UNIT SELF STUDY

School of Oceanography
College of the Environment
Seattle Campus
University of Washington

Titles of Degrees Offered
Bachelor of Science
Bachelor of Arts
Master of Science
Doctor of Philosophy

Year of Last Review
1998-1999

Director
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Name of Self-Study Coordinator/Author
Authored Collaboratively by Faculty Council

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Table of Contents

Part C: Appendices

A. Organization Chart
B. Budget Summary
C. Information about Faculty
D. HEC Board Summary
E. Summary of Undergraduate Curriculum
F. Summary of Graduate Curriculum
G. Research Funding Over Past Five Years
H. Ten Year Plan for Renewing Faculty Expertise
I. Additional Information on Research Areas

~~Executive Summary~~ Perspective of the Director

Russell E. McDuff
Director

Sea-going oceanographers know about storms. Years of work in proposing and preparing for a major cruise are tossed aside in a big blow, changing scope and ambition suddenly. After the gale, the really crucial science moves to the forefront, with progress confounded by the likelihood that all that was not properly tied down is broken.

With our size and complexity, the body of the self-study is in many ways an executive summary. And so this is my own brief overview and perspective rather than a summary of the self-study itself. In my experience this is an unusual self-study: a collaborative effort rather than another chore for administration. Our Faculty Council took responsibility for the core document and the content very much reflects this shared thinking. As a member of the council I have had substantial input, but a limited role in setting major themes. The outcome is one that has substantial intersection of this collective view with my own.

Where there is a difference, tempered by pleasure, is the optimism and willingness to move the bar higher and do more. Those are wonderful attributes, but pragmatically we need to prepare not just for good times. Our review comes during a major transition to the new UW College of the Environment, becoming the blue school in a green college. Great enthusiasm exists for doing this well. But we are in the midst of a major storm of severe budget limitations within UW and significant challenges for federally funded ocean science. Our operational side is already amazingly thin and so to meet *existing* budget constraints and to keep the best of our programs strong, we will have limited capacity to replace faculty as retirements occur. Our self-study suggests often orthogonal paths of doing more by expanding the envelope of possibilities in all directions--among these paths more teaching, stable competitive research funding, more hard money, a large faculty, new joint appointments connecting us more widely across UW. The envelope of realistic possibilities is more constraining. We cannot move in all directions, but need to be poised to move in the most important.

We welcome the insights of our external reviewers, who understand our national peers, and our internal reviewers, who understand the UW context, to help us move forward.

SCHOOL OF OCEANOGRAPHY SELF STUDY

PART A: Required Background Information for Review Committee

Introduction

The oceans serve as our planet's memory–storing vast amounts of heat, chemicals and freshwater, with marine organisms recording in their genomes and in the fossil record a readable history of key events. The field of oceanography provides access to and interpretation of this vast repository of information that is necessary to understand the earth system today and in the future. 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 numbers of people impacted by the oceans is increasing, with 75% of the world's population expected to live within the coastal zone by 2025. As our human footprint on the planet increases, the ocean environment is changing at accelerating rates. Societal needs for oceanographers to understand the complexity of the ocean environment and to make informed predictions of future conditions on our planet far outstrip the available infrastructure, both human and physical, needed to understand the complexity of the ocean environment and make informed predictions of future conditions on our planet. Employment of environmental scientists and specialists is projected to increase by 28 percent between 2008 and 2018, which is ~3x the average rate for all occupations, according to the U.S. Department of Labor. Over the next ten years, oceanography departments must develop ways to amplify their research and instructional capabilities to meet these growing needs and increasing planetary environmental pressures.

The field of oceanography is changing rapidly. Autonomous instrumentation now complements seagoing expeditions, providing a broader and more detailed view of the ocean environment. The School of Oceanography (SoO) plays a commanding role in this transition by being leaders in implementing NSF's Ocean Observatories Initiative's Regional Scale Nodes (OOI-RSN), the development and scientific use of profiling floats and robotic gliders, and incorporating the genomic revolution into oceanography. We are the only academic institution with a research vessel that operates on a global scale with significant dedicated funding for educational activities. The SoO is newly housed within the College of the Environment (CoEnv), which is unified by an Earth-system focus with strong affiliations to disciplines that incorporate human dimensions. The School and College are embedded within 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 SoO has links to local NOAA laboratories, high-tech businesses, diverse maritime industries, and information technology industries, all of which help to expand our breadth. As part of the Pacific Rim, we have in our back yard an accessible tectonic plate–the Juan de Fuca Plate –that spans from an offshore spreading ridge with hydrothermal vents to a subduction zone near our coast, providing a natural laboratory for studying the consequences of plate tectonics. Our Pacific coastline is the site of wind driven upwelling that fuels our fisheries and is modulated by the interaction with freshwater outflow from the Columbia River and impacted by climate variability. We are located on Puget Sound, the largest estuary on the west coast, where human impacts are often amplified, highly visible and thus of immediate societal concern.

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

Research within the SoO can be grouped into two interdependent arenas. In the first, we focus on understanding natural cycles and their variation within the ocean realm. Key topics in this area include the evolution of oceanic plates and cycling of materials between the oceanic crust, continents, mantle, and oceans; the evolution of marine organisms and interactions within marine food webs; the production and fate of organic matter in the ocean; and the transport of mass, salt and heat through the ocean, including polar regions. In the second research arena, we focus on understanding how the marine environment responds to human impacts. Key topics in this area include: ocean uptake of atmospheric CO_2; global warming and ocean circulation; sea ice extent, chemistry and ecosystem responses; eutrophication of coastal waters; modifications to our shorelines and evolution of our continental shelves. The yearly funds raised by faculty to support this research enterprise are ~$17M; including our faculty located at the Applied Physics Laboratory (APL) increases this number to ~$26M. These numbers emphasize our research strength and place us, on a per faculty basis, on a par with the largest private oceanographic research institution (Woods Hole Oceanographic Institution). Within the UW, it places the SoO as the largest recipient of research funding among academic departments outside the health sciences.

With our move into the CoEnv, we find ourselves among academic units with less competitively awarded research support, higher numbers of student credit hours, and more state-funded support per faculty. In preparing this ten-year review document, we evaluated ourselves within the context of our national and international peers as well as our peers within the CoEnv. We have re-affirmed our shared goal of maintaining our international leadership role in oceanography and our commitment to experiential learning. Simultaneously, we are setting goals to increase our teaching responsibilities that will expand our educational impact and make us comparable to other units within the CoEnv. Achieving these goals will require some restructuring of faculty roles and a shared commitment by the CoEnv to help position the SoO for the future.

In the following sections, we review our accomplishments in education and research and the institutional structure that has supported these accomplishments. We use this 10-year review as an opportunity to formalize goals for the next decade and to identify future research directions and educational opportunities. We have identified our highest priority needs as increased hard money support for our faculty, fellowship support for post-doctoral researchers and students, and a replacement vessel for our coastally operating *R/V Barnes*. This will enable us to meet expanded demands over the coming decade and to continue leading new discovery of the ocean frontier, training future leaders in the field, and educating the UW's students and Washington state citizens about the key role the oceans play in maintaining a healthy environment on earth.

Section I: Overview of Organization

Mission

The mission of the SoO is to advance the science of the ocean, educate students in the field and increase the public's awareness of the ocean. The SoO stands out as a leading oceanographic center with 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 (95% of whom stay in the field) who will be future leaders of scientific discovery, teaching and public service.

Degree Programs

Undergraduate:
Bachelor of Science, Bachelor of Arts (rarely used)
Minor in Marine Biology (joint with Biology, Aquatic and Fishery Sciences) and (Pending) Minor in Climate Science (joint with Atmospheric Sciences and Earth and Space Sciences)

Graduate:
Master of Science, Doctor of Philosophy
Joint with Multiple Departments: Graduate Certificates in Astrobiology, in Climate Science and in Interdisciplinary and Policy Dimensions of Earth Sciences

We have no fee-based programs.

Organizational Structure and Governance

The SoO is part of the new CoEnv, composed of five other academic units--Marine Affairs, Aquatic and Fishery Sciences, Forest Resources, Atmospheric Sciences, and Earth and Space Sciences--and several other programs, centers and laboratories.

The Director of the SoO, in consultation with the faculty, is 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 Director is appointed by the Dean to a term of up to 5 years, which may be renewed after a formal review. Appointment and renewal follow procedures in the Faculty Code. The Director may appoint Associate Directors to guide specific operational components. There are currently two Associate Directors with responsibilities in undergraduate education and research infrastructure, including marine operations.

The faculty have responsibility under the Faculty Code for affairs of the School, especially in establishing curriculum and in appointment, promotion and evaluation of faculty peers. The faculty meet monthly during the academic year to discuss most matters. Separate meetings are held in Autumn Quarter to consider promotion and tenure and in Spring Quarter to evaluate merit and merit salary increases. All meetings follow procedures specified in the Faculty Code

All degrees granted are in Oceanography and faculty set the overall academic goals and requirements. Hiring is done on a school-wide basis. Substantial responsibility is vested in

curricular groups based on the four traditional divisions of oceanography: biological oceanography, chemical oceanography, marine geology and geophysics, and physical oceanography. The curricular groups set specific academic requirements, review graduate applications, propose teaching assignments, and put forth hiring needs based on educational and research goals.

All faculty, regardless of rank, can 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.

SoO faculty have delegated to an elected Faculty Council, chaired by a member, with responsibility for recommending 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 Director and Associate Directors are members ex officio.

Resources

Academic Personnel

The faculty are listed in Appendix C. There are 50 voting faculty in the SoO of whom 30 are tenure track positions (17 Full, 5 Associate, 5 Assistant Professors and 3 Emeritus with vote), 18 are WOT positions (11 Full and 7 Associate WOT Professors), and 2 are Lecturers (Table 1). WOT or "without tenure for reason of funding" faculty meet the same promotion criteria as tenure-track faculty but do not have permanent funding. Retired faculty hold 17 Emeritus positions with several still active in research and teaching.

Tenured Professors have nine months of UW support, but typically take only 6 months to reduce their teaching load and increase time for research. Tenured Associate Professors and Assistant Professors receive six months of UW support. The three months of UW support released by Professors is used elsewhere to meet our teaching goals, which is in part accomplished by providing 2 or 3 months support for the WOT faculty depending on rank in return for their participation in the teaching program and mentoring of graduate students. Eight of these WOT faculty have primary appointments as researchers in the APL and their academic support is a shared responsibility between SoO and APL.

There are 45 adjunct and affiliate faculty who serve significant roles in the SoO. About a third regularly support and advise oceanography graduate students. Adjunct faculty hold primary academic appointments in other UW academic units while affiliate faculty are drawn from non-academic UW units, particularly APL and Joint Institute for Study of Atmosphere and Oceans (JISAO), or hold primarily affiliations outside UW, most commonly research positions at the NOAA Pacific Marine Environmental Laboratory (PMEL) but also in the USGS, Seattle University and private industry.

Table 1: Faculty composition (Sep 2010) and support (2009-10) by curricular group

	Bio	Chem	Geo	Phys	Other[1]	Total
Voting Faculty	9	10	9	18	4	50
In Ocean	9	10	9	10	4	42
In APL	0	0	0	8	0	8
Adjunct/Affiliate	8	9	5	22	1	45
Emeritus	4	2	6	5	0	17
Part-time	0	0	1	0	3	4
Postdoctoral Associates	3	2	0	2	1	8
Faculty Support (months)						
Tenure Track Paid	42	42	36	39	9	168
Tenure Track as Tenured	51	48	45	45	9	198[2]
WOT	2	11	5	27[3]	3	48[3]
Lecturer					18	18

[1]Other includes two administrative positions and two lecturers.
[2]198 months represents 22 nine-month FTEs.
[3]APL supports 12 months/yr of WOT salary.

Staff
There are 99 staff in the SoO of whom about half are supported by faculty research grants (Table 2).

Table 2: **Staff Distribution and Support (Sep 2010)**

Function	**FTE**	**Salary**
Operational Staff[1]	11.1	$839K
Marine Operations[2]	24.5	$1,281K
Other Cost Centers	10.3	$684K
Sponsored Research	48.4	$3,531K
Total	96.2	$6,337k

[1]Includes 7 FTE of administrative support for finance (~370 active budgets), payroll (~270 employees), purchasing (~5750 requisitions/yr), proposal preparation (~150/yr); 1.5 FTE for student services, 1.5 FTE for computing and web services, a 1 FTE for facility and building operations.
[2]Marine Operations makes extensive use of temporary personnel. Salary does not include marine premiums.

Space
By January 2011, SoO will be housed in six major buildings: *Oceanography Building* (5000 sf) – teaching laboratories, storage, emeritus offices; *Marine Science Building* (40,000 sf) – biological oceanography, marine geology and geophysics, marine operations, shops and staging; *Oceanography Teaching Building* (40,000 sf) – administration, classrooms and teaching laboratories, OOI-RSN offices; *Ocean Sciences Building* (60,000 sf) – chemical oceanography, physical oceanography, staging, pressure vessel and test tank; *Benjamin Hall Interdisciplinary*

Research Building (10,000 sf) – biological oceanography (Center for Environmental Genomics). APL-based faculty are housed within Henderson Hall and Benjamin Hall IRB. The Marine Science Building and the Ocean Teaching Building have been in service since the late 1960s and are in need of renewal of laboratory spaces and staging areas.

Ships
The SoO operates two academic research vessels, the Global Class R/V *Thomas G. Thompson* and the Local Class R/V *Clifford A. Barnes*. These vessels are important for teaching and research activities in the SoO and are symbolic of our national stature. The contractual commitment of UW to provide 45-days of instructional ship time was critical to our successful proposal to operate the *Thompson* and has strongly influenced our experiential approach towards undergraduate education.

Budget
The operation of the SoO is funded from three sources. One is endowment income which is restricted to specific uses and discussed separately below. The main two sources are UW provided support (derived primarily from state support and tuition revenue) and support earned by the SoO via a 23% share of research cost recovery (RCR) from grants and contracts. These two funding sources serve academic needs and provide shared research infrastructure and thus are crucial to our success despite representing only ~10% of our total SoO budget that is dominated by research grants and contracts. More information is shown in Appendices B and G.

Like the state, UW operates on a biennial basis with a July 1 start to the fiscal cycle. To facilitate comparison with other institutions, recent budgetary information is shown on an *annual* basis.

Table 3: Annual Operational Budget Summary for the SoO

	2003-2005	2005-2007	2007-2009
Deparmental Resources			
UW Provided	$2.68M	$2.91M	$3.27M
SoO Earned (RCR)	$0.74M	$0.81M	$0.73M
Total	$3.42M	$3.72M	$4.01M
Department Expenditures			
Faculty Salary	$2.10M	$2.02M	$2.33M
Staff Salary	$0.78M	$0.83M	$0.91M
Graduate Assistantships	$0.14M	$0.12M	$0.14M
Operations and Faculty Startup	$0.49M	$0.42M	$0.77M
Total	$3.51M	$3.40M	$4.17M
Change in Reserves	-$0.10M	$0.31M	-$0.16M

Some important long-term budget trends are worth noting. UW support has primarily grown to provide salary increases. The low growth rate in faculty salaries is due to loss of faculty without the financial capacity to replace. The minimum in faculty salary costs in 2005-2007 reflects faculty retirements that allowed an increase in reserves. The increase in operations expenditure in 2007-09 reflects the startup costs associated with adding young faculty. Salaries of continuing faculty improved substantially from 2004 to 2008, especially the younger faculty with the salary of an

entering assistant professor improving by 30% and the median salary of full professors improving by 18%.

Although we are doing reasonably well financially, we face three significant budgetary challenges going forward: 1) Full Professors collectively "buy back" ~30 months of salary (~$360K/yr), which represents ~10% of our UW-provided funding. Continuation of this practice is becoming riskier for several reasons, discussed below. 2) We received a 3% permanent budget cut in July 2008, a 6% cut in July 2009, a 5% cut in July 2010, and anticipate an additional cut in October 2010. Not filling vacant faculty positions and moving expenditures onto RCR funds have accommodated these cuts. Upcoming cuts will require further reduction in expenditures. 3) The UW is shifting to a new budgeting system called Activity Based Budgeting (ABB), which when fully implemented will directly relate UW support of CoEnv to student credit hours taught and number of majors. It is within this context that the SoO must manage its resources and position itself for success.

Development
During the "Campaign for Washington: Creating Futures" which lasted eight years, the College of Ocean and Fishery Sciences (COFS) received $56 million in grants from foundations and gifts. The majority of these funds were designated as operating monies for specific individuals or specific projects, with significant funding from the W.M. Keck Foundation for undersea cabled observatories (precursor to the RSN) and the Gordon and Betty Moore Foundation for environmental genomics within the SoO. Scholarship funds for students came primarily from alumni and former faculty and staff and the endowment for student support increased by $3M. Income from all our endowments is primarily directed toward student support and yields ~$250K annually for scholarships for undergraduates and support for graduate students.

SECTION II. TEACHING AND LEARNING

Given societal concern about human-made changes to the environment from the local to the global scale, today's young people possess a great curiosity about the environment, and an urgent desire to make a positive contribution to its preservation and restoration. Environmental scientists represent one of the few job growth areas under the current economic condition, with employment rates projected to grow at ~3x the national average during next decade. Specific expertise in the marine environment will likely be scarce, since university programs that can train students in this area are few. The SoO offers a unique undergraduate major program 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. Our graduate education program is one of the best in the country and consistently produces graduates who are hired at the top institutions and become leaders in the field.

We currently have 103 undergraduate oceanography majors, a significant increase from a low of 54 in 2004 when we initiated new recruiting efforts. About half our graduates obtain either a minor, second major or second BS degree and half participate in optional faculty-supervised research. Of the 2/3 of our graduates in the past decade we have been able to track, 30% attend graduate school and an additional ~50% obtain science staff positions within the federal, state or private sectors. The success of our undergraduates in finding jobs and obtaining advanced degrees indicates the effectiveness of our oceanography major teaching program, notably its breadth and scientific rigor.

Our graduate program consists of ~75 students, with a fairly even distribution across three of the curricular groups. There are substantial fewer students, and due to administrative service fewer faculty members, in marine geology and geophysics. Two recent hires have taken as initial active steps to rectify this problem. 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.

The UW operates on a quarter system, with three 10-week quarters taught during the school year and two sessions taught during the summer. Most teaching faculty (tenured and tenure-track) receive 6 months of state-funded support to teach 2 quarters, which typically is comprised of one undergraduate and one graduate course and yields a wide variation in the number of student credit hours per faculty. A few Full Professors utilize 9 months of UW support and teach 3 quarters. WOT faculty receive 2-3 months of state support (depending on rank) and teach one quarter every other year, which is typically a graduate course or undergraduate field course.

Student Learning Goals and Outcomes
Undergraduate. Undergraduate student learning goals fall into four categories: analytical, 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. (The undergraduate curriculum is summarized in Appendix E.)

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 (Oc220) 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 (Oc443 and 444) includes bi-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 during Oc444 are archived in the Research Works Archive through UW Libraries and the oral presentations are presented in a public symposium.

We evaluate student satisfaction through use of standardized teaching evaluation forms and student feedback coordinated through the Center for Instructional Development and Research (CIDR). Based on student feedback, the undergraduate program has been modified in the following ways. Our two introductory-level oceanography courses were restructured to specifically target either non-science (Oc101) or science majors (Oc200). We created a two-credit laboratory course (Oc201) as a companion to the science-major targeted Introduction to Oceanography course (Oc200) to provide broader opportunities for hands-on learning.

We teach 6 courses aimed at non-majors, each offered once per year with an average total enrollment of about 1100 students per year (~4500 student credit hours or SCHs). Lecturers play the dominant instructional role in these courses accounting for ~3500 SCHs. The learning goals of these courses are for students to understand the importance of the oceans in global climate and human health, appreciate the interconnectedness of oceanic ecosystems, the stressors that are being place on coastal systems and the way technology is changing how we study the oceans and the ability to evaluate existing data and the role of uncertainty in making decisions. Notably, an additional 200 non-majors per year (1000 student credit hours) are taught in courses co-listed in Oceanography, but currently not taught by SoO faculty. Several SoO faculty actively participate in the Honors Program and the Program on the Environment by teaching, including experiential laboratory courses.

Oceanography major requirements are listed on the SoO web site and in brochures given to new majors during their initial advising appointment. A freshman advising seminar (OC 100) has been developed to introduce students to the SoO and encourage them to participate in research during their UW career. Declared majors are assigned a faculty mentor and meet regularly with the student services coordinator to ensure that they are making satisfactory academic progress. Career advice is provided through faculty mentors, SoO-sponsored alumni career panels, graduate school application panels and Envirolink Career fair that featured 50 employers in 2009. Tracking of alumni is done on an informal basis. We know the occupations of approximately 2/3 of our graduating seniors in the last 10 years. Greater than 80% are in graduate school or hold science staff positions within the federal, state and private sectors.

Graduate. Our graduate program emphasizes doctoral study, though we believe that the MS is an important milestone along the way. We admit students with a promise of full support as long as making satisfactory academic progress. Financial backing for this promise limits the size of the program. PhD candidates enter the graduate program in the SoO with a wide range of science- or engineering-based degrees. The goal of our graduate program is to develop successful, active individuals who are capable of independent research, with the ability to communicate results in both written and oral formats. Students are expected to gain sufficient depth of knowledge in their research area (e.g., an oceanography discipline such as biological oceanography) to develop independent research capabilities and sufficient breadth of knowledge in the other disciplines 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 (Graduate curriculum summarized Appendix F). All students must serve as a TA at least once, although some choose to serve as a TA for additional courses to expand their teaching experiences.

Evaluation of graduate student research progress uses several metrics. Progress is evaluated through 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 middle of 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 publicly advertised seminar. The average time to obtain a PhD is ~6.5 years.

Graduate student satisfaction with the program is formally evaluated via the UW Graduate School poll given to all students as they exit advanced degree programs. Our evaluations indicate satisfaction levels higher than University-wide averages in most survey areas (6 of 11 categories for PhDs and 10 of 11 for MS), with the only category ranked below average being 'teaching preparation' by PhD (not MS) students. This exception is likely the result of our graduate students typically being TA for only one course during their career (usually prior to MS) as grant-funded RAs dominate graduate student support. To improve our TA experience, we developed a SoO-specific TA training program. The Dean and Tomi McManus Endowed Fund supports student attendance at workshops and conferences on teaching and to bring workshops to SoO. The UW-based COSEE-OLC (Center for Ocean Sciences Education-Ocean Learning Communities) has established short courses and workshops that our students attend. Our graduate students are expanding their teaching experiences. Five have been awarded GK-12 fellowships to work with teachers in Seattle public schools. Seven have been awarded Huckabay Fellowships by the UW Graduate School (nine are awarded annually) to work on a specific project focused on teaching and learning at the college and university level.

Instructional Effectiveness

All new faculty at UW attend a week-long Faculty Fellows Program, which serves to both orient and assist new faculty improve their teaching skills. Faculty are made aware of the benefits of working with the CIDR to improve their course, syllabus, and assignment design. Graduate students are involved in instruction through their roles as teaching assistants (TA) and are required to attend both UW and SoO-specific TA training sessions.

We rely primarily on standardized teaching evaluation forms to judge instructional effectiveness. We have only used peer evaluation of teaching in specific cases and, as it has proven helpful, plan to increase application in the future. Feedback from course evaluations has resulted in significant instructional improvements to our undergraduate courses including incorporation of computer labs and paper discussions into our senior courses and quiz sections for our introductory courses. TA specific evaluation forms have been developed for our courses that are filled out by students. The annual McManus Teaching Award recognizes outstanding teaching performance by graduate students.

Learning Experiences Outside the Classroom

A defining aspect of our educational program is incorporation of our ships the *R/V Thompson* and *Barnes*, into instructional activities. The 45 state-supported days of Thompson time are used for education in three main ways. First, dedicated educational cruises are deemed central to our required undergraduate field courses. The senior capstone course uses ~10 days of *Thompson* time per year and over the past 5 years, students have participated in cruises in the Galapagos, New Zealand, and Alaska as well as local waters. The result has been extraordinary research experiences

for the students, but with significant cost to the teaching budget when students travel to far-off ports. Second, state-funded ship time is provided as matching support for research projects that find novel ways to incorporate undergraduates into seagoing research and post-cruise analysis. Fifteen days/year is provided for educational experiences centered on planned experimental sites of OOI (20 students participated in 2010). Third, when available, the *Thompson* is used for single day cruises in Puget Sound for undergraduate oceanography classes to provide experiences in field work to more students. The sophomore field course has occasionally used the *Thompson* when the ship is available to work in local waters but primarily relies on the local class vessel *R/V Barnes*, as does the introduction to oceanography lab class. As part of the OC201 lab course, daily cruises on the *Barnes* in Puget Sound allow 70-90 undergraduates to experience oceanography first-hand. These *Barnes* ship days are paid by internal funds rather than a dedicated educational pool, but are critical for incorporating experiential learning in our lower division classes. About half our Oceanography undergraduate majors (~50 students/yr) 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 post-docs. We are particularly proud of this synergy between our education and research programs that distinguishes us from both our research peers at top tier oceanographic centers that are not closely coupled with an undergraduate program and from other oceanography and marine biology undergraduate programs located primarily at 4-year universities.

Recruiting and Mentoring Students

We are using a number of methods to increase enrollment in our undergraduate major. First, we work with existing outreach programs (ORCA Bowl, GK-12 scholars, COSEE) and oversee the teaching of Ocean 101 in 10 high school classrooms across the state (as part of UW in the High School) to promote awareness of our program among local high school students. We hold personal meetings with prospective high school students and their parents when visiting campus and we award scholarships to deserving incoming freshmen that declare oceanography as a major. Second, we have jointly implemented a freshmen seminar for UW students interested in the environment and we participate in numerous student fairs (UW Environmental Opportunities Fair, Dawg Daze, study abroad fair, majors fair and transfer fair). Third, we have increased the numbers and variety of classes aimed primarily at non-majors, which has increased our visibility on campus and resulted in more majors. Fourth, we jointly offer a new minor in marine biology, which has been extremely popular, with over 130 students declared in only its second year. The marine biology academic advisor aggressively promotes the minor and the three sponsoring programs (Oceanography, Aquatic and Fisheries Sciences and Biology) both inside and outside the University. SoO faculty have led the effort to develop a minor in Climate Science (to be offered jointly with Atmospheric Sciences and Earth and Space Sciences) proposed to begin in Winter 2011.

Graduate student recruitment relies on our reputation and on our maintaining an up-to-date web site that describes our research. We typically host a school-wide recruitment visit to highlight the graduate program and allow faculty and applicants to meet one another. We make offers to about 10% of applicants and given that many applicants have offers from several top-flight graduate programs, the acceptance rate of ~50% is a reflection of the overall strength of our program.

As in many environmental fields, there are few underrepresented minority students in Oceanography (6 of 167 BS degrees awarded since 2000). Currently most of our recruiting and

advising of minority students is done on an informal basis. We have a working relationship with minority recruitment programs on campus (OMA, ALVA, GeNOM etc.) to help steer minority students interested in marine science to Oceanography and make them aware of the additional resource opportunities available. Graduate applicants from under-represented groups invited to visit are informed of opportunities to meet with other graduate students from under-represented groups at UW through the GO-MAP (Graduate Opportunities & Minority Achievement Program) office of the Graduate School.

SECTION III: SCHOLARLY IMPACT

Faculty of SoO are leaders within the international oceanographic community as illustrated by our national honors. Two of our faculty are Members of the National Academy of Science, one is a Lifetime National Associate and one is a Kavli Fellow. Three have received the Henry Stommel Award and two have received the Francis P. Shepard medal for Marine Geology. We have several Fellows in the American Geophysical Union, the American Meteorology Society, the American Academy of Microbiology, the American Association for the Advancement of Science, the Acoustical Society of America, the American Academy of Arts and Sciences, and the Geological Society of America. One is a Gordon and Betty Moore Foundation Investigator in Marine Microbiology, three have been awarded National Science Foundation Special Creativity Awards, three have had CAREER Awards, one has been awarded the National Ocean Partnership Program Excellence Prize, three have been awarded either a Secretary of the Navy Chair or Scholar Award and eight have received ONR or NSF young investigator awards. Faculty members have won numerous awards for their publications, including the AAAS Newcomb-Cleveland Prize for outstanding publication in *Science*. Faculty members are the current AGU president and president-elect of its Ocean Sciences section. Our faculty are recognized leaders in communicating science to the public, with one awarded the Science Education Advocate Award given by the Washington State Leadership and Assistance for Science Education Reform.

Our excellent standing within the oceanographic community is equally evident in our funding success. Over the past five years, SoO faculty (including those at APL) have obtained ~$26M annually in research funding (Appendix G). This success in securing extramural funding at an average of ~$500k annually per faculty member provides a strong base of support for our graduate program and fuels new discoveries in the ocean sciences.

Faculty hires over the past several years reflect our desire to maintain disciplinary strength while simultaneously building cross-disciplinary bridges. Over the past five years, we have made four assistant professor appointments building new strength in thematic work around climate and carbon, coastal systems, and extreme environments, expanding teaching capacity in biological oceanography, restoring teaching capacity in marine geology and geophysics and establishing new links to Earth and Space Sciences, Aquatic and Fishery Sciences, and Medicinal Chemistry. With joint support from APL, we made four WOT appointments to already affiliated faculty at full and associate levels continuing connection with APL and bringing teaching capacity in physical oceanography. We developed a 10-year hiring plan in 2005 (Appendix H), with three additional hires targeted for the near-term: a coastal physical oceanographer as key expertise in coastal systems, a climate-related ocean modeler important to integration of existing expertise and critical teaching needs, and a marine seismologist to complement ESS capabilities and create unique new

research opportunities of great societal relevance. Implementation of this plan was interrupted in 2008 with the onset of permanent budget cuts and a University-wide hiring freeze.

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. Here we briefly describe three research areas to illustrate our scientific reach. (More information on the research areas of faculty is included in Appendix I).

Sensing the Ocean

Oceanography is rapidly moving from a data-poor science that relied on sparse sampling of the ocean from ships to a data-rich science that increasingly relies on continuous measurements from remote instruments. This transition in data structure and quantity is revolutionizing how we view the ocean, while simultaneously drawing more non-oceanographers to the field.

We play a respected role in the oceanographic community for the development of a range of sensors and platforms, from autonomous vehicles to sensors that detect methane. We are leaders in the international Argo program (~half of the US effort) that has ~3000 floats worldwide continuously mapping the fundamental properties of the upper ocean. We developed Sea Gliders that map physical, chemical, and biological properties of the upper ocean on regional scales and the ORCA profiling buoy for measuring properties of the coastal waters. We have developed floats that can measure ocean mixing on microscales and, for example, have provided a detailed record of the ocean's response to a passing hurricane. We are leaders in three major Arctic Observation sites and in developing new, instrumented technology for a future Arctic basin autonomous observing network. We have worked closely with NOAA researchers to incorporate pCO_2 and O_2 sensors into moorings to provide detailed annual cycles and instrumented container ships to yield basin-wide view of the ocean's biogeochemical processes. We use satellites to detect large-scale patterns of surface ocean circulation. We have developed a network of hydrothermal sensors and samplers and subseafloor seismometers to investigate long-term linkages between geological deformation, fluid fluxes from vents and seafloor seeps, and chemosynthetic microbial activity that can occur in absolute darkness.

We are the implementing organization for design, installation and operation of the Regional Scale Nodes (RSN) component of the Ocean Observatories Initiative (OOI). The $146 million over 5.5 years awarded to the SoO-APL partnership to construct the OOI-RSN was the largest award of federal funds to the UW. The OOI-RSN will be the first high-power and high-bandwidth regional cabled observatory in the US. Sensors will be distributed on and below the seafloor and throughout the water column on moorings to depths as great as 3000 m. This undertaking will yield new understanding in the SoO's two key research arenas: variation within natural cycles in the ocean and human impacts on these cycles. It offers new educational and outreach opportunities through live streaming of data including high definition imagery.

The Living Ocean

The plankton of the sea integrate the physics and chemistry of their environment, both responding to and influencing biogeochemical interactions. Ecosystem functions occur within the context of organism-organism interactions and the organismal constraints at the genomic and physiological

levels, under the continuous influence of evolutionary and adaptive processes. Thus, the read-out we must interpret spans from the short-term (days to years) to the long-term (millennia) and spatial scales from the micro to the global, within the surface ocean to deep within the seafloor.

Researchers within the SoO are leaders in incorporating tools and insights from the genomic revolution into studies of marine ecosystems and assimilating existing knowledge into models to develop a more mechanistic, ecosystem-based and biogeochemical understanding of life in various regimes of the ocean. We use genomic information to interpret both present and past ocean processes and we have led efforts not only to sequence whole genomes of key marine organisms, but also to sequence communities in the field. We measure and model species distributions and abundance based on knowledge of circulation patterns and nutrient and prey distributions to understand ecosystems dynamics of today and make informed predictions of these dynamics in the future.

We have a strong focus on life in extreme environments, which include the hottest (hydrothermal vents supported by active volcanism and deep within the seafloor) and the coldest (within sea ice in polar regions) environments, as well as those essentially devoid of oxygen. We have discovered new, unexpected, regions where life thrives and we work to understand what defines the limits where organisms exist. The UW Astrobiology Program, in which the SoO is a vital contributor, examines the influence of the physical and chemical environments on evolution and biodiversity.

The Changing Ocean

Rising atmospheric CO_2 concentrations have driven global warming with most of the heat and considerable CO_2 absorbed by the oceans. This has caused rising sea levels, increased stratification, a marked reduction in Arctic sea ice and an apparent expansion of oxygen minimum zones. The absorption of CO_2 has increased the acidity of the ocean with some regions such as the N. Pacific and Arctic Oceans displaying the most extreme effects. Changes in wind patterns due to a redistribution of heat may change patterns of upwelling along our coasts, which has implications for coastal productivity and the possible expansion of dead zones. Increased input of nutrients into our coastal waters, modifications to river flow via dams and dredging, and extensive shoreline modifications (walls and barriers) have dramatically changed our coastal environment. For example, we now see increased incidence of closures to shellfish harvest because of toxic algal events and bacterial contamination and increasing shoreline erosion. Global warming is accelerated in the polar regions and has had marked effects on the extent of sea ice, freshening of the ocean and alteration of ecosystems.

We have been heavily involved in detecting these changes. First, we are leaders in measuring the uptake rate of anthropogenic CO_2 by the ocean and determining resultant impacts on ocean pH and food web dynamics. This work is accomplished in close collaboration with researchers from the NOAA-PMEL, many of who serve as affiliate faculty within the School and help supervise our students. We have strength in estimating the rate of organic carbon cycling by the planktonic food web and following the fate and ultimate burial of this material on the sea floor, where it serves as a record of past conditions read by our geologists and paleo-oceanographers. Second, we have a focus on the intersection between ocean processes and human health. We are home to one of four national centers, the Pacific Northwest Center for Human Health and Ocean Studies that is managed jointly between SoO and the UW School of Public Health and Community Medicine and was

created to understand these links. We collaborate closely with researchers from NOAA Northwest Fisheries Science Center, some of whom serve on student advisory committees. This program builds on our strengths in ocean modeling and studies of the impacts of environmental conditions, including circulation patterns, and food web dynamics on the initiation and delivery of toxic blooms to local waters. Third, we have a strong focus on the coastal ocean in particular on the measuring and modeling the impact of the riverine delivery of nutrients, sediment, and freshwater to coastal regions. In the Pacific Northwest, one response to declining salmon populations has been discussion and implementation of dam removal projects. SoO faculty are involved in studies of the impacts of one such project. Impacts of sea-level rise are addressed by work on the effects of sea-level rise on fringing coral reefs and the changes to our local coastline as increased seawall armoring becomes a pressure in Puget Sound. We have led regional programs to understand causes of low oxygen regions within Puget Sound and Washington coast that capitalize on our modeling expertise, remote measurements, as well as data interpretation. Fourth, we have an important presence in the Arctic and Antarctic Oceans and the sub-Arctic seas, with studies ranging from oceanic driving of Arctic ice-retreat and impact of sea ice loss on ocean circulation and polar ecosystems to the cold temperature limits of microbial life in ice. We play leadership roles in major national and international efforts to understand the impacts of a changing climate on polar and sub-polar ecosystems.

Mentoring and Diversifying the Faculty

Committees appointed by the Director reviews the accomplishments of each Assistant Professor and present a summary of their progress at annual merit review meetings attended by all associate and full professors. Similar reviews of Associate Professors are held to aid in progress towards promotion. The Director, in an annual discussion of progress toward promotion, communicates faculty recommendations. A defining and positive feature of the School is participation of faculty of all ranks in faculty promotion discussions, which allows Assistant Professors to better understand the tenure process and Associate Professors to better understand promotion criteria. In recent years, the Director has presented an annual "State of the School" report addressing significant issues and budgetary matters and is being expanded to include information useful for faculty self-assessment. Informally we have a strong collaborative culture of including junior faculty as part of research proposals. We encourage co-teaching with more senior faculty to help the more junior faculty gain classroom experience.

The SoO has significantly increased the number of women on the faculty. 11 of the most recent 20 faculty hired have been women; we foresee this trend continuing if the gender distribution of new hires matches that of our PhD graduates. However, we have not been successful at diversifying the faculty from under-represented groups. We know from the surveys conducted by Ocean Leadership that this is primarily a pipeline problem: the ocean science community is not attracting a diverse graduate student population. Several faculty members are active in programs directed at increasing interest in ocean sciences among high school students and undergraduates.

SECTION IV. FUTURE DIRECTIONS

In developing our plans for the next ten years, the SoO re-affirmed its shared goal of maintaining our international leadership role in oceanography and our commitment to experiential learning as the central means of educating students. We firmly believe this position will increase the

recognition and impact of the SoO, CoEnv and UW, which have at their core the excellence and scholarly activity of their faculty. We are a strong science department in a strong university. We want to establish new connections at the forefront of the ocean sciences among these in the areas of e-science, genomics and proteomics, and development of novel sensors. Our foundational attribute, synergy of research and education combine to to lead new discovery of the ocean frontier, train future leaders in the field and educate the UW's students and Washington state citizens about the key role of the ocean in maintaining a healthy environment on earth.

To maintain our efficient research engine, the SoO relies more heavily on grant funding than typical geosciences departments: only ~50% of our faculty support is from UW compared with 65-75% for other units in the CoEnv, 75% of our graduate students are supported through research funds rather than teaching assistantships, our overall departmental budget relies heavily and increasingly on RCR. This reliance on soft money makes our support structure more vulnerable to external factors like agency funding levels and thus riskier. We need to reduce this risk to better secure future success.

In particular, three factors have motivated a re-evaluation of our current financial model. First, we are entering a potentially prolonged period of fiscal constraints resulting from intense competition for funds, both at the federal level (which fuels our research enterprise) and at the state level (which fuels our educational enterprise). Second, the UW has implemented Activity Based Budgeting that more directly links budgetary allocations with numbers of students taught. Third, a large proportion of SoO faculty, about one-third, is approaching retirement within the next decade. It is essential that we re-initiate our hiring plan (Appendix H) to bring in new faculty and the opportunity to add new and topical research directions. It is also essential that we reduce the risks associated with our soft-money structure by working with UW to increase hard money support of faculty that will enhance research and teaching activities in the SoO over the next decade.

In this section, we highlight our future directions and goals beginning with research, followed by educational goals. We then discuss the structural changes needed to support these goals.

Future Research Trends

As described throughout this document, the SoO faculty excel in understanding the complex, non-linear, non-steady state conditions that characterize the ocean environment. Our focus is on accessing and interpreting the vast repository of information stored in the ocean, the seafloor, and the genomes of organisms to better understand conditions on the planet in the past, today and in the future. In coming years, oceanographers will be called upon to synthesize and model a hierarchy of interacting systems that function across multiple orders of magnitude in space and time. We are experienced in working across disciplinary boundaries and have a history of effective collaborations with other departments on campus. In recognition of the increasingly interdisciplinary nature of oceanography, we have developed three educational/research themes that integrate across a large portion of the SoO's research interests - Climate and Carbon Cycling, Coastal Ocean and Extreme Environments. The Climate and Carbon Cycling and Coastal Ocean themes provide a natural integration across disciplines within CoEnv; the Extreme Environments theme addresses fundamental questions on extreme physical settings and on the origin and evolution of early life on Earth and elsewhere. We know from past experiences that collaborating across fields is difficult, but intellectually rewarding. We provide examples here of how we will combine our expertise in

understanding the fundamentals of ocean processes with our insights into how humans impact these processes to address important research areas over the next ten years, as oceanography becomes increasily data-rich, as we examine possible instabilities or tipping points, and we develop rigorous analysis of human-ocean interactions

A Data-rich Science

The lure of the sea will always be a powerful force, fueled by the desire for adventure and discovery of new worlds and the organisms that inhabit them. Oceanography has traditionally been a science highly dependent on the sparse sampling provided by ships, with limited data accessed primarily by other oceanographers. Today, the field is rapidly transforming into a data-rich science augmented by autonomous instruments, cabled observatories, satellites and genomic data, all of which provide continuous indications of the frequency of earth's movements and compelling evidence that the ocean is slowly heating up, becoming more acidic, with unforeseen changes appearing at the base of the food web. It is within this new world that those with expertise in data visualization and synthesis are being drawn to oceanography, a field with compelling data streams. Over the coming decade, we will continue working closely with experts in escience, informatics, engineering and computer science to develop new ways to synthesize this data, tease out significant events from background fluctuations, and develop models that allow comparisons across multiple domains. As part of our 10-year hiring plan, we recognized that our heavy involvement in data-rich observational programs and the demand for synthesis of these data requires an expansion of our modeling expertise to integrate across ocean discipline, land-sea and air-sea boundaries. An important direction to consider is a joint appointment with Computer Science and Engineering.

Tipping Points

The oceans, land and atmosphere interact to create the earth system. The oceans are changing rapidly and, in many cases, more rapidly than we had predicted. Our understanding of the links between forcing and response is incomplete. Global warming is changing the freshwater and heat budgets of the ocean. Ocean acidification is causing fundamental changes in the carbonate chemistry of the sea. Eutrophication alters species composition and ecosystem structure. Cultivation of land affects near shore sedimentation. These changes are potentially driving the ocean towards tipping points from which it is difficult to return. Going down this path raises major questions. Will increased stratification result in expansion of oxygen minimum zones? Will a drop in ocean pH cause a shift from species forming carbonate skeletons to those forming silicate skeletons? Will the loss of sea ice diminish the productivity of the arctic ecosystem? Can marine ecosystems evolve rapidly enough to stay apace with environmental changes? These suggest possible joint appointments around climate change and its impacts on humans and ecosystems.

Our leadership role in major ocean observing programs uniquely positions the SoO to detect change and understand the impact of these changes on how the ocean functions. The OOI-RSN observatory is designed to address fundamental questions about how the geology, chemistry, physics and biology respond to major events like volcanic eruptions, seismic events and releases of methane gas from hydrates. Our ability to correctly answer critical questions will rely on our observational capacity to detect change, separate natural and anthropogenic trends, identify key processes controlling change and predict how these processes will respond in the future. Important steps include sustaining strong ties with APL and considering one or more joint appointment with Electrical Engineering, Bioengineering and Genome Sciences around sensor development.

Ocean-Human Interactions
The oceans provide sustenance, a sense of well being, and security to a majority of the billions of people on the planet. The oceans can also be devastating–with vast regions vulnerable to earthquakes and resulting tsunamis, storms, and rising sea levels. Food from the sea is increasingly impacted by toxins produced by microbes and contaminants transferred from the land to sea. Over the next decade, we expect there will be an increased call for oceanographic expertise to address issues with societal impacts, as recently demonstrated by events surrounding the recent Gulf oil spill. As a leader in the field, the SoO must help insure that our scientific knowledge is sufficient to meet these challenges.

The coastal ocean–where land, oceans, and humans are inextricably linked–provides an avenue to apply our basic understanding of natural processes to disturbed systems and a point of integration across the diverse expertise within the CoEnv. Researchers within SoO are already playing major roles this area and are poised to further develop the necessary collaborations to maintain this leadership role. We have created strong ties to researchers within public health and the federal agencies that place our results in a human health context. These connections are facilitated by our co-location on UW and in Seattle. We also have necessary expertise in marine sedimentology, for example, needed to help design and implement restoration projects in urban settings (e.g., dam removal to improve salmon habitat). Of all coastal regions, estuaries are the most heavily impacted by humans and we will continue to focus on our own backyard of the Puget Sound Estuary, helping to guide policy decisions critical to Washington state's goal of restoring the Sound by 2020. As part of our 10-year hiring plan, we identified the need for faculty expertise in coastal ocean circulation and earthquake processes at active ocean-continent boundaries. These positions would strengthen connections with ESS. The theme suggests opportunities for closer interaction and joint appointments with Civil and Environmental Engineering and Public Health and Community Medicine.

Educational Goals
Undergraduate Program
Our overall goal in our undergraduate program is to continue to expand the number of students that have exposure to ocean sciences, while maintaining our commitment to experiential learning. We have already begun implementation of a plan that over the next five years will increase the number of majors from 100 to 150 and double our total student credit hours from at the undergraduate level from ~5000 to 10,000. These levels of undergraduate teaching would equitably share undergraduate teaching with the other units in the CoEnv, while being careful not to undermine our high level of research activity.

Recruitment of additional majors will continue to follow the strategy initiated in 2005, which almost doubled our majors in five years (see 'Recruiting Students' in Section II). Although a 50% increase in our graduating majors from 20 to 40 per year can be accommodated in our current classroom structure, there would be a more noticeable impact on our two field classes, which emphasize individualized instruction. Both courses are currently taught jointly by four faculty members, typically with one from each curricular group, and can readily accommodate more students per faculty. The largest impact will be on the field component, where there are limits to science personnel (for overnight trips ~38 on the *Thompson* and ~6 on the *Barnes*). To accommodate larger class sizes, we have initiated mechanisms to provide alternative research cruise experiences for our

seniors, including incorporation of senior theses into faculty research cruise. The replacement of the *R/V Barnes*, our local research vessel, with a more capable vessel (see below) will be critical to maintain our ability to provide educational opportunities at sea to a significantly larger sophomore class.

A second potential avenue is revamping our rarely used BA in oceanography to include tracks specific to students interested in education, policy and science writing. This degree would build upon the bridges already being formed with policy and human dimension-related units affiliated with the CoEnv. This program would increase enrollment in our upper division courses for the BS, thereby stabilizing them.

A doubling of total student credit hours will most readily be accomplished by increasing the number of students in our lower division, non-major classes. Because fund allocations through ABB occur at the College level, our goal is to attract new students to CoEnv, rather than attract students from other divisions within CoEnv. In 2010-2011 we will offer an additional section of our recently reconstituted Oc101 "Survey of Oceanography: Focus on Washington Waters" and have developed a new 100 level class "Volcanoes and Life in the Deep Sea." In future years we plan to offer additional sections of popular co-listed courses in marine biology and astrobiology that are always oversubscribed and we will partner with Earth and Space Sciences and Atmospheric Sciences to develop a unified 200 level climate series.

An additional means of increasing student credit hours is through distance learning. Although distance learning classes have not been a significant component of our undergraduate teaching program, the development of the OOI-RSN provides an obvious avenue for both educational and outreach activities via this approach. We will explore benefits and costs of establishing distance learning options through discussions with the CoEnv.

Graduate Program

Over the next ten years, the goal for our graduate program is to continue to provide sufficient disciplinary depth and interdisciplinary breadth of knowledge for our students to become leading researchers and teachers in the field. We believe future oceanographers will operate in a world where a systems approach to environmental questions is essential, where access to large amounts of data (from sensors, genomes, models) is the norm, where the demand for increased and rapid communication of ideas to non-scientists and policy makers is high, and where facing ethical issues related to their research is inevitable. Training new oceanographers to be effective in this future world requires the implementation of new strategies in teaching. We already have strong ties to relevant science departments across campus and we have flexibility in the structure of student thesis committees and required coursework. We have initiated more formal ties with CSE and see other joint appointments with science and engineering departments as being important to graduate education and research. In the context of CoEnv, we will strengthen the societal and humanistic components of our curriculum through joint teaching so that are students are conversant with ethics, values, policy and societal dimensions of technological change.

Necessary Structural Changes

Operations and Faculty Support

The successful operation of the SoO is highly dependent on research grants with ~20% of the departmental budget for the SoO supported by RCR (Table 3) and most tenure-track faculty drawing only six months of UW-funded salary. The SoO's financial model is risk laden for several reasons: increasing competition for federal grants, increasing expectation by funding agencies that principal investigators request summer salary only, decreasing UW support for the department, the impact of ABB on future resource allocation and the likely retirement of about two-thirds of the full professors over the next decade.

The future hiring of WOT faculty (non-APL) is an active topic of discussion with the SoO. Some argue that all new hires should be in tenure track positions to provide sufficient hard money support for junior faculty in a toughening funding climate. Others argue that the SoO cannot afford to lose to retirements the breadth of teaching expertise and graduate advising capacity provided by the current number of WOT faculty. A unifying challenge facing the SoO is to find a way to maintain a faculty body that is sufficiently large to preserve our international stature and the excellence of our graduate teaching program while increasing the hard money support available for each faculty. This may seem a daunting task given that our UW-provided budget is shrinking. In the long term, there is no choice other than to find a means to increase the levels of hard money support especially given our plan to increase student credit hours per teaching faculty while maintaining our high levels of research support.

Currently, endowment funds contribute a small proportion to the SoO budget. These funds have significant impact on focused activities particularly scholarships for undergraduate majors and the backing for our department guarantee to graduate students for continuous support. There is a sense among our faculty that our successes are less publicized than at our peer institutions. We propose that the CoEnv highlight the quality and innovation of the science undertaken in the SoO to obtain private support to pursue innovative, risky ideas, with substantial scientific and societal benefits. Support for young faculty, postdoctoral researchers and graduate students should be emphasized because these early career scientists are productive, eager to learn new approaches and the future leaders of the field.

Teaching

The SoO is research-intensive, operating within a state university structure that increasingly emphasizes undergraduate education. A combination of the national structure of ocean sciences and the necessity of year round participation in oceanographic research cruises has resulted in a highly flexible, allocation of faculty teaching responsibilities. We will need to revisit teaching responsibilities, with an expectation that more faculty will teach at the undergraduate level. Teaching large undergraduate, non-major, courses will be critical to attain our goal of doubling student credit hours over the next five years and may also necessitate hiring additional lecturers.

Increasing our undergraduate teaching load will require either a shift from graduate to undergraduate teaching, more teaching per faculty member and/or the addition of more teachers. We have already become more selective in the courses offered by establishing guidelines for minimum class sizes per faculty as 10 at the undergraduate level and as 6 at the graduate level.

Covering the basic sciences important to the ocean for our ~75 students means that many of our core disciplinary graduate courses will now either be taught every other year or be restructured to attract students from other departments. Lower division non-major courses that we have proposed are time intensive to develop and teach. A successful mechanism we have applied to our large introductory, science-oriented oceanography course is to pair a faculty member responsible for course structure and lecture material with a Lecturer responsible for course administration and TA mentoring. The Lecturer then teaches other non-science major, introductory courses during the two other quarters. We will explore this mechanism as a path forward for lower level course expansion. Large undergraduate courses require more TA support and thus we can increase our graduate requirements to 2 quarters per graduate career, which will simultaneously reduce graduate student dependence on grant support (RAs).

Infrastructure

Space. New space requirements stem from the major role that SoO will play implementing the Regional Scale Nodes of the Ocean Observatories Initiative. RSN personnel are moving into space freed up in OTB by the departure of the International Pacific Halibut Commission but the successful implementation of this program requires increased staging and storage space for large pieces of equipment such as moorings, junction boxes and instrument assemblages. An area on the south side of the Harris Hydraulics Laboratory could house a combined outdoor and warehouse staging area that would be easily accessible to the dock.

Renovation requirements are relatively minor but important to support anticipated increases in undergraduate teaching. Specifically, the lecture hall (Rm 14) and teaching labs in OTB need to be refurbished. The Spatial Analysis Laboratory (SAL) in OSB is a key teaching facility. It needs to be improved, expanded and possibly duplicated because computer laboratory access is becoming a bottleneck in scheduling courses and the heavy use of the SAL for teaching limits its availability to students for independent work. An example of a cutting edge SAL classroom is Rutger's "COOL" room that utilizes access to real-time data streams from east coast observatory efforts. The presence of RSN, NANOOS, and IRIS on campus presents a strong opportunity to develop such an educational facility.

Computation. Models will become a much more widely used tool for data analysis during the next decade. Handling large data streams from cabled and non-cabled instruments and satellites will become a fundamental necessity in oceanography. Thus we will need to have ready access to adequate computational capacity. CoEnv took early steps to have capacity in the new UW shared, high performance computer cluster currently growing to a maximum of ~1500 nodes and multiple petabytes of high performance and archival storage. Strategic partnerships around OOI have brought 40 Gbit/s bandwidth to one of our building and access to low-cost cloud computing capacity. We need to invest in technical staff to take advantage of these opportunities for research and teaching.

Ships. The Global Class *R/V Thompson* is approaching 20 years of age and is in need of a mid-life refit to extend the life of the ship's mechanical systems, refurbish science areas, and improve overall capabilities. We must work with the research vessel community to incorporate mid-life refits into agency plans for vessels of the Thompson's class.

The Local Class *R/V Barnes* operates in Puget Sound and other inland waters and is the oldest and smallest vessel in the academic fleet and has become outdated for most research and teaching programs, which creates a large gap in our educational and research infrastructure. SoO is undertaking a conceptual design for a more capable replacement of the Barnes that will support substantially more science and teaching. However, federal agencies have decided that small academic research vessels must be capitalized with local funds. Because of stress on the UW budget, the most feasible means of funding a new vessel will be working with development staff in CoEnv to devise a plan to obtain private funds.

Staff. Technical Services (Engineering Services, Machine Shop, Tank Test Facility) within the SoO operate as cost centers that provide specialized assistance to research programs on an as-needed basis with a fee-for-service structure, and are essential to our research activities. A consequence of reduced UW funds has been a reduction of SoO support for the technical staff, which due to natural fluctuations in grant-supported business, complicates recruiting and training new staff in advance of upcoming retirements. Yet, the faculty recognize the importance of technical services to the School and are concerned that there is no viable long-term plan in place to maintain continuity. The SoO needs to evaluate whether large operations such as the RSN/OOI, the Seaglider Fabrication Center and Marine Operations can provide an alternative means to stabilize support for technically capable personnel while still providing faculty with access to the technical expertise that is critical to their research on an as-needed basis.

Administrative Leadership

The SoO is large, has a substantial research portfolio, is the home to major national facilities, and possesses all of the administrative complexities that come with these. These demands make finding faculty to take on administrative leadership a significant challenge.

The Faculty Code assigns particular responsibilities to the Director, many that scale with size of the faculty; these are "must-dos". The operation of ocean sciences nationally requires the Director to actively contribute to community leadership. Beyond these specific responsibilities, many others can be delegated or shared, through administrative appointments or working faculty committees.

With the present Director stepping down at the end of the calendar year, this is a crucial juncture for ensuring strong faculty engagement in departmental leadership. We have a history of successful full-time Directors and this level of commitment means some skilled, effective, respected individuals do not imagine taking on the position. We must get past this perception. To attract the best leader, we need to create structures and incentives that recognize that the person serving will have varied motivations, and differing needs for maintaining scholarly work and returning to the faculty. We seek the advice of the review committee as we consider the role of the Director and mechanisms for sharing the communal work of the School.

PART B. UNIT-DEFINED QUESTIONS

The SoO faculty identified four unit-specific questions that we felt were important to our future. These have guided much of our self study, our answers below are fairly brief and for the most part recap our thoughts, plans and needs.

Will we be able to sustain the current size and composition of our faculty in the future and, if not, what will be the consequences?
For decades, oceanography has been a soft money science. As a result, we have a much larger faculty than we have academic support (~2:1), research funding per faculty member about double most of our peer units in the CoEnv and ~20% of our departmental budget met by RCR. Several trends suggest this situation may not be sustainable. The upward trajectory of research funding that fueled expansion of the field over the last few decades is flattening. The large pulse of faculty hired into the SoO during its growth phase (~1975-1985) is approaching retirement. The senior faculty typically release one-third of their state salary to reduce their teaching load and increase time for research. The costs of initiating a faculty position are no longer dominated by the salary, but rather by start-up costs (of order $500k). With a reduced presence of ONR and DOE in oceanographic research, NSF stands as the primary supporter of academic oceanographic research. The result is more competition for funds, lower proposal success rates, more proposals submitted per faculty member, and more time devoted to writing proposals. For the junior faculty, this situation makes it more difficult and stressful to establish the research programs needed to meet their tenure expectations. For the senior faculty, this situation makes it more difficult to keep their research groups together and devote time to research in place of teaching through buy-back.

At the UW level, the transition to Activity Based Budgeting (ABB) is another factor influencing our faculty composition because of its potentially negative impact on our level of UW support. Although not yet finalized, the proposed version of ABB weights heavily teaching as the metric for allocation of institutional support, values graduate education less than in the past and makes no allowance for the higher costs of education in the sciences and engineering. The impact of ABB in the SoO is potentially substantial because of our high proportion of research faculty and graduate teaching and the higher costs of incorporating experiential learning into our educational programs. The current formulation of ABB does not reflect the crucial role of research in a Research I institution and so devalues our focus on integration of our research with our teaching. Research-based education in an observational science cannot be carried out at the same cost as classroom, text-based learning.

All these factors suggest a need to increase the amount of hard money support per faculty and provide funding for increasingly expensive faculty startups. Accomplishing this with a flat or decreasing budget will inevitably lead to a smaller faculty. If our faculty composition cannot be sustained in the future and we lose specialized expertise, we stand to lose teaching breadth, research competitiveness and international standing in our field. As discussed above we have in place a plan to increase our student credit hours per teaching faculty and if this can be accomplished with minimal effect on our high levels of research support, we will be in a strong position to argue for increased funding from the UW. Concurrently, we need to fully utilize the formation of the CoEnv and the exciting opportunities within oceanography to increase our profile within the potential

donor community and, over the long-term, substantially increase the level of endowed support for our programs.

How do we increase undergraduate teaching and simultaneously maintain our experiential learning approach for Oceanography majors?

Our educational programs are a source of great pride and our special niche in the oceanographic community. Our experiential learning approach distinguishes the SoO from other teaching units on campus and from most of our national peer institutions. We intend to maintain our extraordinary synergy between our educational programs and our research enterprise, even as we teach more at the undergraduate level.

We cannot increase the size of our BS degree beyond 40 without impacting the quality and availability of the field courses, but we can envision opportunities to increase the number of majors by revamping our BA degree to include tracks for students interested in education, policy and science writing. We also anticipate a modest increase in enrollment of non-ocean science majors in our upper division classes through minors (oceanography and interdisciplinary).

To accomplish these goals we will need support to renovate and expand some of our teaching spaces so that they can accommodate more students and support their computational needs. We will need to secure a replacement for the *Barnes,* ideally with dedicated educational days, to increase our capabilities to provide students with educational opportunities at sea. Internally, we will need to agree on an equitable distribution of this additional teaching load, the balance between undergraduate and graduate teaching, the appropriate allocation between tenure-track and WOT faculty, and the role of Lecturers and TAs. We will need to work with CoEnv to find ways to increase the visibility to potential students of the experiential learning opportunities we provide.

How do we maximize our research, teaching and outreach opportunities in the CoEnv?

The SoO will work with the Dean to determine our role within the CoEnv and to make a major contribution towards defining the CoEnv. A major objective of the CoEnv is to successfully integrate several units focused on geosciences with those focused on policy and human dimensions to become an internationally recognized innovator in environmental research, teaching and outreach. It is clear that we have a lot to offer, especially if we can secure the necessary support to maintain our stature. We are an internationally recognized leader in oceanographic research noted for its rigorous educational programs. We live in a unique location where the opportunities for oceanographers range from understanding anthropogenic influences on an inland ocean to investigating geological processes on the scale of a tectonic plate. We are comfortable working across disciplinary boundaries and have a history of effective collaborations with the other departments in the CoEnv and with many units elsewhere on campus. Much of our research falls into three major interdisciplinary themes (climate and carbon cycling, coastal oceanography and extreme environments) each of which has natural links to other groups in CoEnv. We have a first rate graduate program and our students prosper because of the breadth and quality of our research and their access to the resources of a top research university. We recognize the need to expand our role in undergraduate teaching as UW increases enrollment. We have an expertise in experiential learning that can contribute to CoEnv wide efforts to engage students in the environmental sciences

while we benefit from new opportunities to expose our students to the political and social aspects of our field. Finally, we welcome new educational efforts that arise in CoEnv such as the development of new options for distance learning and professional graduate degrees.

We will continue to identify opportunities to integrate our research and teaching activities across the campus while seeking the support that we need to prosper. CoEnv led initiatives to help market our distinctive undergraduate opportunities nationwide and recruit and retain underrepresented minorities at the undergraduate and graduate level to the environmental sciences would benefit SoO and all CoEnv units. As noted above, the support of CoEnv will be critical in securing additional funds for young faculty, post-docs and graduate students to pursue high risk ideas and increasing our visibility amongst potential donors. We also need to find funding to replace our smaller research vessel and a new more capable boat will not only improve our research capabilities but will also provide an opportunity for increased student access to at-sea learning within the CoEnv. Beyond the clear opportunities within CoEnv, we must have CoEnv also look at joint appointments and other opportunities that complement our science, among them engineering, public health, and the Evans School of Public Policy.

How do we best support infrastructure-based observational programs and integrate them into our educational programs?

We have gained international prominence in several fields that use autonomous instruments to observe the ocean (e.g., OOI, TAO, Argo, Seaglider) and operate a global class research vessel (Thompson). We are leaders in using sensors to measure ocean properties, genomics to unravel marine ecosystem function, tracers to detect anthropogenic change and models to simulate the ocean. All these grant-funded activities depend on innovative measurements that require the availability of technically skilled staff and an ongoing investment in infrastructure.

Larger programs support their own technical staff and we also benefit from our close collaborations with colleagues in APL and PMEL. On a smaller scale our faculty need expertise on an as needed basis to explore and implement new ideas. This is particularly true for young faculty building observational and experimental programs. The SoO has lost the budgetary flexibility to provide temporary support so that new staff can be hired into the cost centers and trained before their predecessors retire. We need to explore alternate means of renewing our technical services cost centers, perhaps by strengthening their linkages to large stably funded programs.

While most functions in the SoO have adequate space, we have limited indoor and outdoor staging areas and much of the indoor space is compartmentalized. The OOI-RSN will need a larger contiguous area to assemble equipment for installation at sea.

Our expertise in experiential teaching has arisen from our commitment to integrate our research activities into our educational endeavors. One of the key assets to support these endeavors is the availability of 45 days of UW time on the *R/V Thompson* that are part of our contract to operate this vessel. The OOI-RSN received a commitment of 15 days per year from this time as part of our proposal to become the implementing organization and in return incorporates students at sea and is developing innovative outreach capabilities such as the capability to broadcast live from the seafloor. We use some of the UW-funded Thompson days to support educational efforts in Puget

Sound and need to offer such opportunities to many more students. One way to expand ship-based educational days is to replace the *R/V Barnes* with a ship that can accommodate more students. Because ship days are expensive, the CoEnv must maximize the impact and visibility of the educational uses of our ships.

A complementary means to integrate our observational programs with education is through the use of information technology. It is increasingly important that our undergraduate and graduate students develop the skills to mine and model large data sets. One example would have students analyze real time data obtained from floats, moorings, gliders and networked instruments. The infrastructural needs (larger computer labs, fast networks) are not insubstantial, but the largest need is for the skilled support staff to help faculty develop and then support innovative computer labs. Since the trend towards data-intensive science is occurring across the environmental sciences, this is likely an area where collaboration with other units in CoEnv and support from the Dean will be critical.

Appendix A

Organizational Charts

A-1: Faculty
A-2: Departmental Operations
A-3: Facilities and Ship Operations

School of Oceanography
Dr. Russell E. McDuff, Director

Associate Director for Undergraduate Education
(S. Hautala)

Associate Director for Facilities and Ship Operations
(W. Wilcock)

Departmental Operations

see separate organizational chart

Facilities and Ship Operations

see separate organizational chart

Biological Oceanography

Core Faculty:
Armbrust, E. Virginia
Baross, John
Deming, Jody
Grunbaum, Daniel
Keister, Julie
Lessard, Evelyn
Morris, Robert
Rocap, Gabrielle

Emeritus/Adjuncts/Affiliate:
Anderson, George
Banse, Karl
Cattolico, Rose
Frost, Bruce
Lewin, Joyce
Mobley, Curtis
Napp Jeff
Newton, Jan
Perry, Mary Jane
Shuman, Randy
Thomsen, Laurenz
Van den Engh, Gerrit

Postdoctoral Research Associate:
Brazelton, William
Kodner, Robin
Ribalet, Francios
Turner, Jeff

Graduate Students (23)
Research Staff (14)

Chemical Oceanography

Core Faculty:
Devol, Allan
Emerson, Steven
Ingalls, Anitra
Keil, Richard
Lilley, Marvin
Murray, James
Quay, Paul
Richey, Jeffrey
Sachs, Julian
Warner, Mark

Emeritus/Adjunct/Affiliate:
Alin, Simone
Balistrieri, Laurie
Bullister, John
Carpenter, Roy
Crusius, John
Feely, Richard
Gammon, Richard
Mecking, Sabine
Resing, Joseph
Sabine, Christopher
Sonnerup, Rolf
Wakeham, Stuart

Postdoctoral Research Associate:
Bridoux, Maxime
Muegler, Ines
Richey, Julie
Shinneman, Avery

Graduate Students (19)
Research Staff (11)

Marine Geology and Geophysics

Core Faculty:
Delaney, John
Johnson, H. Paul
Kelley, Deborah
Nittrouer, Charles
Ogston, Andrea
Sheets, Benjamin
Solomon, Evan
Wilcock, William

Emeritus/Adjunct/Affiliate/Part-Time:
Baker, Edward
Butterfield, David
Creager, Joe
Heath, G. Ross
Holmes, Mark
Lauer, J. Wesley
Lewis, Brian
McManus, Dean
Nelson, Bruce
Pratt, Thomas
Shreve, Ron
Sternberg, Richard

Postdoctoral Research Associate:

Graduate Students (6)
Research Staff (4)

Physical Oceanography

Core Faculty:
Alford, Matthew
D'Asaro, Eric
Eriksen, Charles
Gregg, Michael
Hautala, Susan
Hickey, Barbara
Kawase, Mitsuhiro
Kelly, Kathryn
Lee, Craig
MacCready, Parker
Martin, Seelye
Rhines, Peter
Riser, Stephen
Sanford, Thomas
Thompson, LuAnne
Williams, Kevin
Woodgate, Rebecca

Emeritus/Adjunct/Affiliate:
Aagaard, Knut
Banas, Neil
Cannon, Glenn
Cronin, Meghan
Dushaw, Brian
Duxbury, Alyn
Ewart, Terry
Girton, James
Harrison, Ed
Horner-Devine, Alex
Hermann, Al
Howe, Bruce
Johnson, Gregory
Kessler, William
Kunze, Eric
Lien, Ren-Chieh
McPhaden, Michael
Mofjeld, Harold
Moore, Dennis
Morison, Jamie
Nystuen, Jeff
Oltman-Shay, Joan
Rainville, Luc
Rattray, Maurice
Rigor, Ignatius
Roden, Gunnar

Postdoctoral Research Associate:
Sutherland, David
Hristova, Hristina
McCabe, Ryan

Graduate Students (27)
Research Staff (15)

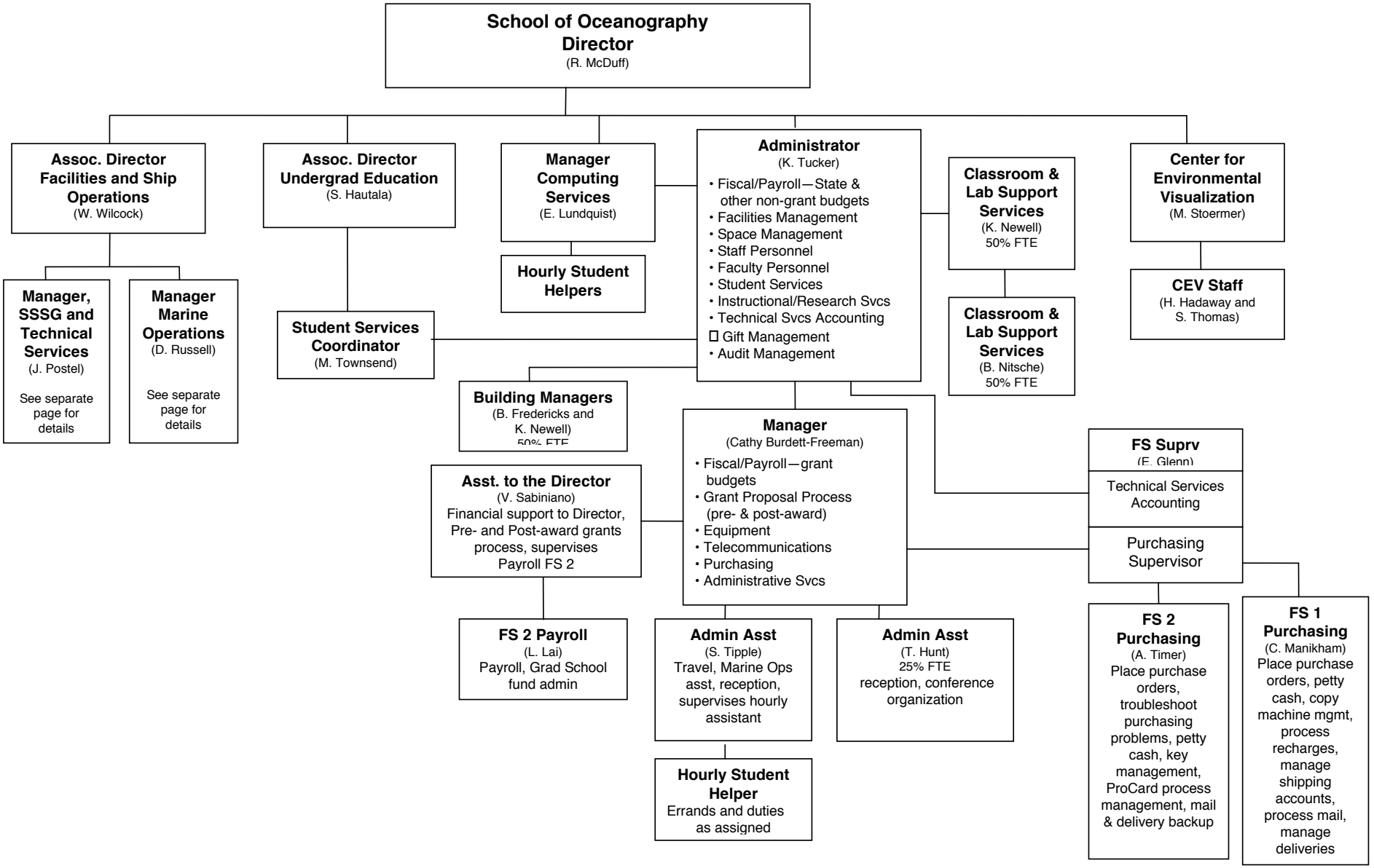
Cross Disciplinary/Instructional

Core Faculty:
Logsdon, Miles
McDuff, Russell
Nowell, Arthur
Nuwer, Mikelle
Waters, Raechel

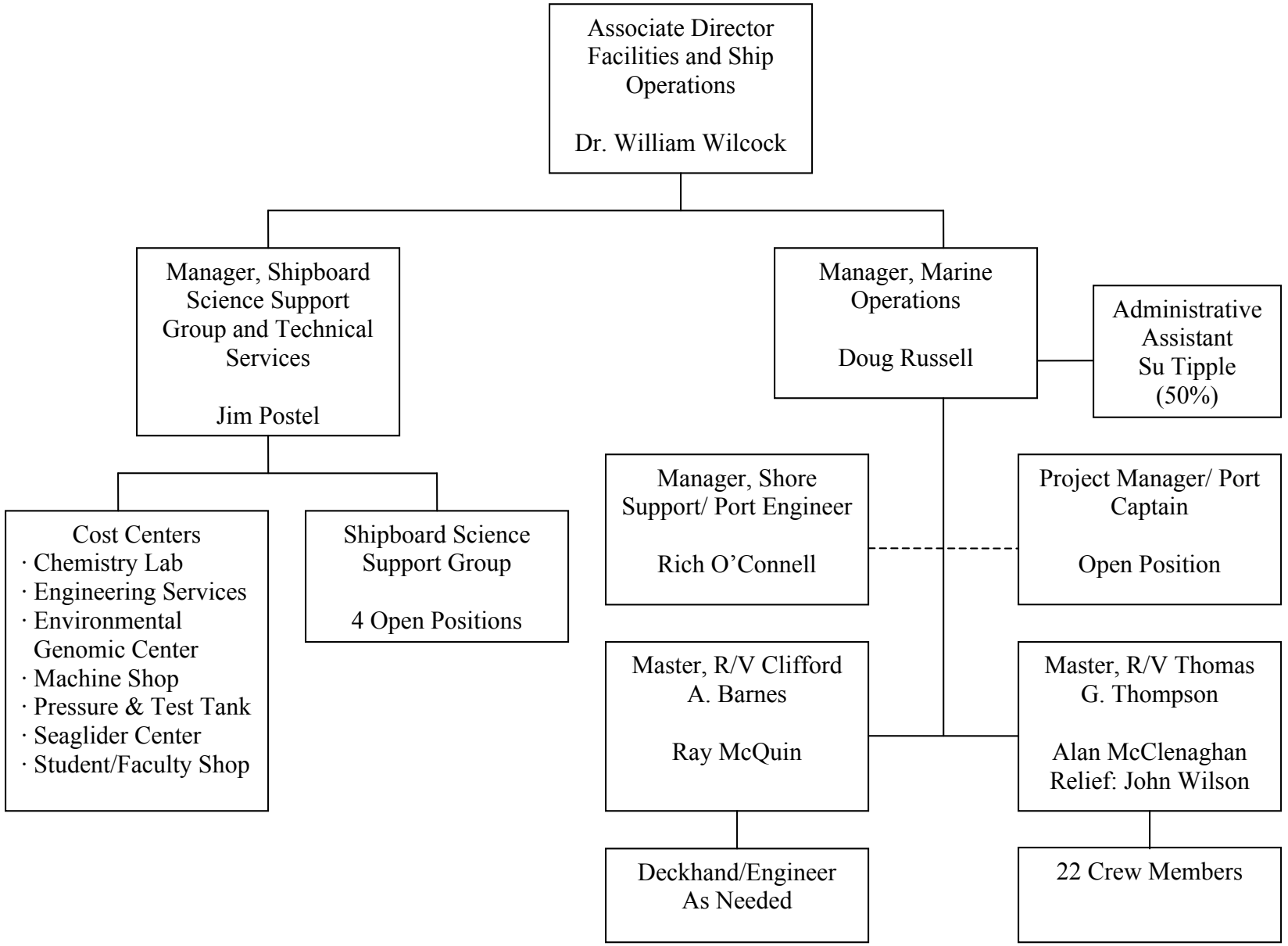
Emeritus/Adjunct/Affiliate/Part-Time:
Illman, Deborah
Johnson, Ronald
Lazowska, Edward
Lombard, John

Postdoctoral Research Associate:
Clay, Tansy

DEPARTMENTAL OPERATIONS



FACILITIES AND SHIP OPERATIONS



Appendix B

Operational Budget Summary for the School of Oceanography by Biennium

(Shown on an Annual Basis)

	2003-2005	2005-2007	2007-2009
Deparmental Resources			
UW Provided	$2.68M	$2.91M	$3.27M
SoO Earned (RCR)	$0.74M	$0.81M	$0.73M
Total	$3.42M	$3.72M	$4.01M
Department Expenditures			
Faculty Salary	$2.10M	$2.02M	$2.33M
Staff Salary	$0.78M	$0.83M	$0.91M
Graduate Assistantships	$0.14M	$0.12M	$0.14M
Operations and Faculty Startup	$0.49M	$0.42M	$0.77M
Total	$3.51M	$3.40M	$4.17M
Change in Reserves	-$0.10M	$0.31M	-$0.16M

Appendix C

Information about the Faculty

Name	*Rank*	*Appointment Type*	*Affiliations with Other Units*
FACULTY			
Alford, Matthew	Associate Professor	WOT	APL (Primary Appointment)
Armbrust, Virginia	Professor	Tenured	
Baross, John	Professor	Tenured	
D'Asaro, Eric	Professor	WOT	APL (Primary Appointment)
Delaney, John	Professor	Tenured	SMA (Adjunct); ESS (Adjunct); APL (Courtesy)
Deming, Jody	Professor	Tenured	
Devol, Allan	Professor	WOT	
Emerson, Steven	Professor	Tenured	
Eriksen, Charles	Professor	Tenured	
Gregg, Michael	Professor	WOT	APL (Primary Appointment)
Grünbaum, Daniel	Associate Professor	Tenured	Biology (Adjunct)
Hautala, Susan	Associate Professor	Tenured	
Hickey, Barbara	Professor	WOT	
Illman, Deborah	Lecturer Part-Time	Term	
Ingalls, Anitra	Assistant Professor	Tenure Track	
Johnson, H. Paul	Professor	WOT	
Johnson, Ronald	Associate Professor	Tenured	Information School (Primary Appointment); CSE (Adjunct)
Kawase, Mitsuhiro	Associate Professor	Tenured	
Keil, Richard	Professor	Tenured	
Keister, Julie	Assistant Professor	Tenure Track	
Kelley, Deborah	Professor	Tenured	
Kelly, Kathryn	Professor	WOT	APL (Primary Appointment)
Lee, Craig	Associate Professor	WOT	APL (Primary Appointment)
Lessard, Evelyn	Associate Professor	WOT	
Lilley, Marvin	Professor	WOT	
Logsdon, Miles	Senior Lecturer	Term	
Lombard, John	Lecturer Part-Time	Term	
MacCready, Parker	Professor	WOT	
Martin, Seelye	Professor	WOT	
McDuff, Russell	Professor and Director	WOT	
Morris, Robert	Assistant Professor	Tenure Track	
Murray, James	Professor	Tenured	Chemistry (Adjunct)
Nitrrouer, Charles	Professor	Tenured	ESS (Joint Appointment)
Nowell, Arthur	Professor	Tenured	Dean Emeritus
Nuwer, Mikelle	Lecturer Full-Time	Term	

Name	*Rank*	*Appointment Type*	*Affiliations with Other Units*
Ogston, Andrea	Associate Professor	WOT	
Quay, Paul	Professor	Tenured	
Rhines, Peter	Professor	Tenured	Atmos Sci (Joint Appointment)
Richey, Jeffrey	Professor	WOT	CEE (Adjunct); Forest Resources (Adjunct)
Riser, Stephen	Professor	Tenured	
Rocap, Gabrielle	Associate Professor	Tenured	
Sachs, Julian	Associate Professor	Tenured	
Sanford, Thomas	Professor	WOT	APL (Primary Appointment)
Sheets, Benjamin	Assistant Professor	Tenure Track	ESS (Adjunct)
Shreve, Ronald	Research Professor Part-Time	WOT	QRC
Solomon, Evan	Assistant Professor	Tenure Track	
Thompson, LuAnne	Professor	Tenured	Atmos Sci (Adjunct); Physics (Adjunct)
Warner, Mark	Associate Professor	WOT	
Waters, Raechel	Research Assistant Professor	Term	Washington Sea Grant
Wilcock, William	Professor	Tenured	ESS (Adjunct)
Williams, Kevin	Associate Professor	WOT	APL (Primary Appointment)
Woodgate, Rebecca	Associate Professor	WOT	APL (Primary Appointment)
EMERITUS			
Aagaard, Knut	Professor Emeritus		
Anderson, George	Professor Emeritus		
Banse, Karl	Professor Emeritus		
Carpenter, Roy	Professor Emeritus		
Creager, Joe	Professor Emeritus		ESS (Professor Emeritus)
Duxbury, Alyn	Associate Professor Emeritus		SMA (Associate Professor Emeritus)
Ewart, Terry	Professor Emeritus		
Frost, Bruce	Professor Emeritus		
Gammon, Richard	Professor Emeritus		
Heath, G. Ross	Professor Emeritus		
Holmes, Mark	Research Professor Emeritus		
Lewin, Joyce	Research Professor Emeritus		
Lewis, Brian	Professor Emeritus		
McManus, Dean	Professor Emeritus		
Rattray, Maurice	Professor Emeritus		
Roden, Gunnar	Research Professor Emeritus		
Sternberg, Richard	Professor Emeritus		

Name	*Rank*	*Appointment Type*	*Affiliations with Other Units*
POSTDOCTORAL			
Brazelton, William	Research Associate, Postdoctoral		
Bridoux, Maxime	Research Associate, Postdoctoral		
Clay, Tansy	Research Associate, Postdoctoral		
Hristova, Hristina	Research Associate, Postdoctoral		
Kodner, Robin	Research Associate, Postdoctoral		
McCabe, Ryan	Research Associate, Postdoctoral		
Mügler, Ines	Research Associate, Postdoctoral		
Ribalet, François	Research Associate, Postdoctoral		
Richey, Julie	Research Associate, Postdoctoral		
Shinneman, Avery	Research Associate, Postdoctoral		
Sutherland, David	Research Associate, Postdoctoral		
Turner, Jeff	Research Associate, Postdoctoral		
ADJUNCT			
Cattolico, Rose Ann	Adjunct Professor		Biology (Primary Appointment)
Horner-Devine, Alexander	Adjunct Assistant Professor		CEE (Primary Appointment)
Lazowska, Edward	Adjunct Professor		CSE (Primary Appointment)
Nelson, Bruce	Adjunct Professor		ESS (Primary Appointment)
AFFILIATE			
Alin, Simone	Affiliate Assistant Professor		NOAA/PMEL
Baker, Edward	Affiliate Professor		NOAA/PMEL
Balistieri, Laurie	Affiliate Professor		USGS
Banas, Neil	Affiliate Assistant Professor		APL (Primary Appointment)
Bullister, John	Affiliate Associate Professor		NOAA/PMEL
Butterfield, David	Affiliate Associate Professor		JISAO (Primary Appointment)

Name	*Rank*	*Appointment Type*	*Affiliations with Other Units*
Cannon, Glenn	Affiliate Professor		NOAA/PMEL
Cronin, Meghan	Affiliate Professor		NOAA/PMEL
Crusius, John	Affiliate Associate Professor		USGS
Dushaw, Brian	Affiliate Associate Professor		APL (Primary Appointment)
Feely, Richard	Affiliate Professor		NOAA/PMEL
Girton, James	Affiliate Assistant Professor		APL (Primary Appointment)
Harrison, Don	Affiliate Professor		ESS (Affiliate Professor)
Hermann, Albert	Affiliate Associate Professor		JISAO (Primary Appointment)
Howe, Bruce	Affiliate Professor		EE (Affiliate Professor)
Johnson, Greg	Affiliate Professor		NOAA/PMEL
Kessler, William	Affiliate Professor		NOAA/PMEL
Kunze, Eric	Affiliate Professor		APL (Primary Appointment)
Lauer, J. Wesley	Affiliate Assistant Professor		Seattle University
Lien, Ren-Chieh	Affiliate Professor		APL (Primary Appointment)
McPhaden, Michael	Affiliate Professor		NOAA/PMEL
Mecking, Sabine	Affiliate Assistant Professor		APL (Primary Appointment)
Mobley, Curtis	Affiliate Professor		Sequoia Scientific, Inc.
Mofjeld, Harold	Affiliate Professor		NOAA/PMEL
Moore, Dennis	Affiliate Professor		NOAA/PMEL
Morison, James	Affiliate Professor		APL (Primary Appointment)
Napp, Jeffrey	Affiliate Associate Professor		NOAA/Alaska Fisheries Science Center
Newton, Jan	Affiliate Assistant Professor		APL (Primary Appointment); SMA (Affiliate Assistant Professor)
Nystuen, Jeffrey	Affiliate Professor		APL (Primary Appointment)
Oltman-Shay, Joan	Affiliate Associate Professor		Northwest Research Associates
Perry, Mary Jane	Affiliate Professor		University of Maine
Pratt, Thomas	Affiliate Professor		ESS (Affiliate Professor)
Rainville, Luc	Affiliate Assistant Professor		APL (Primary Appointment)
Resing, Joseph	Affiliate Assistant Professor		JISAO (Primary Appointment)

Name	*Rank*	*Appointment Type*	*Affiliations with Other Units*
Rigor, Ignatius	Affiliate Assistant Professor		APL (Primary Appointment)
Sabine, Christopher	Affiliate Professor		NOAA/PMEL
Shuman, Randy	Affiliate Associate Professor		King County
Sonnerup, Rolf	Affiliate Assistant Professor		JISAO (Primary Appointment)
Thomsen, Laurenz	Affiliate Professor		University of Keil, Germany
Van den Engh, Gerrit	Affiliate Professor		BD Biosciences
Wakeham, Stuart	Affiliate Professor		Skidaway Institute of Oceanography

APPENDIX D

EXISTING PROGRAM REVIEW: HEC BOARD SUMMARY

Name of unit: School of Oceanography
Name of school/college: College of the Environment
Degree title(s): B.A., B.S., M.S., Ph.D.
Year of last review: 1998-99
Current date: September 2010

A. Documentation of continuing need, including reference to the statewide and regional needs assessment

The School of Oceanography is a top-tier national program, with a strong graduate program and widely recognized for its rigorous undergraduate program, unmatched in the United States. As a costal state and enclosing the largest marine estuary in the US, basic and applied research and educated graduates are crucial to the State of Washington. Our graduates at all degree levels work principally in oceanography or a related environmental science. The U.S. Department of Labor estimates that employment of environmental scientists and specialists is projected to increase by 28 percent between 2008 and 2018, approximately three times the average rate for all occupations.

Our count of undergraduate majors has very nearly doubled in the past five years and we anticipate continuing, more modest, growth. A particular focus will be increasing visibility and enrollment in our BA degree and growing participation in minors in which we are major participants. Together these are avenues to build ocean literacy among students pursuing interests in public policy, planning in coastal cities and towns, and K-12 education.

B. Assessment information related to expected student learning outcomes and the achievement of the program's objectives

The most important measure of our success is that students use his or her degree.

For undergraduates, our learning goals include having students 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. Greater than 80% are in graduate school or hold science staff positions within the federal, state and private sectors.

The goal of our graduate program is to develop successful, active individuals who are capable of independent research, with the ability to communicate results with peers and the public. Students are expected to gain sufficient depth of knowledge in their research area and to develop independent research capabilities and sufficient breadth of knowledge in a core science discipline and across the science disciplines of oceanography to work effectively within this interdisciplinary field. 95% use his or her terminal degree. They occupy state and national leadership roles in the ocean sciences. Within

Washington, they serve on the faull and staff of UW and in other state universities and agencies. They hold positions at peer institutions nationally. They serve in federal agencies, on the staff of the National Academy of Sciences/National Research Council and in well-known non-governmental organizations.

C. Plans to improve the quality and productivity of the program

Our quality is very high and to sustain our national stature requires continuous innovation. We use our (primarily federally funded) research as a foundation for our educational programs. The pace of innovation requires that these programs adapt and change quickly.

We believe future oceanographers will operate in a world where a systems approach to environmental questions is essential, where access to large amounts of data (from sensors, genomes, models) is the norm, where the demand for increased and rapid communication of ideas to non-scientists and policy makers is high, and where facing ethical issues related to their research is inevitable. These require us to develop courses that increase the cyber skills of our students, expand opportunities for developing communication skills, and provide a more formal introduction to societal and ethical dimensions of being a scientist.

Within the context of the flagship research university of the state, our productivity is very high. We use our externally funded research to strongly amplify the educational experience of our students. Our net cost, tuition and state funding offset for federal indirect costs, puts our contribution to teaching on par with science and engineering programs across the campus. Our specific plans for improving our contribution are to continued growth of our undergraduate program to the maximum sustainable level within present resources, add value through growth of our B.A., and to work with our college to increasing environmental literacy.

Number of instructional faculty, students enrolled, and degrees granted over last three years (Autumn-Summer)

	2007-2008	2008-2009	2009-2010	TOTAL
FTE instructional faculty	24.2	24.13	22.9	
FTE graduate teaching assistants	2	2.3	3	
B.S.				
Headcount of enrolled students	78	81	88	
Number of degrees granted	20	14	23	57
M.S.				
Headcount of enrolled students	44	55	56	
Number of degrees granted	9	9	10	28
Ph.D				
Headcount of enrolled students	26	17	17	
Number of degrees granted	12	8	8	28
TOTAL				113

NOTE: "Headcount of enrolled students" (undergraduate) = number of declared majors as of 10th day of Autumn Quarter.

Appendix E

Summary of Undergraduate Curriculum

Our curriculum combines a thorough foundation in disciplinary science with extensive opportunities for experiential learning. Students are required to take 3 quarters of math, 3 quarters of physics, 2 quarters of biology, 2 quarters of chemistry and one quarter of Earth science. These foundational courses are typically taken in the freshmen and sophomore year. An introductory series in the major includes a paired lecture and lab covering essential concepts in all 4 disciplines (Oc200 & 201), a course on the large scale circulation of the oceans (Oc210) and a sophomore field course that provides an introduction to the scientific method and field techniques (Oc220). Four 400 level core courses, one in each oceanographic discipline (OC430-biological, OC400-chemical, OC420-physical, OC410-marine geology and geophysics), are taken in the junior year. All students complete a capstone project and paper during the 2-quarter senior thesis series (Oc443/444). Elective coursework includes 6 credits within oceanography (options include advanced topics within a discipline, theme based interdisciplinary courses and special cruise courses that provide additional field experience), and 20 credits of 300-400 level science courses from anywhere in the university. This latter requirement makes Oceanography one of the most flexible science majors at UW and allows our students to pursue in-depth coursework in complementary areas of science, often resulting in minors or double degrees.

Appendix F

Summary of Graduate Curriculum

The course requirements vary by curricular group. There are a prescribed number of courses within the discipline for the PhD degree (6 in Biological Oceanography; 7 in Chemical Oceanography; 8 in Physical Oceanography and 6-8 in Marine Geology and Geophysics) and additional course requirements outside the SoO (e.g. Applied Math for PO and Earth and Space Sciences for MG&G). There is an out of option or breadth requirement for all PhD students that consists of taking three courses outside their discipline, one from each of the curricular groups outside the student's discipline based on a list of courses compiled by the curricular group. The course requirements are typically met by the students third year.

Appendix G

Research Funding Over Past Five Years

	2005-06	2006-07	2007-08	2008-09	2009-10
Research Funding					
Proposal submitted[a]	91	109	94	86	127
Total Funding / yr ($, millions)					
SoO (w/o APL and OOI)	17.5	15.4	16.3	18.2	13.8
Including OOI				24.2	58.8
Including 8 APL WOT faculty	28.9	27.0	26.4	36.3	65.8
Funding /fac/yr[b] ($, mil.)					
SoO only	0.46	0.41	0.43	0.48	0.36
SoO plus APL	0.63	0.59	0.57	0.66	0.45
Graduate Student Support[c]					
Total Graduate Students	73	73	70	72	73
Fellowships	11	13.5	10.5	11.3	6.3
TAs (9 months)	2.0	2.0	2.0	2.3	3.0
RAs[d]	56	53.5	53.5	53.8	57.8
Students/Faculty	An average of 1.7 grad students (including APL)				
Undergraduates Employed					
Student years[e]	25.8	23.5	27.5	23.3	
Faculty Publications[f]	An average of 2.3 Papers / year				

a. SoO only (36 faculty, excluding admin and lecturer positions)
b. SoO plus APL funding and faculty (44 faculty)
c. All students including those funded by APL and PMEL
d. Total students minus those funded by other resources (Fellowships, TAs, other)
e. 1 year = 4 quarters; in 2008-09 it was 32 different students working ~13 hr / week
f. Average number of papers / year for the last 10 years, not including APL faculty or assistant professors

Appendix H

Ten Year Plan for Renewing Faculty Expertise (2005)

Phase	Timing	Ocean		APL WOT Partnership	
		Num	Expertise	Num	Expertise
I	2006-2007	2	• microbiologist with interests in biogeochemical cycling (Bob Morris hired) • zooplankton biologist/ecologist (Julie Keister hired)	--	
II	2007-2008	2	• marine stratigrapher, using observational and modeling approaches (Ben Sheets hired) • marine hydrogeologist spanning physical and chemical approaches (Evan Solomon offer pending)	--	
III	2008-2009	3	pending ads • coastal observational physical oceanographer • integrative, climate-related, ocean modeler • marine seismologist with interest in subduction zones, transforms, or geodynamics	2	potential areas of intersection: mixing, remote sensing, Arctic oceanography, environmental sensing
IV	2009-2010	2	somewhat prioritized • biogeochemical modeler (s) with expertise in carbon and nutrient cycling • phytoplankton ecologist with interests in remote sensing and climate change • trace metal chemist with interests in their influence on biogeochemical processes • large scale ocean physicist with interests in climate • vent molecular biologist (geobiologist) with expertise in the linkages between rock/sediment/sub-seafloor environments and community structure	2	
V	2011-2014	4		4	
VI	2014-2017	4	• vent biogeochemist • land/ocean carbon and nutrient cycle interactions • light stable isotope expertise • benthic biologist with interests in benthic/pelagic coupling • regional biogeochemical modeler • particle dynamics • gas hydrates and climate		

Appendix I

Additional Information on Research Areas

Climate and the Carbon Cycle

SoO and PMEL researchers have been deeply involved in the study of the modern and past carbon cycle. Major contributions have been made in the use of chemical tracers to determine the marine fate of anthropogenic CO_2, ocean acidification, the strength of the ocean biological carbon pump, and the trajectories of past climate change based on the use of tracers in marine sediments. A recent initiative successfully competed to develop a new experimental facility (at FHL) to study ocean acidification. SoO faculty have been instrumental in integrating environmental genomics into the study of carbon cycling with a focus on both photosynthetic and heterotrophic microbes. Our sediment dynamics group studies climate change through the use of modern and ancient formation of sedimentary strata in continental-margin environments.

Ocean Observing

We have a national leadership position in ocean observing. At the global scale, the international Argo array currently has ~3000 floats worldwide, mapping the changing properties of the upper ocean every ten days. UW and PMEL are responsible for ~50% of the US effort and UW is a key leader internationally in sensor performance and incorporation of biological and chemical sensors on Argo floats. The TAO array in the equatorial Pacific is the key component of El Nino detection system and run by adjunct faculty located at PMEL. Joint SoO and APL development of the Sea Glider provides a robust platform for regional scale studies, with important application to high latitude oceanography and coastal Washington. ORCA profiling buoys are an important technology for study of our coastal waters, for example hypoxia in Hood Canal. We have faculty using satellites to remotely detect large ocean circulation and heat transport. Within the next several years the Ocean Observatories Initiative (OOI) will become the largest NSF-sponsored facility within the oceanographic community. The existence of this facility is in large measure due to the vision and persistence of SoO faculty. The observatory will include global scale moorings, a regional scale cabled network in the northeast Pacific, and coastal mooring and glider arrays on the Washington and Oregon shelf. The SoO is the implementing organization for the design, installation and operation of the regional scale, cabled nodes. That much of the OOI will be installed in the NE Pacific represents an extraordinary opportunity for us, both for research and for education. We are leaders in measuring and modeling of CFC tracers as part of WOCE and CLIVAR international programs.

Coastal Systems

We have considerable strength in ocean studies in our region, both in the Salish Sea and coastal Washington. Faculty at the SoO has recently led a number of large interdisciplinary studies, involving collaborations with institutions on the entire US and Canadian west coast. These projects (ECOHAB, RISE, PNWTOX) have explored interdisciplinary questions in our shelf waters, looking at Harmful Algal Blooms and the effect of rivers on coastal productivity. Several of our faculty have been involved in these and other coastal programs, especially from biological and physical oceanography, giving us a strong foundation for continuing work in coastal circulation and ecosystem modeling and the study of primary production and zooplankton dynamics. Some of these collaborations, linking to our environmental genomics group (Armbrust, Rocap), have spawned the Pacific Northwest Center for Human Health and Ocean Studies. This center brings together researchers from five departments within UW and from six outside agencies and institutions, to bring together work on marine systems, public health and medical genetics. We also have many research projects focused on Puget Sound. Notably the Hood Canal Dissolved Oxygen Program (HCDOP) involves a diverse group of faculty studying the factors, including human activity and natural forcing, causing hypoxia in Puget Sound. Our sediment dynamics group has active research in local waters on the relationships between ancient and modern geomorphology and identifying the impact of human activity (e.g., upcoming removal of the Elwha River dam).

High Latitude Oceanography

The SoO and APL faculty are on the forefront of research in the Arctic and Antarctic Oceans and subarctic seas, studying topics that range from the impact of sea ice loss on ocean circulation to the cold temperature limits of microbial life in ice. Many of our faculty and their students have been part of several major national and international interdisciplinary programs (e.g., NOW and CFL in the Canadian Arctic, BEST in the eastern Bering Sea) studying the potential consequences of climate change on the functioning of polar and subpolar ecosystems. This area of research has become increasingly interdisciplinary with the recognition of that high latitude oceans are especially sensitive to climate change, with present day and projected impacts on important fisheries, threatened marine mammals, and native populations who depend on the ocean for their subsistence living.

Microbial Diversity

Microbial diversity addresses fundamental questions: which organisms are present, at what abundances, doing what work, at what rates? Research includes: study of microbial life at deep-sea vents, which contain chemical and thermal gradients that are ideal to address questions about the limits and elemental requirements of microbial life, microbial strategies for survival in arctic winter sea ice, laboratory and field-based studies addressing basic questions about the function of

diatoms, autotrophic bacteria and heterotrophic bacteria in marine ecosystems. UW has led the way in sequencing the first diatom genome, combined genomics and transcriptomics to identify genes involved in short-term response and long-term acclimation to changing environmental conditions, and in use of MS/MS based proteomics approach to explore the transport functions of microbial communities.

Mixing and Turbulence

SoO and APL faculty actively focus on ocean mixing, internal waves, submesoscale physics and upper ocean dynamics. Extensive technology development has been integral to these efforts, producing a range of instruments that include microstructure profilers, towed profiling vehicles, Lagrangian floats, and gliders and Argo floats equipped to measure turbulence. These technological innovations allowed sampling at the short spatial and temporal scales inherent to the mixing physics. The resulting measurements have essentially defined the ocean mixing problem, and with it the key, heretofore missing arm of the global overturning circulation. Moving up in scale, these platforms have also been used to resolve submesoscale (< 1 km) dynamics that may offer a pathway from the mesoscale to dissipation. Novel, fully Lagrangian floats that have been used to study upper ocean dynamics, tropical storms (hurricanes and typhoons) and biogeochemical processes. Air-deployable Lagrangian and EM-APEX floats provide unique, rapid-response, synoptic sampling capabilities that have been used to capture the first detailed account of the ocean's response directly beneath a hurricane.

Seafloor Venting

SoO faculty are at the forefront of research on seafloor hydrothermal activity, subduction zone venting and hydrate-driven methane seeps. Especially important are long-term integrative studies at Endeavour Segment and Axial Seamount on the Juan de Fuca Ridge efforts and the Lost City field on the Mid-Atlantic Ridge. Some major research themes include tidal forcing of seismicity and fluid flow and characterization and function of microbial ecosystem across steep gradients of temperature and chemical composition.

Experimental Fluid Dynamics

SoO is home to a variety of experimental facilities for studying fluids in the environment. Important threads include large scale simulation of circulation in a unique rotating table facility, 3-dimensional characterization of organismal movement and behavior and development of sedimentary strata. A key direction is establishing, in collaboration with Atmospheric Sciences and several engineering departments, a sustainable, well-staffed experimental facility for teaching and research.

E-Science

Several faculty members have growing collaborations with Computer Science and Engineering

and the UW E-Science Institute. These have led to important advances in computation for genomics work, visualization of model output, and the cyber infrastructure associated with the OOI. Expanding these existing collaborations and building new ones is a crucial future direction.