ocean technology initiative. Offered: AWSp.

OCEAN 475 Current Research in Climate Science Seminar (3, max. 6) Talks focusing on climate from invited speakers, complemented by class discussion, readings, and final paper. Promotes interdisciplinary understanding of climate concepts. Prerequisite: either ESS 201, ATM S 211, or ATM S 321. Offered: jointly with ATM S 475/ESS 475; A.

OCEAN 477 Seminar in Marine Biology (3) NSc Reviews current research in marine biology. Emphasizes critical readings and discussion of primary literature. Prerequisite: FISH 250, OCEAN 250, or BIOL 250; Q SCI 381, STAT 220, or STAT 311. Offered: jointly with BIOL 477/FISH 477; W.

OCEAN 479 Research in Marine Biology (1-15, max. 15) Individual research on topics in marine biology. Research projects supervised by an individual faculty member. Projects may include laboratory work, fieldwork, and literature surveys. Prerequisite: BIOL 250/FISH 250/OCEAN 250; Q SCI 381. Offered: jointly with BIOL 479/FISH 479/MARBIO 479; AWSpS.

OCEAN 480 Global Ocean - Human Culture (3) SSc/NSc Exploration of the role of the ocean basins in human history, music and the arts, the evolution of ships, development of trade routes, modern marine commerce and communications, living and non-living resources, hazards, projection of sea power, entertainment and recreation, ocean science-modulation of climate, exploration of exotic submarine hydrothermal systems, and oceans beyond earth.

OCEAN 481 Puget Sound and Estuarine Oceanography (3) NSc Explores fundamental physical-biological processes in estuarine systems, using Puget Sound as a primary example. Topics include effects of circulation and mixing on residence time, nutrients, phytoplankton, zooplankton, and fish. Also covers hypoxia, the estuarine turbidity maximum, the intertidal zone, harmful algal blooms, and effects of climate change.

OCEAN 482 The Changing Arctic Ocean (3) NSc Investigates the interacting physical, chemical, and biological components of the Arctic ocean-ice-atmosphere system, including the most recent scientific advances. Considers the impacts of Arctic Change on Arctic and global climate, marine organisms and ecosystems, native communities, and future exploitation of an ice-free summer ocean. Prerequisite: OCEAN 200 or OCEAN 210 and BIOL 180, BIOL 200 or BIOL 220.

OCEAN 492 Friday Harbor Apprenticeship (9/15) NSc Intensive, full-time research training experience where teams of students work on focused research problems guided by a group of faculty, postdoctoral, and graduate student mentors. Research questions vary.

OCEAN 494 Field Experiences in Marine Science (1-15, max. 30) NSc For participants in oceanography field work. Specific content varies and is individually evaluated. Credit does not apply to major requirements without approval.

OCEAN 496 Study Abroad: Oceanography (1-15, max. 30) NSc For participants in UW study abroad program. Specific content varies and is individually evaluated. Credit does not apply to major requirements without approval.

OCEAN 497 Advanced Special Topics in Oceanography (1-15, max. 15)

OCEAN 499 Undergraduate Research (1-15, max. 24)
Individual research supervised by a faculty member. May involve laboratory work, fieldwork, or literature surveys.

Graduate Education and Courses

School of Oceanography graduate students must select the option in which they pursue their degrees. There are four options, Biological Oceanography, Chemical Oceanography, Marine Geology & Geophysics, and Physical Oceanography. For each option, the student must complete prescribed courses, attend the weekly seminar, and complete advanced coursework. The program offers a non-thesis Master's degrees which is earned on the way to a student's Ph.D. in Oceanography. Our website offers extensive links to programs, support and resources for current and prospective graduate students.

For details of all requirements, see the Graduate Student Guide. *We were going to add this guide as its own appendix, but at 32 pages we didn't want to overwhelm the review committee.* **It is well worth reading to get deep knowledge on our graduate degree.** The Graduate Student guide provides in depth tables and flow paths for students in our program so that they can succeed. The table for the entire PhD flow is reproduced here, followed by a list of our current graduate course offerings.

SUMMARY CALENDAR FOR DOCTORAL DEGREE PROGRAM

	ACTION	WHEN
1.	Meet with faculty adviser to outline first-year curriculum	On arrival on campus
2.	Establish an Advisory Committee of three faculty and meet at least on a semi-annual basis*	At the beginning of Autumn Quarter of the first year
3.	Restructure Advisory Committee into a Supervisory Committee. Inform the Student Services Coordinator and/or Graduate Program Coordinator.	By June, after one year of graduate study
4.	Oral presentations of research progress to student and faculty colleagues	Autumn Quarter of the second year of graduate study in this School
5.	Meet with Supervisory Committee to decide on future research plans and date for dissertation defense	In Spring Quarter of second year
6.	Complete required course work	By end of second year
7.	Fulfill first TA requirement	Before M.S. defense (or before Ph.D. defense if committee approves prior M.S.)
8.	Oral presentation of research progress to student and faculty colleagues (may be fulfilled by M.S. defense)	Autumn Quarter of third year (waived if M.S. defense occurs sooner)
9.	Fulfill second TA assignment	Prior to dissertation defense
10.	Request appointment of Doctoral Supervisory Committee. Add GSR to committee.	No later than four months prior to application for admission to General Examination

11. Submit application for warrant for General Examination	At least three weeks prior to proposed examination date
12. Submit dissertation research proposal to committee	At least two weeks prior to proposed examination date
13. Take General Examination	Normally no later than end of fourth year of study (16 quarters in residence)
14. Awarding of candidate certificate	After successfully passing the General Examination
15. Outline research tasks necessary to complete Ph.D. with Supervisory Committee	After completion of General Examination. Meet semi-annually with committee
16. Work out schedule for dissertation submission with Supervisory Committee	Before end of quarter prior to that of expected graduation
17. Request appointment of dissertation Reading Committee (approval of all members required). Inform Student Services Coordinator and/or Graduate Program Coordinator.	At least six weeks prior to date of Final Examination. (Be sure to provide them 4-6 weeks to evaluate the dissertation)
18. Doctoral Supervisory Committee requests Final Examination (approval of all members required).	Three weeks before proposed date of Final Examination
19. Put notice in School Events calendar.	Two weeks before proposed date of Final Examination
20. Register as a full-time or part-time student at UW	During the quarter in which the Final Examination is taken and degree requirements are completed
21. Take Final Examination and present public seminar	No earlier than one quarter after passing General Examination
22. Submit an electronic dissertation through the Graduate School	By the last day of the quarter in which the degree is to be conferred, and within 60 days of the Final Examination

Annotated Graduate Course offerings in Oceanography

OCEAN 500 Proposal Writing and Professional Development Seminar for Entering Graduate Students (1/2, max. 3) Seminar for entering graduate students in the School of Oceanography. Topics include development of a research proposal suitable for submission to the National Science Foundation Graduate Research Fellowship Program competition, oral communication skills, peer review, time and stress management, communication with advisors and committee members, and post-graduate career planning.

OCEAN 502 Marine Geospatial Information Science (3) Introduces the use of Geographic Information Systems (GIS), seafloor mapping, hydrographic surveying, and spatial analysis in ocean science. Emphasizes sampling and analysis of spatially-referenced data about the coastal and marine environments, integrating these technologies in an applied research setting. Offered: jointly with FISH 502; A. ***Not currently offered due to lack of expertise (retirement that was not replaced)***

OCEAN 504 Seismic Exploration (3) Introduction to theory and practice of seismic exploration. Application of refraction and reflection techniques to geologic investigations, tectonics and mineral exploration. Practice in the interpretation of subsurface structure. ***Will not be offered until Christine Chesley arrives on campus.***

OCEAN 506 Interdisciplinary Seminar in Oceanography (1-3, max. 12) Lectures, discussions, and work on selected problems of an interdisciplinary nature.

OCEAN 507 Puget Sound and Estuarine Oceanography (3) Explores fundamental physical-biological processes in estuarine systems, using Puget Sound as a primary example. ***Not currently offered due to lack of expertise (WOT retirement and faculty member poached by NOAA)***

OCEAN 508 The Changing Arctic Ocean (3) Investigates the interacting physical, chemical, and biological components of the Arctic ocean-ice-atmosphere system, including the most recent advances and considering the impacts of Arctic Change on Arctic and global climate, marine organisms and ecosystems, native communities, and future exploitation of an ice-free summer ocean.

OCEAN 509 Seminar (1, max. 30) Introduction to current research topics for beginning graduate students. Credit/no-credit only.

OCEAN 510 Physics of Ocean Circulation (3) Structure of ocean basins; physical properties of seawater and the equation of state; heat, salt, fresh water budgets; tidal potential; Coriolis effect and geostrophic balance; major current systems and water masses; mixing, stirring in the ocean; simple waves; modern experimental methods in physical oceanography.

OCEAN 511 Introduction to Fluid Dynamics (4) Eulerian equations for mass-motion; Navier-Stokes equation for viscous fluids, stress-strain relations; Kelvin's theorem, vortex dynamics; potential flows, flows with high-low Reynolds numbers; boundary layers, surface gravity waves; sound waves, and linear instability theory. ***Instructors rotate with those from Atmospheric Sciences***

OCEAN 512 Geophysical Fluid Dynamics I (4) Dynamics of rotating stratified fluid flow in the atmosphere/ocean and laboratory analogues. Equations of state, compressibility, Boussinesq approximation. Geostrophic balance, Rossby number. Poincare, Kelvin, Rossby waves, geostrophic adjustment. Ekman layers. Continuously stratified dynamics: Inertia-gravity waves, potential vorticity, quasigeostrophy. ***Instructors rotate with those from Atmospheric Sciences***

OCEAN 513 Geophysical Fluid Dynamics II (3) Theories, models of large-scale dynamics of oceans, atmospheres. Potential vorticity, Q principles; Rossby waves, ray tracing, Green's function, setup of general circulation; atmospheric "channels" versus ocean "basins"; wave-mean flow interaction, mountain drag, internal momentum flux; "Lagrangian" motion of particles, tracers; cascades, eddy flux of heat, moisture, Q. ***Instructors rotate with those from Atmospheric Sciences***

OCEAN 514 Waves (3) Application of marine hydrodynamics principles to wave motion in oceans. ***Not currently offered due to retirement***

OCEAN 515 Ocean Circulation: Observations (3) Modern large- and mesoscale ocean observations, interpreted in terms of contemporary circulation theories. Spectrum of temporal variability; eddies and eddy fluxes; ventilation; advection and diffusion in the abyss; transports of heat and salt; climatic scale of variability; modern methods for determining circulation.

OCEAN 517 Methods and Measurements in Physical Oceanography (3) Principal instruments and experimental methods of physical oceanography. Devices and systems that measure pressure, temperature, electrical conductivity, sea state, and velocity. Prerequisite: permission of instructor.

OCEAN 518 Scientific Writing and Graphics (2) Covers principles of scientific writing; methods of ensuring clarity in writing for scientific journals and research proposals; principles of graph construction; and authorship, peer review, and citations. For graduate students in Earth-science related fields.

OCEAN 519 Seminar in Physical Oceanography (1, max. 9)

OCEAN 520 Marine Chemistry (3) Processes controlling the chemical composition of seawater. Chemical distributions in the ocean, marine physical chemistry, chemical equilibrium, and concepts of mass balance. Mechanisms and models used to explain distributions of stable and radioactive isotopes, gases, trace metals, and biochemicals in the world's oceans.

OCEAN 521 Aquatic Chemistry (3) Application of physical chemistry and thermodynamics to processes that control chemical composition of natural waters. Equilibrium approach. Acid/base chemistry, the carbonate system, dissolution and precipitation, metal ions in solution, oxidation-reduction chemistry, silicate mineral reactions.

OCEAN 522 Marine Organic Geochemistry (3) Sources, reactions, and fates of organic molecules in the marine environment along with the stable isotope geochemistry of marine organic substances.

OCEAN 523 Geochemical Cycles (4) Descriptive, quantitative aspects of earth as biogeochemical system. Study of equilibria, transport processes, chemical kinetics, biological processes; their application to carbon, sulfur, nitrogen, phosphorus, other elemental cycles. Stability of biogeochemical systems; nature of human perturbations of their dynamics. Offered: jointly with ATM S 508/CHEM 523.

OCEAN 529 Seminar on Chemical Oceanography (*, max. 30) Lectures, discussions, and readings on selected problems of current interest. Prerequisite: permission of instructor.

OCEAN 530 Marine Bacteria, Archaea, and Viruses (3) Explores the role of marine microorganisms in transformations of dissolved and particulate organic matter. Covers the functional and phylogenetic diversity of bacteria, archaea, and viruses in the marine environment; the fate of organic carbon in the microbial loop; and the interrelationship of the carbon cycle with other biogeochemical cycles. Prerequisite: permission of instructor.

OCEAN 531 Marine Phytoplankton and Biogeochemistry (3) Covers phytoplankton in the marine environment: evolution, ecology, primary productivity, and physiology, emphasizing their role in the global carbon cycle; spatial and temporal distributions of phytoplankton and how these patterns may change as ocean conditions change; and methods for determining distributions and rates in different ocean ecosystems.

OCEAN 532 Marine Zooplankton Ecology (3) Examines the roll of zooplankton in ecosystems and biogeochemical cycles. Covers the distribution and abundance of zooplankton in space and time; small-scale distributions; morphology and behavior; population dynamic, energetics, and secondary production; trophic structure and dynamics; biogeography; impacts of climate change; and models of populations and food chains. ***Not currently offered due to faculty member being poached by NOAA***

OCEAN 533 Marine Benthic Ecology (3) Analyzes marine communities associated with the porous boundaries of the ocean, from sedimented seafloor and hydrothermal vents to sea ice (inverted benthos); emphasizing nutrition to these communities, including sinking organic aggregates, themselves porous habitats, and the role of symbiosis. Prerequisite: permission of instructor.

OCEAN 535 Biological Oceanography (3) Examines major patterns and processes in upper ocean pelagic ecosystems, emphasizing quantitative analysis of mechanisms controlling production and abundances of organisms, from plankton to fish. Introduces interdisciplinary study of effects of anthrogenically induced changes in climate and ocean chemistry on organisms, ecosystem processes, and biogeochemical cycles.

OCEAN 539 Seminar in Biological Oceanography (*, max. 30) Lectures, discussions, and work on selected problems of current interest. Prerequisite: permission of instructor.

OCEAN 540 Marine Geology and Geophysics Processes (3) Synthesis of processes that form ocean basins and fill them with sediment, including: plate tectonics and the creation, evolution, and subduction of ocean crust; accumulation of terrestrial, biogenic, and authigenic sediments; and the history of paleoceanographic events recorded in the seafloor.

OCEAN 541 Marine Sedimentary Processes (3) Investigates fundamental process of marine sedimentation, including equations characterizing boundary-shear flows, initiation of grain motion, bedload and suspended-load transport, and sediment accumulation. Applies concepts to sediment dispersal in rivers, deltas, estuaries, beaches, continental shelves, slopes, and rises, with emphasis on the relationships between active processes and resulting deposits.

OCEAN 544 Subseafloor Hydrogeology and Geochemistry (3) Introduces the occurrence, composition, and movement of groundwater in the ocean crust and its role in a wide range of geologic and biogeochemical processes. Includes basic theories of groundwater motion, heat transport, solute transport, and hydromechanics with applications to diverse subseafloor environments ranging from mid-ocean ridges to subduction zones.

OCEAN 545 Oceanic Lithosphere (3) Principles of elasticity, fluid flow, and heat transport with specific applications to the formation and evolution of the oceanic lithosphere. Includes deformation of the earth, flow in porous media, heat transport, and marine seismological and potential field techniques. Prerequisite: OCEAN 540. Offered: jointly with ESS 568.

OCEAN 546 Continental-Margin Sedimentation (3) Detailed evaluation of recent studies into processes forming strata on continental margins, including the diverse time scales ranging from sediment transport to sequence stratigraphy. Highlights the linkages with physical oceanographic processes, the fates of geochemical components, and the relationship to biological communities.

OCEAN 549 Seminar in Geological and Geophysical Oceanography (*, max. 30) Lectures, discussions, and field and laboratory work on selected problems of current interest.

OCEAN 550 Geochemistry and Geophysics of Melt Generation (3) Mantle flow beneath mid-ocean ridges and hotspots, major element systematics, constraints from trace elements and isotopes on melting and mantle reservoirs, melt extraction, and crustal thickness and axial topography.

OCEAN 552 Seminar in Geophysics and Geological Data Analysis (1) Practical geophysical data analysis, map projections, gridding multibeam bathymetry processing, gravity and magnetic anomalies, downward continuation, magnetic inversion, seismic refraction and reflection, and microearthquake locations.

OCEAN 554 Paleoclimate Proxies (3) Provides a critical evaluation of the most commonly applied paleoclimate proxies from the ocean, land, and ice sheets. Offered: jointly with ATM S 554/ESS 554.

OCEAN 558 Climate Modeling (3) Principles of Earth system modeling. Emphasis on atmosphere, ocean sea ice, and land-surface components. Climate forcing. Appropriate use of models. Topics of current interest including carbon cycle, atmosphere chemistry, and biogeochemistry. Prerequisite: either ATM S 587/OCEAN 587/ESS 587, ATM S 504 or ATM S 505. Offered: jointly with ATM S 559/ESS 559. ***Not currently offered due to lack of expertise (retirement that was not replaced)***

OCEAN 559 Advanced Seminar on Mid-Ocean Ridge Processes (*, max. 9) Lectures, discussions, and practical work on selected topics of current interest in mid-ocean ridge research.

OCEAN 560 Atmosphere/Ocean Interactions (3) Observations and theory of phenomena of the coupled atmosphere-ocean system. El Nino/Southern Oscillation; decadal tropical variability; atmospheric teleconnections; midlatitude atmosphere-ocean variability. Overview of essential ocean and atmospheric dynamics, where appropriate. Offered: jointly with ATM S 560.

OCEAN 569 Topics in Physical Oceanography (1-4, max. 30) Lecture series on topics of major importance in physical oceanography.

OCEAN 570 Marine Microbial Interactions (1-3, max. 9)

OCEAN 572 Marine Protist Ecology (1-3, max. 9) Examines the phagotrophic (protozoa) and mixotrophic (both photosynthetic and phagotropic) protists, including: interactions with predators and prey; and adaptations to changing environments, evolutionary, and ecological implications of mixotrophy.

OCEAN 580 Aquatic Kinetics (3) Reaction rates and mass transport in water. Theories of chemical kinetics; experimental results from: CO2 hydrolysis, Fe, Mn, and H2S oxidation, stable isotope fractionation, mineral dissolution; homogeneous, heterogeneous, microbial catalysis; reaction and transport at air-water, sediment-water, and O2/H2S interfaces. ***Not currently taught due to professor on leave***

OCEAN 583 Isotope Biogeochemistry (3) The use of stable isotopes to study biogeochemical cycles in the oceans and atmosphere; specifically carbon, nitrogen, and sulfur cycles. Isotopic effects during photosynthesis, respiration, organic matter degradation. CaCO3 dissolution, methanogenesis, nitrification/denitrification, and sulfate reduction.

OCEAN 584 Ocean Tracers and Mixing (3) The applications of tracers to studies of ocean circulation and ventilation. Processes within the ocean for which tracers have provided important information include gas exchange, mixed layer dynamics, thermocline ventilation, deep water formation and spreading, and mixing. Knowledge of partial differential equations suggested.

OCEAN 586 Current Research in Climate Change (2, max. 20) Weekly lectures focusing on a particular aspect of climate (topic to change each year) from invited speakers (both UW and outside), plus one or two keynote speakers, followed by class discussion. Credit/no-credit only. Offered: jointly with ATM S 586/ESS 586.

OCEAN 587 Fundamentals of Climate Change (3) Examines Earth's climate system; distribution of temperature, precipitation, wind ice, salinity, and ocean currents; fundamental processes determining Earth's climate; energy and constituent transport mechanisms; climate sensitivity; natural climate variability on interannual to decadal time scales; global climate models; predicting future climate. Offered: jointly with ATM S 587/ESS 587.

OCEAN 588 The Global Carbon Cycle and Climate (3) Oceanic and terrestrial biogeochemical processes controlling atmospheric CO2 and other greenhouse gases. Records of past changes in the earth's carbon cycle from geological, oceanographic, and terrestrial archives. Anthropogenic perturbations to cycles. Develop simple box models, discuss results of complex models. Offered: jointly with ATM S 588/ESS 588; W.

OCEAN 589 Paleoclimatology: Data, Modeling, and Theory (3) Evidence for past changes in land and sea surface temperature, in precipitation and atmospheric dynamics, and in ocean circulation: both long and interannual timescales. Paleoclimate modeling and theory. Time series analysis and climate noise. Rapid climate change. Statistical reconstruction of interannual variability. Offered: jointly with ATM S 589/ESS 589.

OCEAN 590 Advanced Topics in Oceanography (9-18, max. 18) Advanced topics examining specialized and interdisciplinary areas of oceanographic research. Offered at Friday Harbor Laboratories. Prerequisite: permission of Director of Friday Harbor Laboratories. Offered: S.

OCEAN 593 Climate Science Seminar (1) Focuses on how to communicate climate science to many different audiences through careful construction of figures and through written and oral communication. Credit/no-credit only. Offered: jointly with ATM S 593/ESS 593; W.

OCEAN 596 Climate Science Capstone Project ([1-5]-, max. 5) Climate capstone directed by a mentor, may be a group effort, and may encompass curriculum development, internships, workshop organization, etc., capturing interdisciplinary aspects of climate science and effective communication of climate science. Offered: jointly with ATM S 596/ESS 596; AWSpS.