Review of Provisional Academic Program to Established Status

Bachelor of Science (B.S.) degree in

Marine Biology

Department of Biology
College of Natural Sciences
University of Hawai‘i at Mānoa

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Introduction

This document reviews the provisional academic program instituted as “Marine Biology” at the University of Hawai‘i at Mānoa (UHM). This program initially was administered by the Biology Program and now is part of the Department of Biology, which was formed by the merger of the Biology Program and the Department of Zoology.

The provisional Bachelor of Science in Marine Biology program was approved in 2002. The delay in proposing transfer from provisional to established status has been due to the rapid growth of this popular major, which has required ongoing adjustments of both the curriculum and the resources devoted to the program. Enrollments appear to have leveled off recently so that we can now project costs and revenues reasonably confidently. The major administrative reorganization required by the merger of the Biology Program and Department of Zoology to create the Department of Biology and the disruption caused by the renovation of Edmondson Hall and resulting temporary relocation of Biology faculty and staff also contributed to the delay in this request for established status.

Synopsis

The Marine Biology B.S. degree program has been very successful. It has proved even more attractive to students than anticipated: the number of declared majors climbed rapidly and now is around 350, accounting for more than one fourth of all majors in the Biology Department. Graduates have fared well both in the job market and in pursuing further education in marine biology, and have indicated high levels of satisfaction with the degree.

This success is easy to understand: Our island setting and the expertise of our faculty combine to provide opportunities for undergraduate study in marine biology unrivaled in the country. Readily accessible marine environments and two UHM marine laboratories provide unique opportunities for hands-on field and laboratory training in research and experimental methodologies. A long tradition of world class scientific marine research by UHM faculty contributes to an exciting learning environment.

Faculty from the UHM Departments of Biology, Botany and Microbiology contribute to the Marine Biology curriculum, providing the breadth essential to this interdisciplinary program. Through coursework and research experiences, the program provides students with a solid foundation in general biology and related fields (chemistry and mathematics), together with a rigorous upper-division curriculum focused on biology in the marine environment.

Because of its popularity the Marine Biology program also is very successful financially: the tuition generated by program – most of it from students drawn to UHM specifically by their interest in marine biology -- far exceeds the costs of providing it.
SPECIFIC POINTS FOR ASSESSMENT OF PROVISIONAL TO ESTABLISHED PROGRAMS

(1) Is the program organized to meet its objectives? (Discussion of curriculum, requirements, admissions, advising and counseling, and other aspects of the program, with reference to its objectives.)

Objectives

The primary objective of the BS degree in Marine Biology at UHM is to provide students with rigorous, high quality training in biology and a broad exposure to marine biology. This degree is intended to prepare some students for graduate training in marine biology, and also to provide preparation for other employment opportunities for students who see the BS as their terminal degree. This degree utilizes Hawaiʻi’s unique island state location and remarkable tropical marine resources to provide a challenging place-based education. Students in this degree have access to a supportive educational environment. Examples of careers and educational paths BS Marine Biology graduates pursue include:

- Graduate programs in marine biology and related disciplines
- K-12 teaching in marine biology and biology
- Employment with government, non-government and private agencies in areas including marine resource management, environmental consulting, monitoring, and aquaculture, as well as public education, outreach, and ecotourism.

Curriculum

Below is the current curriculum for a BS degree in Marine Biology.

Curriculum--Course Requirements, 2015-2016
Bachelor of Science Degree in Marine Biology
Requirements (includes Major Related): 89 - 91 credits
(All courses require a “C” Grade minimum, not “C-“)
*Overall UHM Major GPA MUST be maintained at 2.5

A. Marine Biology Core Courses (26 credits)
- BIOL 171 & 171L Introduction to Biology I & Lab (3/1)
- BIOL 172 & 172L Introduction to Biology II & Lab (3/1)
- BIOL 265 & 265L Ecology & Evolutionary Biology & Lab (3/1)
- BIOL 275 & 275L Cell & Molecular Biology & Lab (3/1)
- BIOL 301 & 301L Marine Ecology and Evolution & Lab (3/2)
- BIOL 375 & 375L Concepts of Genetics & Lab (3/2)

B. Additional Required Courses (19 credits)
• OCN 201 Science of the Sea (3)
• BOT 480 Algal Diversity and Evolution (4)
• ZOOL 475 & 475L Biology of the Invertebrates & Lab (3/2)
• MICR 401 & 401L Marine Microbiology & Lab (3/1)
• BIOL 404 Advanced Topics in Marine Biology (3)

C. Related Requirements (31-33 credits)
• MATH 215 Applied Calculus I (or 241 or 251A) (4)
• MATH 216 Applied Calculus II (or 242 or 252A) (3)
• ECON 321 (DS) Introduction to Statistics (or NREM 310, or SOCS 225) (3)
• CHEM 161 & 161L General Chemistry I & Lab (3/1)
• CHEM 162 & 162L General Chemistry II & Lab (3/1)
• CHEM 272 & 272L Organic Chemistry I & Lab (3/2)
• PHYS 151 & 151L College Physics I & Lab (or PHYS 170/L) (3/1)
• PHYS 152 & 152L College Physics II & Lab (or PHYS 272/L) (3/1)

D. Directed Research (4 credits)
• BIOL 499 Biological Problems or BIOL 403 Field Problems in Marine Biology

E. Elective Courses – (9 credits from the Approved Electives list)
• BIOL 402 Principles of Biochemistry (or BIOC 441) (4)
• BIOL 331/331L Marine Mammal Biology/Lab (3/2)
• BIOL 390 Communicating In Biological Sciences (3)
• BIOL 402 Principles of Biochemistry (or BIOC 441) (4)
• BOT 456 Plant-Animal Interactions (3)
• BOT 420 Functional Form of Plants (4 lecture / lab)
• MATH 304 Mathematical Modeling (4)
• MATH 305 Mathematical Modeling (4)
• MICR 485/485L Microbes and Their Environment/Lab (3/2)
• MICR 490/490L Animal Virology/Lab (3/2)
• OCN 310/310L Global Environmental Change/Lab (3/2)
• OCN 320 Aquatic Pollution (3)
• OCN 331 Living Resources of the Sea (3)
• OCN 450 Aquaculture Production (3)
• ZOOL 306/306L Ethology/Lab (2/1)
• ZOOL 320/320L Vertebrate Zoology/Lab (3/2)
• ZOOL 340/340L Parasitology/Lab (2/2)
• ZOOL 410 Corals and Coral Reefs (3)
• ZOOL 420 Developmental Biology (3)
• ZOOL 430/430L Animal Physiology/Lab (3/2)
• ZOOL 432 Comparative Physiology (3)
• ZOOL 439 Animal Ecology
• ZOOL 439L Animal Ecology Lab (2)
- ZOOL 465/465L General Ichthyology (3/1)
- ZOOL 466 Fisheries Science (3)
- ZOOL 467 Ecology of Fishes (3)
- ZOOL 470/470L Limnology/Lab (2/1)
- ZOOL 480 Animal Evolution (3)

Requirements

The introductory core and related-course requirements are similar to those of the BS degree in Biology. The main difference is intensive training in four additional upper-level marine biology courses that give students breadth and depth in this discipline (see below). Also, four credits in a field immersion course or directed research are required for graduation.

Two upper division courses, Marine Ecology and Evolution (BIOL 301/L) and Marine Microbiology (MICR 401/L) were developed for the Marine Biology major, to reinforce the basics of marine organismal biology, evolution, and ecology. These and other existing marine biology courses provide opportunities for independent study, creativity, and development of technical communication skills.

A field immersion course entitled Field Problems in Marine Biology (BIOL 403) provides students with an intensive learning experience in marine field settings. The site for this immersion course is at the Hawai‘i Institute of Marine Biology (HIMB) at Coconut Island in Kāne‘ohe Bay.

The capstone course, entitled Advanced Topics in Marine Biology (BIOL 404), is designed to train students in critical thinking and synthesis by presenting, discussing, and analyzing complex subjects in marine biology in an interactive, student-based, small-group format. In this course students integrate and apply the knowledge and skills they have acquired throughout the marine biology curriculum and develop and practice oral and written communication skills.

Admissions

At present there are no specific or additional requirements for admission to this major beyond the general UHM requirements.

We are considering requiring satisfactory completion of the lower-division core curriculum, including related-required courses in chemistry and mathematics, before students can declare as Marine Biology majors. This would allow us to better predict enrollments in the upper-division core courses and also would lessen the problem of some students taking a very long time to obtain the degree due to having to repeat some of the core courses. Such a change would reduce the number of Marine Biology majors, with a concomittent increase in the number of Biology majors, but should have much less of an effect on the number of Marine Biology degrees awarded, since currently students who struggle in the core and related-required
courses often switch out of the Marine Biology degree. Although the details of this plan remain to be determined, we expect to propose the program change in the coming fall semester.

Advising

Academic advising is provided by the advising office of the Department of Biology. Since summer 2014 the office has been responsible for all academic advising of Marine Biology majors, as well as Biology, Botany, Microbiology, Molecular Cell Biology, and Zoology majors. In fall 2014 the Department of Biology advising office assumed all college-level advising responsibilities from the Colleges of Arts and Sciences Student Academic Services. The advising office currently is comprised of three professional advisors (one faculty Specialist and two APTs), four Manoa Peer Advisors, and one student assistant. These advisors track the progress of these students with a focus on the 15 to finish campaign, match individual students’ academic strengths with opportunities within the curriculum, and nurture students’ intellectual and personal development. Specifically marine-focused academic and career mentoring also is provided on an individual basis by Marine Biology faculty from the Departments of Biology, Botany, and Microbiology, and through the Marine Option Program (MOP).

The Department of Biology provides other sources of student support and guidance which, while not restricted to Marine Biology students or directly part of the Marine Biology curriculum, largely serve Marine Biology students. First and foremost of these is the Marine Option Program (MOP). Participation in MOP is not required of Marine Biology majors but approximately 25% of MB students participate in MOP. MOP provides a certificate and strengthens research, internship, and job placement opportunities for MOP students. MOP has a network of faculty and offices on all UH campuses. The experiential education provided by MOP through placement of students into federal, state, and local internships and research projects provides students opportunities to acquire knowledge and skills that are not part of curricula at other universities. MOP prepares students for QUEST (Quantitative Underwater Ecological Survey Techniques) based at UH-Hilo, and MAST (Maritime Archaeology Survey Techniques) offered at UH-Mānoa. MOP also conducts courses to train students in safe boating practices through the Motorboat Operators Certification Course, and Marine Underwater Techniques with the National Marine Fisheries Service. The UH Mānoa MOP Coordinator works closely with MOP Coordinators throughout the UH system to ensure transfer students from UH-Hilo, UH-Maui College, UH-West Oahu, and the community colleges receive appropriate support upon coming to UHM.
(2) Is the program meeting its learning objectives for students? (An assessment of the quality of student learning as indicated by systematic analysis of student performance with reference to standard expectations, surveys of student satisfaction with instructional aspects of the program, etc.)

Although program Student Learning Outcomes (SLOs) were created years ago by the Department of Biology, no program-level assessment was performed until recently. In June 2012 Dr. Stephanie Kraft-Terry was hired as a Faculty Specialist to oversee advising and assessment for the Department of Biology. The program SLOs, which are for all undergraduate degrees in the department, were revised by the faculty in June 2013. Faculty then were asked at a December 2013 workshop to map how their course SLOs aligned with the program SLOs (see map below).

Undergraduate Student Learning Outcomes

**Biological Knowledge: Synthesis and Application**

Student will be able to:

1. Explain biological processes from molecules to ecosystems in an evolutionary context, including being able to use examples from Hawai‘i.

**Critical Thinking and Reasoning Skills**

Student will be able to:

2. Demonstrate scientific literacy by critically evaluating scientific evidence, identifying gaps in knowledge, and applying strong evidence-based biological arguments to real-world problems.

3. Apply the scientific method to generate new hypotheses, formulate experimental approaches and outline potential outcomes, applying appropriate logical and quantitative methods.

**Values**

Student will:

4. Demonstrate inquisitiveness regarding, and respect for, the biological world.

5. Work ethically, individually and in teams, and demonstrate respect for diversity of viewpoints.

**Communication skills**

Student will:

6. In oral and written forms, be able to communicate biological information clearly and professionally.
### B.S. Marine Biology Curriculum SLO Map (Core Courses)

<table>
<thead>
<tr>
<th>Course Number and Title</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6 (OC)</th>
<th>6 (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 171 Introduction to Biology I</td>
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<td>I</td>
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<tr>
<td>BIOL 171L Introduction to Biology I Lab</td>
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<tr>
<td>BIOL 172 Introduction to Biology II</td>
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<tr>
<td>BIOL 172L Introduction to Biology II Lab</td>
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<td>I</td>
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<td>I</td>
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<td></td>
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</tr>
<tr>
<td>BIOL 265 Ecology and Evolutionary Biology</td>
<td>R</td>
<td>I</td>
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<tr>
<td>BIOL 265L Ecology and Evolutionary Biology Lab</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
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<tr>
<td>BIOL 275 Cell and Molecular Biology</td>
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<td>R</td>
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<tr>
<td>BIOL 275L Cell and Molecular Biology Lab</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
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<tr>
<td>BIOL 301 Marine Ecology and Evolution</td>
<td>R</td>
<td>R</td>
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<td></td>
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<tr>
<td>BIOL 301L Marine Ecology and Evolution Lab</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
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<tr>
<td>BIOL 375 Concepts of Genetics</td>
<td>R</td>
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<tr>
<td>BIOL 375L Concepts of Genetics Lab</td>
<td>R</td>
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<td>R</td>
<td>R</td>
</tr>
<tr>
<td>MICR 401 Marine Microbiology</td>
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We now are assessing one or two SLOs each year and are using those results to improve the program through curricular modification. A summary of our recent assessment activities is found below.

In May 2014 the Department of Biology Curriculum Committee assessed SLO 6W (written communication). Using the Association of American Colleges and Universities (AAC&U) Values Written Communication rubric, the Curriculum Committee scored 17 writing assignments from Advanced Topics in Marine Biology (BIOL 404). The rubric assesses student writing in 5 major categories. The committee decided that 75% of the students must meet or exceed the benchmark set by the Curriculum Committee in any given area to consider the area mastered. The percentages of students that met or exceeded the benchmark were:

- Context and Purpose – 75%
- Content Development – 35%
- Genre and Disciplinary Conventions – 58%
- Sources and Evidence – 71%
- Control of Syntax and Mechanics – 35%

The Department of Biology Curriculum Committee reevaluated the core curriculum to determine what improvements could be made to ensure student were better writers by the time they reach their capstone, BIOL 404 course. The *Introduction to Biology I Laboratory* (BIOL 171L) curriculum was recently revised to emphasize basic scientific writing skills. This curriculum was implemented during Fall 2013, so it is too early to assess the effects on
performance in BIOL 404. We are confident that improvements in BIOL 171L, coupled with continued reinforcement of scientific writing skills in later laboratory courses such as Ecology and Evolutionary Biology Laboratory (BIOL 265L), which is now writing intensive, will improve student writing skills and significantly impact their assessment scores in future years. Most recently, in spring semester of 2015 the Curriculum Committee assessed SLO 1 to analyze how well students were able to link factual information together in an evolutionary context within Biology of the Invertebrates (ZOOL 475). Assignments for all eleven Marine Biology majors in the course were evaluated. In total, seven out of the eleven were able to satisfactorily complete the task. The committee required that 70%, or 8 out of the 11 must meet the benchmark for the learning outcome to be successful. Because the results fell just below the minimum acceptable outcome, we are planning to create a working group of the instructors of the relevant courses to determine how we can further incorporate these concepts throughout the curriculum to improve student learning for SLO 1.
(3) Are program resources adequate? (Analysis of the number and distribution of faculty, faculty areas of expertise, budget and sources of funds, and facilities and equipment.)

The number of Marine Biology majors has grown rapidly and now stands at about 350 students. The upper-division marine biology curriculum is served by eight core faculty from three departments as well as numerous other contributing faculty from diverse departments and colleges within UH (see table below). The large number of majors has required expansion of several lecture and lab sections in required courses as well as of opportunities for students to fulfill the research requirement, as outlined below.

Faculty and Facilities

The BS degree in Marine Biology has attracted a large number of local, US mainland and international students who are interested in studying marine biology. The number of Marine Biology majors had passed 350 by the Fall 2013 semester, and appears to have stabilized at roughly that level. This is well more than double the 160 students originally projected to be enrolled in the program’s 5th year, and is about 40% of the BS majors in the Department of Biology (including Zoology) and nearly 30% of all the majors enrolled in the Department of Biology as a whole (BS and BA students).

Instruction for these students is supported by faculty and teaching assistants from the Departments of Biology, Botany and Microbiology, instructional staff (APT) from the Department of Biology, equipment and supplies from the Department of Biology and the College of Natural Sciences (CNS), and research space and facilities on the UH Mānoa campus. Research facilities and faculty oversight of research projects were also provided by the Kewalo Marine Laboratory (PBRC), the Hawai‘i Institute of Marine Biology (SOEST), the Center for Microbial Oceanography: Research and Education (C-MORE), the College of Tropical Agriculture and Human Resources (CTAHR), and numerous other departments at UHM.

Below is a summary of the faculty resources provided for the degree and currently available to support it.

Marine Biology Teaching Faculty: Four new faculty positions were created in 2002 by CNS to teach the required courses for the Marine Biology major. These include two in the Department of Biology to teach Marine Ecology and Evolution (BIOL 301/L) and Field Problems in Marine Biology (BIOL 403), one in the Department of Botany to teach Algal Diversity and Evolution (BOT 480) and one in the Department of Microbiology to teach Marine Microbiology (MICRO 401/L). These faculty helped develop these courses and handled multiple sections of the required Marine Biology capstone course Advanced Topics in Marine Biology (BIOL 404).

Faculty currently involved with the Marine Biology undergraduate program are listed in the table below. These include the faculty who teach the four courses listed above, faculty who
teach other required and elective courses for Marine Biology majors, and additional Biology faculty with expertise in the field who contribute to teaching courses in the major.

Faculty involved in teaching courses for the Marine Biology undergraduate degree program, excluding the Biology Core Courses and Related Requirements courses.

<table>
<thead>
<tr>
<th>Name</th>
<th>Department</th>
<th>Expertise</th>
<th>Teaching Duties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(R = required course, E = elective course)</td>
</tr>
<tr>
<td><strong>Core Faculty</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. Donachie</td>
<td>Microbiology</td>
<td>Marine microbiology</td>
<td>MICR 401/L: Marine microbiology (R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>BIOL 404 (R)</td>
</tr>
<tr>
<td>M. Hixon</td>
<td>Biology</td>
<td>Marine ecology &amp; conservation biology</td>
<td>MBIO 715: Marine Conservation Biology (E for Honors students)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>BIOL 404 (R)</td>
</tr>
<tr>
<td>C. Hunter</td>
<td>Biology</td>
<td>Coral reef ecology</td>
<td>BIOL 403: Field Problems in Marine Biology (R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>BIOL 404 (R)</td>
</tr>
<tr>
<td>P. Marko</td>
<td>Biology</td>
<td>Marine ecology &amp; evolution</td>
<td>BIOL 301/L (R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>BIOL 404 (R)</td>
</tr>
<tr>
<td>A. Moran</td>
<td>Biology</td>
<td>Larval biology</td>
<td>BIOL 404 (R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ZOOL 475/L (R)</td>
</tr>
<tr>
<td>A. Sherwood</td>
<td>Botany</td>
<td>Aquatic algae</td>
<td>BIOL 404 (R)</td>
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<tr>
<td>C. Smith</td>
<td>Botany</td>
<td>Marine plant biology</td>
<td>BOT 480 (R)</td>
</tr>
<tr>
<td>L. Watling</td>
<td>Biology</td>
<td>Deep sea marine life</td>
<td>BIOL 404 (R)</td>
</tr>
<tr>
<td><strong>Contributing Faculty</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R. Alegado &amp; E. DeCarlo</td>
<td>Oceanography</td>
<td>Oceanography</td>
<td>OCN 320: Aquatic Pollution</td>
</tr>
<tr>
<td>J. Bailey-Brock</td>
<td>Biology</td>
<td>Invertebrate zoology</td>
<td>ZOOL 475: Biology of the Invertebrates (R)</td>
</tr>
<tr>
<td>K Barton</td>
<td>Botany</td>
<td>Plant biology</td>
<td>BOT 420: Functional Form of Plants (Lecture and Lab) (E)</td>
</tr>
<tr>
<td>Name</td>
<td>Department</td>
<td>Program</td>
<td>Course Description</td>
</tr>
<tr>
<td>-----------------------------</td>
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<tr>
<td>P. Bienfang</td>
<td>Oceanography</td>
<td>Oceanography</td>
<td>OCN 331: Living Resources of the Sea (E)</td>
</tr>
<tr>
<td>M. Butler</td>
<td>Biology</td>
<td>Animal evolution</td>
<td>ZOOL 430/430L: Animal Physiology and Lab (E)</td>
</tr>
<tr>
<td>K. Cole (Chair of Biology)</td>
<td>Biology</td>
<td>Ichthyology</td>
<td>ZOOL 465 &amp; 465L: General Ichthyology (E)</td>
</tr>
<tr>
<td>C. Daehler</td>
<td>Botany</td>
<td>Plant biology</td>
<td>BOT 456: Plant Animal Interactions (E)</td>
</tr>
<tr>
<td>L. Freed</td>
<td>Biology</td>
<td>Avian ecology</td>
<td>ZOOL 320/320L: Vertebrate Zoology and Lab (E)</td>
</tr>
<tr>
<td>D. Ho &amp; M. Mottl</td>
<td>Oceanography</td>
<td>Oceanography</td>
<td>OCN 310/310L: Global Environmental Change (E)</td>
</tr>
<tr>
<td>M. Lammers &amp; L. Munger</td>
<td>HIMB</td>
<td>Marine mammals</td>
<td>BIOL 331/L: Marine Mammals and Lab (E)</td>
</tr>
<tr>
<td>J. Lemus</td>
<td>HIMB</td>
<td>Marine Education</td>
<td>BIOL 390: Communication In Biological Sciences (E)</td>
</tr>
<tr>
<td>S. Malecha</td>
<td>Animal Sciences</td>
<td>Animal aquaculture</td>
<td>ANSC 450: Aquaculture Production (E)</td>
</tr>
<tr>
<td>T. Tricas</td>
<td>Biology</td>
<td>Marine animal behavior</td>
<td>ZOOL 306 &amp; 306L: Ethology (E)</td>
</tr>
<tr>
<td>R. Thompson</td>
<td>Biology</td>
<td>Evolutionary biology</td>
<td>ZOOL 480: Animal Evolution (E)</td>
</tr>
<tr>
<td>J. Walguarnery</td>
<td>Biology</td>
<td>Instructor</td>
<td>ZOOL 439: Animal Ecology (E)</td>
</tr>
<tr>
<td>L. Wilson</td>
<td>Math/PBRC</td>
<td>Math modeling</td>
<td>MATH 304: Deterministic models (E)</td>
</tr>
<tr>
<td>Y. Milenko</td>
<td>Math/PBRC</td>
<td>Math modeling</td>
<td>MATH 305: Probabilistic Models (E)</td>
</tr>
<tr>
<td>A. Castelfranco</td>
<td>Math/PBRC</td>
<td>Math modeling</td>
<td>MATH 304: Deterministic models (E)</td>
</tr>
<tr>
<td>C. Womersley</td>
<td>Biology</td>
<td>Parasitology</td>
<td>ZOOL 340/340L: Parasitology (E)</td>
</tr>
<tr>
<td>A. Wright</td>
<td>Biology</td>
<td>Ecology</td>
<td>ZOOL 439: Animal Ecology (E)</td>
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<tr>
<td>M. Yoshizawa</td>
<td>Biology</td>
<td>Developmental biology</td>
<td>ZOOL 420/420L: Developmental Biology (E)</td>
</tr>
</tbody>
</table>

**Marine Biology Faculty and Staff Resources:** The popularity of the Marine Biology major has necessitated substantial increases in the capacity of its required courses. For example, the required course **Biology of the Invertebrates** (ZOOL 475 and 475L) was previously offered with
only one lab section, limiting enrollment to 20 students per year. Since Fall 2013, however, this course has been taught every semester with multiple lab sections, tripling the annual capacity. Similarly, the capstone course (BIOL 404) now is taught each semester rather than once per year, and a third offering each year may be added as the number of Marine Biology seniors grows. The growing number of Marine Biology majors also has contributed to the demand for the core courses taken by all Biology majors, which has necessitated increases in the sections of these courses as well. These increases in instructional offerings have been accommodated by the hiring of new faculty as noted above, by shifts in the teaching assignments of other faculty, and by hiring of additional teaching assistants; these additional resources have been provided by the College of Natural Sciences.

In addition, Marine Biology majors are required to have formal research experience by completing either Field Problems in Marine Biology (BIOL 403) or four units of Directed Research (BIOL 499). The BIOL 403 course is taught only in the summer and is limited to 16 students, meaning many Marine Biology majors need to complete directed research projects (BIOL 499) to complete their research requirement. The Biology Department currently is working with faculty in related units to increase research opportunities for all our students, including Marine Biology majors, and also is considering creating an undergraduate course in Biology Research that would be offered each semester and satisfy this research requirement.

Academic advising for Marine Biology students is pooled with advising for all Biology majors and is currently adequate. A Faculty Specialist coordinates (1) the advising of majors, (2) the development of informational brochures for potential local, mainland and international students, and (3) an outreach program to engage other campuses in the UH system, and the community.

Budget

There is no explicit budget for the undergraduate Marine Biology program since it is one of several degree programs provided by the Biology Department and many of the costs are shared among these programs. How we attributed costs and revenue to the Marine Biology program is explained in the Appendix, accompanying the Academic Program Cost and Revenues Template.

The Academic Program Cost and Revenues Template shows that tuition revenue attributable to Marine Biology majors far exceeds the cost of courses specific to the major. Although the total number of Marine Biology majors appears to have stabilized, enrollments in the upper-division courses are expected to continue to increase somewhat over the next few years, as indicated in the Cost and Revenues Template. Even with the resulting increase in expenses, however, the program will continue to generate much greater revenue than expenses.
(4) Is the program efficient? (An assessment of productivity and cost/benefit considerations
within the overall context of campus and university mission and planning priorities. Include quantitative
measures comparing, for example, SSH/faculty, average class size, cost per SSH, and cost per major with
other programs in the college, on the campus, and as appropriate, similar programs on other UH
campuses.)

The Marine Biology curriculum builds upon the core curriculum of the BS Biology degree to
provide a strong foundation in the biological sciences and then expands into more marine-
specific content at the upper level. As a result, many of the core courses in the Marine Biology
curriculum are also required by the general Biology degree, along with other degrees on
campus. In total, four courses were created or upgraded for the Marine Biology undergraduate
degree: Marine Ecology and Evolution (BIOL 301/L), Algal Diversity and Evolution (BOT 480),
Marine Microbiology (MICR 401/L), and Advanced Topics in Marine Biology (BIOL 404). Of
these courses, only BIOL 404, the capstone course for the degree, is restricted to Marine Biology
majors, but Marine Biology majors comprise a majority of students enrolled in the other three
courses as well. These are the courses we accounted for when calculating our program costs.

Currently the Marine Biology degree costs (excluding fringe) are around $250,000 per year,
while the tuition revenue is over to $1.7 million. In the next few years, costs are expected to
increase slightly as retention within the major improves and enrollments in the upper-division
courses grow. With the addition of more laboratory sections, we project the need for additional
teaching assistants. More sections of the capstone course (BIOL 404) also may be needed,
increasing the faculty FTE assigned to the degree. These projections are outlined in the
Projected Years of the Academic Program Cost and Revenue Template (Appendix). When
accounting for predicted growth, the cost of the program grows to only $270,000 by the 2019-20
academic year, with revenue projected to increase to nearly $2 million. The increased number
of teaching assistants will be funded from the College while an increase in offerings of BIOL 404
will be accommodated by shifting faculty teaching assignments.

The Academic Program Cost and Revenues Template projects income and expenses out to the
2019-20 academic year. The projected instructional cost per student semester hour (SSH) during
2019-20 is $47, assuming an enrollment of 350 majors. A narrative explaining the Cost and
Revenues Template may be found in the Appendix.

The Academic Program Cost and Revenues Template provides a detailed comparison between
the undergraduate program in the College of Tropical Agriculture and Human Resources
(CTAHRR) and the undergraduate Marine Biology program. The instructional cost per student
semester hour (SSH) in Marine Biology ranges from about one-quarter to one-third that in
CTAHRR. At the lower-division level, Marine Biology majors typically take the same courses as
Biology majors, so the key efficiency measures are at the upper-division level.

As enrollment has increased, we have increased the number of upper-division laboratory course
sections in an effort to maintain a maximum enrollment per section of 20 students. The
increased cost of adding laboratory sections is largely due to adding teaching assistantships, e.g., in spring 2014 MICR 401/L doubled the number of sections that had been offered previously, and this required an additional teaching assistant. Corresponding lecture sections have grown in enrollment without increasing the number of sections. However, Advanced Topics in Marine Biology (BIOL 404) is a writing intensive course and is therefore capped at 20 students per section. For this course, the number of sections has steadily increased to accommodate increasing enrollment in the Marine Biology major. Similarly, Algal Diversity and Evolution (BOT 480/L) is also writing intensive, and has added more sections to accommodate the increased enrollment by Marine Biology majors. The increased cost of adding BIOL 404 sections arises from both increased faculty teaching time and assignment of teaching assistants to this course; the increased cost of adding BOT 480 sections is from increased numbers of teaching assistants.

At present, while resources have been strained by the larger-than-expected enrollment in the degree, the modifications to the curriculum and shifts in faculty teaching assignments described above have allowed us to meet the needs of the program. We also are actively exploring ways to make more efficient use of current resources and obtain additional resources (i.e. external funding for BIOL 403, and recruitment of additional faculty and non-UH researchers to mentor Directed Research projects). We also are considering instituting admissions requirements to the major, as described in Section (1) above, which would help us regulate and predict enrollments in the upper-division courses.
(5) **Evidence of program quality.** (A qualitative assessment of the program in relation to competing demands for resources by new programs and continuing programs. Accreditation or other external evaluation, student performance [e.g., on external exams], satisfaction, placement and employer satisfaction, awards to faculty and students, faculty publication record, evaluation of faculty, etc.)

The Department of Biology maintains a database of the activities of the 103 students who completed a BS degree in Marine Biology at UH Mānoa between 2005 and 2013. Of 49 alumni who have reported their post-graduation activities:

- **33, or 67% attended graduate school,** 24 in masters programs (all working on MS degrees except for one MEd degree) and 9 in doctoral programs (7 working on PhD degrees in Natural Sciences, and 2 on veterinary degrees). Graduate schools attended were:
  
  - California State University at Long Beach
  - Florida State University
  - Georgia Institute of Technology
  - Texas A&M
  - Tufts University
  - University of Calgary
  - University of California at Riverside
  - University of Central Florida
  - University of Colorado at Denver
  - University of Hawai‘i at Mānoa
  - University of Melbourne

- **14, or 29% were employed,** most positions being associated with marine biology. Employers included:
  
  - Alaskan Observers Inc.
  - Arbonne International Independent Consultants
  - California Academy of Sciences
  - Genoptix Medical Lab
  - Hubbs Seaworld Research Institute
  - Kamehameha Schools
  - Kona Blue Water Farms
  - Nature Conservancy
  - NOAA Fisheries Observer Program
  - NOAA Hawaiian Monk Seal Program
  - Pacific Whale Foundation
  - Professional aquarium fish collector
  - Research Corporation of the University of Hawai‘i
  - UH Maui College
  - U.S. Navy
• 1, or 2% reported being an intern at the Mote Marine Laboratory, and

• 1, or 2% reported being unemployed.

In a separate analysis, alumni were asked if they would recommend the BS Marine Biology program to someone looking for a good undergraduate education. Out of 42 responses, 35, or 83%, said yes. Limited availability of required courses was cited as the primary reason graduates would not recommend the Marine Biology program, and as discussed above, this problem has been resolved by substantially increasing the capacities of these courses. In addition, graduates referred to challenges in navigating the complex web of required courses and their necessary prerequisites, but consolidation of all advising services within the Department has lessened these problems.

When asked what former students liked most about the Department of Biology, they cited the hands-on nature of the courses, academic advising, willingness of the staff to assist them, and the willingness of the department to listen to student concerns.

Fig. 1. Summary of 74 recent graduates’ responses when asked to provide three words to best describe the Department of Biology. Word size is proportional to the number of times that word was mentioned.

In recent years, one or more of the Marine Biology graduates reported receiving the following awards or recognitions:

• ASUH Scholarship
• Dean’s List
• CNMI Scholarship
• Saipan Chamber of Commerce Award
• Kawaiahao Church Scholarship
• University of Hawai‘i Alumni Association Scholarship
• Student Success Scholarship
• Mānoa Centennial Scholarship
• Athletics Scholarship
• Chancellor’s Scholarship
• John P Craven Award
• Mānoa Scholarship
• Arts and Science, Natural Science Achievement Scholarship
• Marine Option Program–Sherwood D Maynard Award
• Mānoa Opportunity Grant
• Honors Forum – Best Oral Presentation for the Natural Sciences
• Best Undergraduate Presentation – Tester Symposium
• Best Poster – University of Hawai‘i at Mānoa Poster Conference
• ASUH Research Award
• Hubert and Mable Frings Endowed Scholarship
• Kaplan Test Prep Scholarship

In addition, one or more graduates reported participating in the following programs:
• Honors Program
• CMORE Scholars
• Phi Beta Kappa
• NSCS
• Undergraduate Research Opportunity Program
(6) Are program outcomes compatible with the objectives? (Analysis of numbers of majors, graduates, SSHs offered, service to non-majors, employment of graduates, etc., in relationship to objectives.)

Enrollment in the Marine Biology major grew rapidly initially, greatly exceeding the expected number by the fifth year, and appears to be stabilizing at around 350 students (Figure 2). During part of the most rapid increase in Marine Biology enrollment there was a slight decrease in enrollment in other majors in the department (i.e. Biology and Zoology) but the total number of students in all the degrees increased throughout this period. Enrollments in all our degrees have decreased slightly in the past year or two.

In the first years of the program problems in both retention and time to degree led to much slower growth in the number of graduates (Figure 3) than in the number of majors (Figure 2). We identified three reasons for these problems and have taken or are planning steps to resolve them, as described below. As a result the number of graduates per year has increased substantially in the last few years and times to degree now are comparable to those for the campus as a whole (Figure 3).

![Graph showing Marine Biology and Biology and Zoology majors enrollment over time](image)

**Fig. 2.** The number of Marine Biology majors has grown substantially, in absolute numbers and relative to the numbers of majors in the other Biology degrees.
The first cause of low early graduation rates was that as originally designed the degree had a large number of required courses, which created a challenging and complex path to graduation. We recently removed a number of required courses to bring the degree in line with the current University of Hawai‘i at Mānoa graduation requirements of 120 credits to graduate. Previously, the Marine Biology degree required 131 credits to graduate, when all required major and general education courses were included. To bring the degree to 120 credits, we eliminated the following required courses: Animal Ecology (ZOOL 439; eliminated starting Fall 2014), Organic Chemistry II (CHEM 273; eliminated starting Fall 2015) and Biochemistry (BIOL 402 or BIOC 441; eliminated starting Fall 2015). Animal Ecology and Biochemistry are now approved Marine Biology electives. We also decreased the number of required directed research credits from 6 to 4. In addition, we increased the number of Marine Biology elective credits from 6 to 9, to allow the students more flexibility in the courses they select so they can tailor the degree to their interests. With the decreased credit requirements and increased elective options, we believe more students will complete the degree in a timely manner.

In summary, we have streamlined the Marine Biology major by reducing the number of required credits from 131 to 119, as follows:

- mandatory advising has resulted in many students taking ECON 321 (3 credits) as their additional mathematics course, because this course also fulfills the Diversification in Social Sciences requirement, thereby reducing the number of required credits by 3;
- reducing the BIOL 499 Biological Problems requirement from 6 to 4 credits;
- moving ZOOL 439 Animal Ecology (3 credits) from required to elective status;
- removing CHEM 273 Organic Chemistry II (3 credits) as a requirement;

Fig. 3. Number of graduates with a BS in Marine Biology, with times to graduation.
• moving BIOL 402 Biochemistry (4 credits) from required to elective status; and
• increasing the number of free major electives from 6 to 9.

The second factor that affected graduation and retention rates was limited availability of required courses. We identified the primary bottlenecks and took steps to relieve them. The required course **Biology of Invertebrates** (ZOOL 475/L) was offered once a year and capped at 20 students until Fall 2013, but since then has been offered both spring and fall semesters with a total capacity of at least 78 seats per year. Also in Fall 2013, we started offering **Special Topics in Marine Biology** (BIOL 404) during both fall and spring semesters, rather than only in spring, increasing available seats from 20 to 40 per year. **Marine Microbiology Laboratory** (MICR 401L) increased to two sections for Spring 2014, will have three in 2015-16, and will continue to have a minimum of two sections in coming years. Available seats in **Algal Diversity and Evolution** (BOT 480) also have increased over time to meet demand, including a recent increase to four lab sections.

In summary, we have eliminated bottlenecks in course availability by:
• Doubling the number of offerings per year of **Advanced Topics in Marine Biology** (BIOL 404),
• Increasing capacity in **Algal Evolution and Diversity** (BOT 480) by increasing the number of lab sections and the number of students in lecture,
• Doubling, and in 2015-16 tripling, the number of lab sections in **Marine Microbiology Laboratory** (MICR 401L), and
• Nearly quadrupling the capacity of **Biology of the Invertebrates** (ZOOL 475/L).

The third cause of low retention and long times to graduation is the difficulty some biology students have in the introductory core and especially the related-required courses in mathematics and chemistry. Having to repeat any of these courses delays a student’s progress but organic chemistry is particularly problematic in this regard: it is a prerequisite for a sequence of two other required courses (BIOL 275 and BIOL 375). It is to address this problem that we are considering instituting admissions requirements to the degree as described in section (1) above, so that only students who perform satisfactorily in the core and related-required courses would be admitted into the relatively structured Marine Biology degree, with others staying in the more flexible Biology degrees.

**Service to Non-Majors**

Marine Biology courses and faculty provide services to students in the Marine Option Program (described in Question 1), approximately ¼ of whom are not Marine Biology majors.

**Employment of Graduates**

As reviewed above for Question 5, a substantial percentage of Marine Biology graduates find employment in this field.
(7) Are program objectives still appropriate functions of the college and university? (Relationship to university mission and development plans, evidence of continuing need for the program, projections of employment opportunities for graduates, etc.)

Overall, our program has been an enormous success in terms of enrollment. For example, in Fall 2013, 354 students were enrolled in the Marine Biology major, representing 28% of all Biology/Marine Biology/Zoology majors. Our major serves students from the State of Hawai‘i while attracting students from across the mainland USA and Pacific Rim.

The Marine Biology BS degree objectives and outcomes remain closely aligned and consistent with the goals, mission, and values of both the College of Natural Sciences, and the University of Hawai‘i at Mānoa, as outlined in the UH Mānoa 2011-2015 Strategic Plan.

Relationship to University Mission and Development Plans

Goal 1. A Transformative Teaching and Learning Environment

A major goal of the University of Hawai‘i at Mānoa is to “provide students with more opportunities to be active researchers/scholars in their chosen disciplines and leverage the unique opportunities offered by our place in the Hawaiian archipelago to produce individuals equipped with skills and knowledge unavailable to students at any other university in the world.” In line with the second part of this goal, the University of Hawai‘i at Mānoa is rightfully seen as an ideal location in which to gain education and research experience in the ocean sciences. Students are taught upper-level marine science courses by faculty from two colleges (CNS and SOEST), faculty who are actively engaged in research on marine organisms and systems in the Hawaiian archipelago. Thus, examples and questions from Hawaiian systems are emphasized throughout the curriculum. The core lab class in the degree program Marine Ecology and Evolution Laboratory (BIOL 301L) takes students to a variety of marine habitats where they are introduced to field sampling techniques, hypothesis testing, and experimental design; in the lab, students process samples with techniques such as PCR and DNA sequencing, and are shown how to use flow cytometry; they analyze and interpret data using statistical software packages, and present their results in written and oral forms. The complementary required botany course, Algal Diversity and Evolution (BOT 480), and Microbiology course, Marine Microbiology (401/L), expand the lecture/lab training to include important plant and microbial topics. Majors are then required to obtain 4 credits of individualized research experience under the guidance of a UH faculty member. Because of the wide range of participating faculty, facilities, and accessible marine environments, students gain unique experiential learning in Hawaiian marine biology that can be applied more broadly to marine ecosystems throughout the world.
Goal 2: A Global, Leading Research University

As one of only 33 Sea Grant universities and one of only six in the Pacific Region, the University of Hawai‘i is uniquely positioned to train students for the emerging “blue economy” that is fueled by our increasing reliance on ocean resources. All majors in the Marine Biology program engage in a meaningful, supervised research project that provides them with laboratory research and safety skills, and training for jobs in resource management, research, or higher education. Although many research projects are focused on Hawaiian ocean resources or management, providing links to the local community and job market, students have participated in research that spans the entire Indo-Pacific region and draws in collaborators and visitors from across the globe. Outstanding students have the opportunity to be rewarded by competitive research and travel funding from the UH Mānoa Undergraduate Research Opportunities Program (UROP), and are eligible to present their research at the annual Tester Symposium, organized by the Department of Biology.

Goal 3: An Engaged University

Many of the research projects completed by students in the Marine Biology major focus on Hawaiian ocean resources or management. In 2013, students in BIOL 499 (Directed Research) surveyed fish populations around O‘ahu, assessed the usefulness of sea urchins as biological controls on invasive algae, studied the accumulation of toxins in butterflyfish, and researched the acoustics of whale communication (among many other projects). In addition to students who conduct research in faculty labs on the Mānoa campus, many also work with faculty and staff at the Hawai‘i Institute of Marine Biology, Kewalo Marine Laboratory, the Bishop Museum, the Waikiki Aquarium, NOAA, the Anuenue Fisheries Research Center, and other agencies. Marine Biology majors are instilled, through coursework and research experiences, with a Hawaiian sense of place and an understanding of the importance of community-driven and locally oriented science in our state. Marine Biology faculty also sponsor students through the Native Hawaiian Science and Engineering Mentorship Program (NHSEMP), a program that places native Hawaiian undergraduate students (generally from outside our major) in labs to gain experience and interact with graduate students and faculty working in STEM fields. Despite limited funding and mentorship pressure created by our own majors having to fulfill research requirements, we value and support our partnership with NHSEMP.

Goal 4: Facilitating Excellence

The Marine Biology major provides students with a strong background in biology, the primary sciences and mathematics, and a broad exposure to marine biology, including experimental design, data management and analysis, and interpretation of results, particularly in the use and application of marine monitoring techniques. Students also gain proficiency in laboratory practices and safety, as well as oceanographic and marine biological laboratory methods and field techniques.
In meeting these goals from the University’s Strategic Plan, the Marine Biology major also meets the goals of the College of Natural Sciences (CNS). Through the rigorous scientific education and meaningful research experiences described above, the Marine Biology major is particularly aligned with the first three goals of CNS: (1) to prepare students to function in a world of rapid scientific and technological change, (2) to teach the meaning and role of scientific method and its importance to society, and (3) to prepare students for significant positions in the increasingly technological societies of Hawai‘i, the United States and the Pacific Rim.

**Evidence for Continuing Need of the Program**

While marine biology has been a popular and important field for centuries, the singular importance of ocean resources in the modern world is driving an ever-increasing need for graduates with a strong background in marine biology to work in industry, government, non-government, and private agencies, K-12 and higher education, aquaculture, marine resource management, consulting firms, analytical laboratories, ecotourism, and public education. After an initial period of very rapid growth the marine biology undergraduate program has had >200 majors every year since 2006; enrollment continues to increase, demonstrating evidence of strong continuing demand from students.

**Projections of Employment Opportunities for Graduates**

A summary of students’ post-degree activities is in Section 5 (Evidence of Program Quality), so we provide only a short summary here as evidence that our graduates succeed in obtaining jobs or being admitted to graduate schools. Overall, our graduates have done well in the job market and furthering their education and experiences in marine biology related disciplines We have information on post-graduation activities and employment from 49 recent Marine Biology graduates. A large majority (69%) of these alumni are currently in graduate school or internship programs: 24 are in Master’s programs, 9 in Doctoral programs, and one is in an internship program at a marine laboratory; 29% of our alumni are employed, mostly in marine biology related positions (e.g., NOAA, The Nature Conservancy), schools (e.g., Kamehameha Schools), museums (California Academy of Sciences), and environmental consulting firms. Only a very small percentage (2%) of respondents are unemployed or working outside of marine science. Based on these data and on the burgeoning need for marine scientists, educators, and managers, we believe employment projections are excellent.
Explanation of Academic Program Cost and Revenues Template

The Marine Biology B.S. is only one of several degrees offered by the Department of Biology, most of the courses taken by Marine Biology majors also are taken by students in other majors, and some of those courses are taught at least in part by faculty from other departments. It therefore is difficult to clearly identify costs and revenues directly attributable to the Marine Biology degree program. The approach we have adopted in order to estimate these costs and revenues is as follows:

**Costs:** We included only costs directly attributable to the four required upper-division courses: BIOL 301/L, BIOL 404, BOT 480 and MICR 401/L. On the one hand this omits costs for all the other courses the Marine Biology students take as well as the Marine Biology program’s share of general departmental costs (administration, advising, etc.). On the other hand, this attributes the entire costs of these four courses to the Marine Biology program, while students from other majors are substantial fractions of enrollment in all of the courses but BIOL 404.

**Revenues:** We calculated, for each year, what fraction of students enrolled in all the majors offered by the Department of Biology (Biology and Zoology BA and BS degrees as well as the Marine Biology BS) were Marine Biology majors. We then assumed Marine Biology majors accounted for this same fraction of the Department’s total SSH (row B of the Template) and resulting tuition revenue (row G of the Template).

**Explanation of specific components of the Template:**

A. Total students declared Marine Biology in fall of that academic year.
B. Total undergraduate SSH for ZOOL and BIOL courses multiplied by the proportion of undergraduate students in the Department of Biology that were Marine Biology.

\[
\text{Annual SSH} = (\text{SSH ZOOL} + \text{SSH BIOL}) \times \frac{\# \text{ MB Students}}{\# \text{ ZOOL+BIOL+MB Students}}
\]

C. Estimated 1.0 FTE Faculty salary without fringe at $100,000
   a. Faculty FTE for teaching contribution for BIOL 301, MICR 401, BOT 480, and BIOL 404 (1 course, 1 semester=0.25 FTE)
   b. No part time lecturers hired for the above stated courses.
D. Other personal costs
   a. TA salaries; calculated using current (2014) step 6, 9 month salary (1 semester course=0.25FTE)
E. Unique Program Costs: lab costs for BIOL 301L, MICR 401L, BOT 480
H. Other revenue: lab fees
**Historical and Projected Costs:**

*Faculty*

Through the early years of the program each of the four required upper-division courses was offered once per year, with two instructors for BIOL 404 and one each for the other three courses, for a total of 1.25 FTE. The faculty required for BIOL 301/L and BOT 480 have not changed and are not expected to do so.

Since 2013-14, BIOL 404 has been offered both semesters. In 2013-14 this added 0.5 faculty FTE. Starting in Spring 2015 we began providing a TA for BIOL 404 in place of one of the instructors, reducing the course back to 0.5 faculty FTE per year. We anticipate needing a third section of BIOL 404 beginning in 2016-17, requiring 0.25 additional faculty FTE.

MICR 401/L will be offered in both semesters of this academic year (2015-16), as a one-time addition to eliminate a backlog of students needing the course. This will add 0.25 faculty FTE for the year.

*Teaching Assistants*

Initially there was one teaching assistant per year for MICR 401L, two for BIOL 301L, and three for BOT 480, for a total of six. One additional teaching assistant has been added to each course as the number of lab sections has increased, so that the current and projected number of teaching assistants for these courses is nine; the one-time addition of a section of MICR 401L this year (2015-16) will require one more teaching assistant.

BIOL 404, which does not have a laboratory, initially did not have teaching assistants. We have recently decided to assign an experienced teaching assistant to this course so that it only one faculty instructor will be required per section, while retaining the heavy grading workload required for this course’s Writing Intensive designation. This added one teaching assistant in 2014-15 and is expected to add one more in 2015-16 and possibly a third beginning in 2016-17.

*Laboratories*

The laboratory costs in two of the three required upper-division courses with laboratories have increased with increasing enrollment, the exception being BOT 480, the costs of which were relatively unchanged despite steep increases in enrollment. We expect enrollments in these courses to increase slightly over the next few years and then to level off, with costs only moderately greater than at present.