**PROPOSAL**

*Bachelor of Science in Marine Science*

**School/College and Department/Unit:** UH Hilo Marine Science Department, Natural Sciences Division, College of Arts and Sciences

**Program Category:** New

**Level of Program or Major:** Undergraduate

**Degree or Certificate Proposed:** Bachelor of Science (B.S.) in Marine Science

**Proposed Date of Implementation:** Fall semester 2008 (for catalog)

**Brief Description:** Marine Science, which currently offers a B.A., proposes to offer two well-rounded and multi-disciplinary degree programs, a B.A. and a B.S., both of which have been carefully designed to take full advantage of the unique variety of marine environments available for study around the island of Hawai‘i. In both the B.A. and B.S. degrees, introductory lecture and laboratory courses in general oceanography and marine biology are followed by intermediate level courses in marine ecology, marine sampling and analytical methods, and statistical applications in marine science. The B.S. degree provides a more comprehensive background in the natural sciences than the B.A. degree, including upper level required courses in the focal areas of Marine Biology, Marine Ecology and Oceanography. The sole capstone course for the B.S. degree is Senior Thesis, in which a student designs and carries out a one-year research project, mentored by a faculty member in the department.
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Objectives of the Marine Science Degree Programs

Mission Statement
The mission of the undergraduate degree programs in Marine Science is to provide students with a comprehensive understanding of the world’s oceans, and an appreciation of the importance of marine ecosystems to the global environment and human life, through a combination of hands-on laboratory and field experience, inquiry-based instruction and direct interactive learning. This is supported by a broad background in the marine sciences, including basic knowledge of the natural science disciplines of biology, chemistry, physics, geology, and mathematics.

Content Goals
Students in both B.A and B.S. programs will be provided with a solid background in:

- The primary sciences and mathematics, including proficiency in biology, chemistry, physics, calculus, computer applications related to the natural sciences, and laboratory techniques;
- Marine science, including proficiency in marine biology, oceanography, and marine ecology; and
- Advanced multidisciplinary undergraduate training in their choice of a variety of focal areas, including but not limited to geography, geology, biology, ecology, oceanography, fisheries and aquaculture.

General Goals
Students in both B.A and B.S. programs will be provided with knowledge of and experience in:

- The scientific method and critical thinking, including the ability to design and carry out an inquiry-based research or internship project, analyze primary scientific literature, write a scientific proposal, and write a research paper or compile a portfolio; and
- Scientific presentations and discussion, including the ability to formally present a science project and discuss scientific issues

Technical Goals
Students in both B.A and B.S. programs will be provided with an understanding of and proficiency in:

- Laboratory practices and safety;
- Oceanographic and marine biological laboratory methods and field techniques;
- The use and application of biostatistical and microcomputer techniques; and
- Experimental design, data management and analysis, and interpretation of results, particularly in the use and application of marine monitoring techniques.
Relationship of Program Objectives to the Mission of the College and University

Justification for the new B.S. Program
The new B.S. degree in Marine Science was proposed because of the increasing number of students in the B.A. in Marine Science Degree program who wish to continue their education in graduate school. This was inspired in part by the changes in University academic programs, including new graduate programs, such as the Master’s program in Tropical Conservation Biology and Environmental Sciences, in which some of our graduates have enrolled.

Marine Sciences at the University of Hawai‘i at Hilo has always been a strong draw for students, and the University is well placed to offer a broad-based program in Marine Sciences. Presently, we offer a B.A. degree, which has worked well for a wide diversity of students interested primarily in entering the work force directly after earning their degree. Over the years, we have increased the rigor of the degree program, in order to help the students who want to pursue graduate studies. In doing so, we have tried to serve many needs with one degree program. It has been increasingly obvious that a one-degree-fits-all program, especially with one as broad-based as Marine Science, does not address all the need of the students. So, we propose to split the current Marine Science Degree program into a new B.S. degree and a modified B.A. degree, so that both these degree programs can be better tailored to the students they serve. The new B.S. degree, similar to other programs in the Natural Sciences, is tailored to include all of the courses (e.g., the full year each of Chemistry, Physics, Calculus, as well as Biology, Statistics, Organic Chemistry, plus the basic Oceanography courses and Methodological courses) needed by a student approaching graduate studies in the Marine Sciences, either here, at UH Manoa, or elsewhere. In proposing this degree, we are then modifying our existing B.A. degree to better serve the broader base of students, including local students and Pacific Islanders, as the university’s mission requires.

Relationship to the Mission of the College of Arts and Sciences
“The purpose of the College of Arts and Sciences is to provide quality education in the liberal arts and sciences, as well as a select group of high quality professional and pre-professional programs” (http://www.uhh.hawaii.edu/academics/cas/cas_philosophy.php accessed 12 June 2007). The proposed B.S. degree in Marine Science will satisfy this purpose as a quality pre-professional program focused in the marine sciences.

Relationship to UH Hilo’s Strategic Plan
One of the primary goals of the University of Hawai‘i at Hilo (http://www.uhh.hawaii.edu/uhh/strategic/goals.php, accessed 12 June 2007) is to “distinguish ourselves by taking full advantage of the extraordinary natural environment and cultural diversity afforded by our island setting”. A second goal is to “offer high quality undergraduate liberal arts and professional programs”. The proposed B.S. degree in Marine Science will satisfy both of these goals, as a quality baccalaureate program focused on education about the marine environment surrounding the Hawaiian Islands. Specifically, this new program will act as a pre-professional program enabling students to receive training necessary for graduate programs at UH Hilo, UH Manoa, or elsewhere. The Marine Science program overall relies on a balance of theoretical and empirical training to achieve its goals, thus students in the program are given a
multitude of opportunities in their required and elective courses to use the local marine environment as a ‘learning laboratory’. Finally, the new program will require that students finish their degree with an independent research project (a two-semester senior thesis), which will allow them to apply the knowledge and skills they have learned during their coursework in a research project with a faculty mentor.

*Relationship to the University of Hawai’i System Strategic Plan*

One of the basic goals of the UH system strategic plan (http://www.hawaii.edu/ovppp/stratplan/UHstratplan.pdf accessed 12 June 2007) is “to excel in basic and applied research for the discovery and dissemination of new knowledge”. The proposed degree in marine science contributes directly to this goal by training undergraduates in marine science to carry out scientific research. These students will be well prepared to contribute to our next generation of research scientists. The proposed degree program will build on existing research strengths at the University of Hawai‘i at Hilo, and capitalize on Hawaii’s natural systems.
Program Description

Marine Science will offer two well-rounded and multi-disciplinary degree programs, a B.A. and a B.S., both of which have been designed to take full advantage of the unique variety of marine environments around the island of Hawai‘i. In both B.A. and B.S. degrees, introductory lecture and laboratory courses in oceanography and marine biology are followed by intermediate level courses in marine ecology and evolution, marine sampling and analytical methods, and statistical applications in marine science. The B.S. degree provides a more comprehensive background in the sciences, including organic chemistry, calculus, and physics courses not required for the modified B.A., and upper level required courses in the focal areas of marine biology, marine ecology and oceanography. The sole capstone course for the B.S. degree is the Senior Thesis, in which a student designs and carries out a one-year marine research project, mentored by a faculty member.

The Marine Science Major: B.S. Option

To earn a B.S. in Marine Science, students must complete all requirements outlined in 1-3 below, and also meet all of the University’s other baccalaureate degree requirements. Students must obtain a minimum grade of C in all required courses and prerequisite courses.

1. Required Courses from Marine Science (34 semester hours)
   - MARE 171-171L (4) Marine Biology
   - MARE 201-201L (5) Oceanography
   - MARE 250 (3) Statistical Applications in Marine Science
   - MARE 265 (3) Marine Ecology and Evolution
   - MARE 350 (4) or Coastal Methods and Analyses
     - MARE 353 (4) Pelagic Methods and Analyses
   - MARE 425 (3) Chemical Oceanography
   - MARE 440 (3) Physical Oceanography
   - MARE 461 (3) Geological Oceanography
   - MARE 470 (3) Senior Thesis Research
   - MARE 471 (3) Senior Thesis Report

2. Required Courses from Related Fields (48 semester hours)
   - BIOL 125 (3) Introduction to Cell and Molecular Biology
   - CHEM 124-124D-124L, 125-125D-125L (10) General Chemistry I, II
   - GEOL 111 (3) Understanding the Earth
   - PHYS 170-170L, 171-171L (10) General Physics I, II
   - MATH 205, 206 (8) Calculus I, II
   - COM 251 (3) Public Speaking
   - ENG 225 (3) Writing for Science and Technology
3. Electives: Choose 9 semester hours from the following courses (6 credits must be MARE 300-400 courses)

MARE 264 (3) Quantitative Underwater Ecological Survey Techniques (QUEST)
MARE 282 (3) Global Change
MARE 310 (3) The Atoll Ecosystem
MARE 325 (3) Coral Reef Ecology
MARE 350 (4) Coastal Methods and Analyses
MARE 353 (4) Pelagic Methods and Analyses
MARE 360 (3) Marine Resources
MARE 364 (3) Advanced QUEST
MARE 366 (3) Tropical Marine Research Investigations
MARE 371 (3) Biology of Marine Invertebrates
MARE 371L (1) Biology of Marine Invertebrates Lab
MARE 372 (3) Biology of Marine Plants
MARE 372L (1) Biology of Marine Plants Lab
MARE 390 (3) Biology of Marine Mammals
MARE 390L (1) Biology of Marine Mammals Lab
MARE 394A-Z (1-3) Special Topics in Marine Science
MARE 400 (4) Aquacultural Engineering
MARE 434 (3) Teaching Marine Science (usually taught as WI)
MARE 435 (3) Marine Field Experience for Teachers
MARE 444 (3) Biological Oceanography
MARE 460 (3) Marine Conservation
MARE 465 (3) Marine Molecular Ecology
MARE 484 (3) Biology of Fishes
MARE 484L (1) Biology of Fishes Lab
MARE 490 (3) Marine Reptile Conservation and Ecology
MARE 490L (1) Marine Reptile Conservation and Ecology Lab
MARE 494A-Z (1-3) Special Topics in Marine Science
ECON 380 (3) Natural Resource and Environmental Economics
GEOG 340 (3) Principles of Land Use Planning
GEOG 440 (3) Advanced Environmental Planning
GEOG 470 (3) Remote Sensing and Air Photo Interpretation
GEOG 480 (3) Geographic Information Systems and Computer Mapping
POLS 335 (3) Environmental Politics and Policy

In order to make timely progress toward graduation, students are urged to pay careful attention to all degree requirements. When planning a schedule of courses, it is imperative that students be aware of course prerequisites and the frequency with which courses are offered, information that is available for each course in the listing at the back of this catalog. To ensure progress toward degree completion, students are strongly encouraged to meet with an advisor each semester before registering.
Comparison of B.A. (modified) and B.S. degree requirements in Marine Science

R = required, E = elective, NC = not in curriculum

R\textsuperscript{a} For B.A. = only one of the three listed options must be taken
R\textsuperscript{b} For BA = students must take either MATH 115 or MATH 205
\textsuperscript{c} If student chooses MARE 480 or 495 as their capstone course, they are required to take 3 additional MARE credits at the 300-400 level

<table>
<thead>
<tr>
<th>Courses</th>
<th>Credits</th>
<th>B.A.</th>
<th>B.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARE 171-171L</td>
<td>4</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>MARE 201-201L</td>
<td>5</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>MARE 250</td>
<td>3</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>MARE 265</td>
<td>3</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>MARE 282</td>
<td>3</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>MARE 350 or 353</td>
<td>4</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>MARE 425</td>
<td>3</td>
<td>E</td>
<td>R</td>
</tr>
<tr>
<td>MARE 440</td>
<td>3</td>
<td>E</td>
<td>R</td>
</tr>
<tr>
<td>MARE 461</td>
<td>3</td>
<td>E</td>
<td>R</td>
</tr>
<tr>
<td>MARE 470 and 471 (both WI)</td>
<td>6</td>
<td>R\textsuperscript{a}</td>
<td>R</td>
</tr>
<tr>
<td>MARE 480 (WI)</td>
<td>3</td>
<td>R\textsuperscript{a}</td>
<td>NC</td>
</tr>
<tr>
<td>MARE 495</td>
<td>3</td>
<td>R\textsuperscript{a}</td>
<td>NC</td>
</tr>
<tr>
<td>BIOL 125</td>
<td>3</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>CHEM 124/124D/124L</td>
<td>5</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>CHEM 125/125D/125L</td>
<td>5</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>CHEM 241/241L</td>
<td>4</td>
<td>NC</td>
<td>R</td>
</tr>
<tr>
<td>CHEM 242/242L</td>
<td>4</td>
<td>NC</td>
<td>R</td>
</tr>
<tr>
<td>MATH 115</td>
<td>3</td>
<td>R\textsuperscript{b}</td>
<td>NC</td>
</tr>
<tr>
<td>MATH 205</td>
<td>4</td>
<td>R\textsuperscript{b}</td>
<td>R</td>
</tr>
<tr>
<td>MATH 206</td>
<td>4</td>
<td>NC</td>
<td>R</td>
</tr>
<tr>
<td>PHYS 106/170L</td>
<td>4</td>
<td>R</td>
<td>NC</td>
</tr>
<tr>
<td>PHYS 170/170L</td>
<td>5</td>
<td>NC</td>
<td>R</td>
</tr>
<tr>
<td>PHYS 171/171L</td>
<td>5</td>
<td>NC</td>
<td>R</td>
</tr>
<tr>
<td>GEOL 111</td>
<td>3</td>
<td>NC</td>
<td>R</td>
</tr>
<tr>
<td>COM 251</td>
<td>3</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>CS 102</td>
<td>3</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>ENG 225 (WI)</td>
<td>3</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>MARE electives</td>
<td>9 or 12\textsuperscript{c}</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Electives approved from other departments</td>
<td>9</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Total credits for degree programs</strong></td>
<td><strong>72 to 76</strong></td>
<td><strong>91</strong></td>
<td></td>
</tr>
<tr>
<td>Writing intensive courses from Marine Science (expected):</td>
<td>(2 or 3)</td>
<td>(3)</td>
<td></td>
</tr>
<tr>
<td><strong>General Education Requirements</strong> (without the Natural Science area requirements, which are met by the Marine Science degree requirements)</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td><strong>Hawaiian/ Asian/ Pacific Requirement</strong></td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total (120 required)</strong></td>
<td><strong>105-109</strong></td>
<td><strong>124</strong></td>
<td></td>
</tr>
</tbody>
</table>
Student Demand

The Intended Student Population
The B.S. degree in Marine Science was proposed in part to increase student retention and to make the degree programs in Marine Science appealing to a broader diversity of students than we presently serve. We hope to achieve this by better serving our students’ great diversity of career interests than we presently do with our B.A. degree. The B.S. degree, similar to other programs in the Natural Sciences, is tailored to include all of the courses needed by a student approaching graduate studies in the Marine Sciences. The students this program will serve are primarily those interested in teaching high school marine science, or in research careers in academia, local, state, or federal government.

In proposing the B.S. degree, we are modifying our existing B.A. degree program to give it a broader appeal, flexibility, and applicability. It will have fewer required courses, and a greater diversity of electives from across the university curricula. This restructured degree program will allow students to better optimize their degree to suit their job/career objectives.

Evidence of Student Interest
Interest among current Marine Science students for a B.S. degree in Marine Science is very high. This is not surprising because we developed the degree partly in response to student demand. A poll of undergraduate students in Marine Science classes resulted in 76 responses. Of these, over 60% of the students responding were potentially interested in attending graduate school. Interestingly, an even higher number (almost 83%) reported that they were potentially interested in enrolling in a B.S. degree. Most of the students who professed an interest in graduate education had not yet decided what area they wanted to pursue.

Survey demographics:

<table>
<thead>
<tr>
<th>Interest</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshmen</td>
<td>18</td>
<td>23.7</td>
</tr>
<tr>
<td>Sophomores</td>
<td>13</td>
<td>17.1</td>
</tr>
<tr>
<td>Juniors</td>
<td>26</td>
<td>34.2</td>
</tr>
<tr>
<td>Seniors</td>
<td>19</td>
<td>25.0</td>
</tr>
<tr>
<td>Total</td>
<td>76</td>
<td></td>
</tr>
</tbody>
</table>

Are you interested in going to graduate school?

<table>
<thead>
<tr>
<th>Interest</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>45</td>
<td>59.2</td>
</tr>
<tr>
<td>Later</td>
<td>3</td>
<td>3.9</td>
</tr>
<tr>
<td>Maybe</td>
<td>12</td>
<td>15.8</td>
</tr>
<tr>
<td>No</td>
<td>16</td>
<td>21.1</td>
</tr>
<tr>
<td>Total</td>
<td>76</td>
<td></td>
</tr>
</tbody>
</table>
If you were starting college now, would you be interested in the B.S. program in Marine Science?

<table>
<thead>
<tr>
<th>Interest</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>59</td>
<td>77.6</td>
</tr>
<tr>
<td>Maybe</td>
<td>4</td>
<td>5.3</td>
</tr>
<tr>
<td>No</td>
<td>13</td>
<td>17.1</td>
</tr>
<tr>
<td>Total</td>
<td>76</td>
<td></td>
</tr>
</tbody>
</table>

In what area? Some students gave two answers and are counted twice, and many left this blank.

<table>
<thead>
<tr>
<th>Area</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine Science</td>
<td>10</td>
</tr>
<tr>
<td>Marine Biology</td>
<td>10</td>
</tr>
<tr>
<td>Conservation/ Resource Management</td>
<td>3</td>
</tr>
<tr>
<td>Oceanography</td>
<td>2</td>
</tr>
<tr>
<td>Education</td>
<td>2</td>
</tr>
<tr>
<td>Marine Mammal Behavior/ Physiology</td>
<td>2</td>
</tr>
<tr>
<td>Marine Geology</td>
<td>1</td>
</tr>
<tr>
<td>Physics</td>
<td>1</td>
</tr>
<tr>
<td>Deep Sea Archaeology</td>
<td>1</td>
</tr>
<tr>
<td>Marine Vertebrate Biology</td>
<td>1</td>
</tr>
<tr>
<td>Ecology</td>
<td>1</td>
</tr>
<tr>
<td>Aquaculture</td>
<td>1</td>
</tr>
<tr>
<td>Medical School</td>
<td>2</td>
</tr>
<tr>
<td>Hotel Management</td>
<td>1</td>
</tr>
<tr>
<td>Political Science</td>
<td>1</td>
</tr>
<tr>
<td>Not sure</td>
<td>12</td>
</tr>
<tr>
<td>Total responses</td>
<td>47</td>
</tr>
</tbody>
</table>

**Careers of Marine Science Graduates**

We have data from a number of students who have graduated with B.A. degrees in Marine Science, and have collated these data to get an indication of what our students do after graduation. Of 141 students, at least 47 (33%) of them have continued their education in graduate school, almost all in Master’s Programs. The careers of our B.A. graduates are incredibly diverse (see Appendix 1). The proposed B.S. degree is expected to increase the success and the number of students continuing in graduate school, especially those desiring Ph.D. degrees, and to allow them to enter careers in academia or government research positions.
Resource Requirements

New courses
No new courses are proposed for the B.S. degree.

Faculty
The new B.S. degree primarily represents a restructuring of the Marine Science degree programs. All courses required for the B.S. degree are currently being taught by UH Hilo faculty. No new faculty or other personnel will be required to meet the needs of this degree program.

Library resources
No additional library resources are needed for the B.S. degree. The Marine Science programs overall are heavily dependent upon the Mookini Library’s access to full text electronic journal databases (such as Science Direct, BioOne and JSTOR), and electronic indexes, such as Biological Abstracts and Oceanic Abstracts. UHH lacks access to many important Science journals and indexes (e.g., Science Citation Index and Web of Science), but that is not a limitation unique to the proposed degree program.

Physical resources
No new facilities or equipment will be required over what is currently available for the existing courses.

Administrative Support
No additional administrative support is required for the proposed program.

Estimate of additional position counts and budget implementation for first five years of the program
N/A

Total cost of new resources
No additional funds will be needed for this degree program unless there is a dramatic increase in student enrollment.
Projected enrollment

Enrollment data from the UHH Biology and Geology programs were obtained to suggest a basis for the proportion of Bachelor of Science majors in the Marine Science Degree Programs, and trends in enrollment. Since fall 2003, students enrolled in the Biology B.S. program have comprised between 50% and 68% of Biology’s total enrollment, and students in the B.S. program have comprised a much higher proportion of Geology’s enrollment (see graphs below). Many students in the Biology B.S. program may be planning to enter Pre-Medical programs, which is not the case for Marine Science. We anticipate the proportion of Marine Science majors enrolled in the B.S. will be somewhat lower than in Biology’s B.S. program at equilibrium, no more than 50% of our total headcount. Conservatively, we estimate that the degree program will constitute 30% of Marine Science majors at its inception, and will increase up to 50% of the program majors over the course of five years. Our Fall 2006 total enrollment is 218 students, and enrollment has oscillated between 202 and 226 since 2000/2001. Total enrollment may increase due to degree restructuring (Geology’s head count increased, then decreased again after starting their B.A. program). We are conservatively projecting an overall 1.035% increase at this time in the SSH calculations, which are calculated for the entire Marine Science program. Given a current enrollment of 218, 65 students are projected for the first year, with increases of 5% of the department head count per year after that.
**Estimated tuition revenue**

Revenues generated by Marine Science are typically high because many of the program’s students are from out of state. We expect that additional tuition revenue may be generated from new students entering Marine Science or increased retention in Marine Science, because of the new and modified degree programs.

**Costs associated with the resources noted above**

No new resources are needed, so there are no new costs.

**Budget**

No new funds are required for this proposed degree, and a flat budget situation should not interfere with the department’s ability to offer this new degree program.
### Academic Program Cost and Revenues Template

**ENTER VALUES IN HIGHLIGHTED CELLS ONLY**

**CAMPUS/Program**

<table>
<thead>
<tr>
<th>Proposed B.S., Marine Science</th>
</tr>
</thead>
</table>

**ENTER ACADEMIC YEAR (i.e., 2004-05)**

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
</table>

**Students & SSH**

| A. Total headcount enrollment (B.S. Program) | 218 (65) | 226 (79) | 234 (94) | 242 (109) | 251 (125) |
| B. Annual SSH | 2,728 | 2,823 | 2,921 | 3,023 | 3,129 |

**Direct and Incremental Program Costs**

| C. Instructional Cost without Fringe | $510,942 | $556,927 | $612,619 | $765,774 | $730,384 |
| C1. Number (FTE) of FT Faculty/Lecturers | 8 | 8 | 8 | 8 | 8 |
| C2. Number (FTE) of PT Lecturers | 1 | 1 | 1 | 1 | 1 |
| D. Other Personnel Costs | $12,082 | $13,169 | $13,290 | $16,462 | $16,462 |
| E. Unique Program Costs | $11,462 | $12,494 | $12,608 | $15,617 | $15,617 |
| F. Total Direct and Incremental Costs | $534,486 | $582,590 | $638,518 | $797,853 | $762,463 |

**Revenue**

| G. Tuition | $635,624 | $790,440 | $981,456 | $1,218,269 | $1,514,436 |
| Tuition rate per credit | $233 | $280 | $336 | $403 | $484 |
| H. Other | |
| I. Total Revenue | $635,624 | $790,440 | $981,456 | $1,218,269 | $1,514,436 |

**J. Net Cost (Revenue)**

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
</table>

**Comparable Cost per SSH**

**Program Cost per SSH**

<table>
<thead>
<tr>
<th></th>
<th>$157</th>
<th>$165</th>
<th>$175</th>
<th>$212</th>
<th>$205</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1. Total Salary FT Faculty/Lecturers</td>
<td>$561,492</td>
<td>$612,026</td>
<td>$673,229</td>
<td>$841,536</td>
<td>$841,536</td>
</tr>
<tr>
<td>K2. Cost Including Fringe of K1</td>
<td>$758,014</td>
<td>$826,235</td>
<td>$908,859</td>
<td>$1,136,074</td>
<td>$1,136,074</td>
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<tr>
<td>K3. Total Salary PT Lecturers</td>
<td>$69,630</td>
<td>$75,897</td>
<td>$83,486</td>
<td>$104,358</td>
<td>$104,358</td>
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<tr>
<td>K4. Cost Including fringe of K3</td>
<td>$73,112</td>
<td>$79,692</td>
<td>$87,661</td>
<td>$109,576</td>
<td>$109,576</td>
</tr>
<tr>
<td>K5. Annual Comparable SSH</td>
<td>5,307</td>
<td>5,493</td>
<td>5,685</td>
<td>5,884</td>
<td>6,090</td>
</tr>
<tr>
<td>L. Support Cost/SSH</td>
<td>$262</td>
<td>$262</td>
<td>$262</td>
<td>$262</td>
<td>$262</td>
</tr>
<tr>
<td>Non-Instructional Exp/SSH</td>
<td>$227</td>
<td>$227</td>
<td>$227</td>
<td>$227</td>
<td>$227</td>
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<tr>
<td>System-wide Support/SSH</td>
<td>$35</td>
<td>$35</td>
<td>$35</td>
<td>$35</td>
<td>$35</td>
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<tr>
<td>Organized Research/SSH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. Total Program Cost/SSH</td>
<td>$419</td>
<td>$427</td>
<td>$437</td>
<td>$474</td>
<td>$467</td>
</tr>
<tr>
<td>N. Total Campus Expenditure/SSH</td>
<td>$366</td>
<td></td>
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</tbody>
</table>

**Instruction Cost with Fringe per SSH**

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<th></th>
<th>$265</th>
<th>$279</th>
<th>$295</th>
<th>$356</th>
<th>$344</th>
</tr>
</thead>
<tbody>
<tr>
<td>K. Instructional Cost/SSH (w/o fringe)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O. Comparable Cost/SSH (with fringe)</td>
<td>$157</td>
<td>$165</td>
<td>$175</td>
<td>$212</td>
<td>$205</td>
</tr>
</tbody>
</table>

**Program used for comparison:**

- Biology
Impact on current courses or programs

Marine Science Department will continue to offer the B.A. degree in its proposed modified form. While some students currently enrolled in the B.A. in Marine Science will transfer to the B.S. degree, the combination of the two bachelor degrees will expand the options and fill in currently vacant niches in our undergraduate education (see Program Justification above).

The primary impact on other programs will be to change the numbers of Marine Science students in courses offered by other programs (e.g., more students will be taking Geology 111 and Organic Chemistry, which are not required in our existing B.A. degree). This may be relatively minor; even though we project a large number of majors in the program, there are relatively few differences between the B.A. and B.S. programs until the students become second semester sophomores or juniors and sign up for Organic Chemistry. In cases where changes to the degree programs are expected to result in changing enrollment patterns outside Marine Science, we have contacted these departments to help them prepare for the expected numbers.
Student Learning and Assessment (from our recent Program Review)

Departmental learning objectives are stated with the department’s Mission Statement as Content Goals, General Goals, and Technical Goals (See Mission Statement). Some of the learning objectives are addressed and assessed in specific courses; for example, “Proficiency in the use and applications of biostatistical techniques” is the focus of Statistical Applications in Marine Science (MARE 250). The final grade in this course is a measure of the student’s learning and mastery of this learning objective. Other departmental learning objectives are integral to courses throughout the marine science curricula, i.e., “Ability to analyze primary scientific literature or presentations.” The aim of the capstone courses is to provide a cumulative measure of the departmental learning objectives.

The diversity of fields of study within marine science requires great variety in teaching approaches; however, “active learning” and “hands-on” are the watchwords for most courses in this department, whether lecture or lab-based. In typical lower-division lecture courses, faculty use group discussions, “hot topic” articles, organism charades, in-class demonstrations, debates, videos, and guest speakers, to augment the lecture format. In the labs that accompany these courses, units or activities are centered around specific learning objectives and their application, (e.g. “the ability to calculate the diameter of the field of view on a compound microscope and estimate the size in μm of a microscopic organism”; “the ability to interpret a phase change diagram for water in terms of latent heat”). These courses include activities that develop the students’ power of observation in the classroom, aboard ship, in the intertidal zone, and often underwater with masks and snorkels.

In upper-division lecture courses, faculty use discussions, group and individual projects, group critiques, primary literature readings, reaction papers, oral presentations, and journals to provide a variety of learning opportunities. In the Marine Invertebrates courses (MARE 371 and 371L), students keep an Invertebrate-Watcher’s List, much like a bird watcher’s life list: what species they see, description, when, where, how many, behavior, etc. In Marine Plants (MARE 372 and 372L), in addition to traditional lectures and labs, students collect and identify field specimens for their personal herbaria, prepare a meal of seaweed dishes, and work in groups on a different marine plant research topic each semester, i.e., Bioactive Compounds in Hawaiian Seaweed Extracts, Culture Conditions for Growth of Local Seaweeds, Analysis of Seaweeds on Turtle Foraging Reefs and in Turtle Stomach Contents, etc. In the two Marine Monitoring courses (MARE 350 and 353), most learning is hands-on and project-based. Students design experiments, collect data, analyze samples, statistically analyze the results, write papers in scientific manuscript-style, and give oral presentations. This independent project-based approach is continued in the capstone courses: Senior Thesis (MARE 470 and 471), Senior Internship (MARE 480), and Senior Seminar (MARE 495A and B). In Senior Thesis and Senior Internship, students begin with proposal writing for their individual project, read and review the pertinent literature, carry out the project, interpret the results, write scientific papers or compile portfolios, and present their work orally. In all three capstone courses, reading and understanding primary literature is emphasized, and career-oriented writing skills are developed.
Student products in marine science courses are as varied as the topics and teaching approaches. Faculty members assess student learning through traditional means: exams, quizzes, term papers, write-ups of assigned readings, lab worksheets and lab practicals, as well as through discussions, oral presentations, problem sets, journals, and concept diagrams (e.g. food web drawings). Class attendance is used as a grading criterion in some courses, especially labs. Some faculty members check and reward attendance by using in-class worksheets to accompany in-class videos or other in-class activities in lecture classes. Scientific-format papers are used to assess student learning in several courses: a scientific review paper in MARE 171, statistical analyses papers in MARE 250, group project papers in MARE 350 and MARE 353, term papers in MARE 372, and the individual thesis in MARE 471. In writing intensive courses, such as Senior Thesis (MARE 470 & 471), and Senior Internship (MARE 480), students submit several types of written work: draft proposals, re-written proposals, progress reports, abstracts, résumés, cover letters, reaction papers, journals, draft and final theses (in scientific style), or internship portfolios. In Teaching Marine Science (MARE 434), which is also a writing intensive course, student products include lesson plans, an application project, a portfolio and response papers based on readings.

The Marine Science Department excels in another area of student learning: collaboration between undergraduates and faculty on research projects, including underwater habitat characterization, resource utilization sampling, GIS mapping, genetic diversity of zooxanthellae, water quality, submersible dives, macroalgal reef surveys, Northwestern Hawaiian Islands research cruises, analyses of nutritional content of edible Hawaiian seaweeds, and molecular genetics of marine snails. Marine Science Department faculty members often co-author symposium talks, posters, and even journal articles with their undergraduate collaborators. Being directly involved in real marine science research as an undergraduate is one of the experiences and strengths that we encourage our students to obtain. Students are given such opportunities as volunteers or paid student assistants, or via paid internships such as Keaholoa STEM program, and the summer REU program. Some of these students and others who take on unpaid research opportunities count their experience as Directed Studies (MARE 299, 399, 499) courses.

**Primary Assessment Activities for the Next Five Years**

- Direct Assessment of Student Learning: The department plans to institute an entrance/exit exam (Appendix II) to provide a direct assessment of student learning, and to allow us to identify courses that may need additional improvement. This will be given when students enter the program and at the end of their capstone course, and will include demographic questions that will allow us to identify transfer students who have already had some courses, and what they have had, vs. new students who have not. We also plan to modify capstone courses vis-à-vis their role as cumulative measures of student learning, and mastery of departmental learning objectives. Part of this modification will include the design and application of a system to compare student achievements and products over several years, i.e., faculty review of random samples of theses and portfolios to determine how effectively students are meeting criteria for organization, analytical skills, and technical writing skills. Trends in performance of the students will lead to changes and improvements in teaching, curriculum, and/or student support services.
• Direct Assessment of Student Learning: Embedded assignments and course activities in non-capstone courses in order to collect and review information relevant to specific departmental learning outcomes, i.e., statistics exams in MARE 250 or lab assignments in MARE 171L or group projects in MARE 350. A protocol needs to be established to pool the results across courses and among instructors to indicate program accomplishments or shortcomings.

• Indirect Assessment of Student Learning: The department needs to know more about the expectations and satisfaction level of stakeholders in the program, i.e. seniors in capstone courses, alumni, employers, the community, and graduate school advisors. We intend to design and implement procedures for obtaining this information, assessing the stakeholder feedback, and utilizing that feedback to improve the program. One method could be a survey of various stakeholders, review of the results by faculty, adoption of appropriate recommendations and action pathways within the department, and subsequent surveys every two years.
Appendix I. Careers of Marine Science B.A. graduates

- Submersible pilot/boat captain, Oahu
- Environmental Consulting, San Diego
- Education specialist, Monterey Bay Aquarium
- Naval Oceanographic Office, Stennis Space Center
- Attorney, NOAA General Counsel, Washington DC
- Substitute teaching, science
- Research technician, Kona Aquaculture facility
- Alaska - NMFS observer
- Volunteer instructor, Pohnpei Agriculture and Trade School (PATS)
- Fishery Analyst (as of 2004), Western Pacific Regional Fishery Management Council
- Ecological consulting
- Works with Hawaii DLNR-DAR
- Park Service, Honokohou
- Technician at Scripps
- Scientific diver, National Park Service, Molokai
- Works at Island Naturals, tech for chemistry
- Stewardess for Japan Air
- Intern, US Navy Marine Mammal Program
- State water resources control board, Calif.
- Hawaii DOH - Environmental Specialist, Clean Water Branch
- Education director, Maui Ocean Center, until 2006
- Commercial Diver, Gulf of Mexico
- Teaching high school science
- Save our Seas, Kauai
- Aquarist
- Marine survey work, Rarotonga
- NMFS Fisheries Observer
- High school science teacher, Pohnpei
- Hawaii State Park Ranger (1st one)
- Aquarium Biologist, Waikiki Aquarium (as of 2004)
- GIS analyst, marine science technician, etc
- Postdoc, MBARI (as of 2003)
- Oahu, Storm Water Branch, Dept. of Environmental Services
- Public Relations & Education Specialist, Maui Invasive Species Committee
- Teaching and consulting, computer industry
- Marine Science educator, Hilo Intermediate School
- NOAA Fisheries, coral reef work (2002)
Appendix II. Marine Science Entrance/ Exit Exam

Survey Questions

If you are a new student in the department please answer Questions 1-6; if you are graduating, answer Questions 7-18.

1. How did you find out about the Marine Science program?
___________________________________________________________________________
___________________________________________________________________________

2. What was the main reason you chose the UH Hilo Marine Science Program?
___________________________________________________________________________
___________________________________________________________________________

3. What is your primary area of interest in Marine Science? _______________________

4. What are your career goals?
___________________________________________________________________________
___________________________________________________________________________

5. What terminal degree do you hope to complete? ______________________________

6. What do you see your self doing in 10 years?
___________________________________________________________________________
___________________________________________________________________________

7. Are you a transfer student? If not, skip to Question 10
   1. Yes
   2. No

8. If you are a transfer student, how many credits did you transfer?
   A. Accredited A.A. degree
   B. 24 credits or less
   C. 25 to 54 credits
   D. 55 to 88 credits
   E. More than 88 credits

9. Please list any Marine Science course requirements that you took at another institution
   (provide on another sheet if necessary).
___________________________________________________________________________
___________________________________________________________________________

10. If you took any Marine Science courses in High School, please list the school and the courses
    taken (use another sheet if necessary):
___________________________________________________________________________
___________________________________________________________________________
11. What did you like most about the Marine Science program?
___________________________________________________________________________
___________________________________________________________________________

12. What did you like least about the Marine Science program?
___________________________________________________________________________
___________________________________________________________________________

13. What was your favorite course? ___________________________________________

14. What course do you think will prove most useful in the future?
___________________________________________________________________________

15. Did you feel that department facilities were adequate? If not, why not?
___________________________________________________________________________
___________________________________________________________________________

16. What do you see yourself doing in ten years?
___________________________________________________________________________
___________________________________________________________________________

17. How have your career goals changed during your time at UH Hilo?
___________________________________________________________________________
___________________________________________________________________________

18. Any other comments?
___________________________________________________________________________
___________________________________________________________________________

BIOL 125

1. A large body of information, with broad range of evidence, which is a scientifically accepted general principle or body of principles
   A. concept
   B. hypothesis
   C. law
   D. theory
   E. premise

2. Which of the following statements correctly describe(s) catabolic pathways?
   A. They do not depend on enzymes
   B. They consume energy to build up polymers from monomers
   C. They release energy as they degrade polymers to monomers
   D. They lead to the synthesis of catabolic compounds
   E. They do not release or consume energy
3. During photosynthesis, visible light has enough energy to;
   A. force electrons closer to the nucleus
   B. produce heat energy by synthesizing gaseous oxygen from water molecules
   C. split a water molecule into hydrogen and oxygen
   D. facilitate glycolysis
   E. excite electrons

4. What is the term used for the metabolic pathway in which glucose \((C_6O_12H_6)\) is degraded to carbon dioxide \((CO_2)\) and water?
   A. cellular respiration
   B. glycolysis
   C. fermentation
   D. oxidative phosphorylation
   E. photosynthesis

5. Which of the following statements about genes is INCORRECT?
   A. Genes correspond to segments of DNA.
   B. Many genes contain the information needed for cells to synthesize enzymes and other proteins.
   C. Genes are translated to amino acid sequences that compose proteins.
   D. In all haploid organisms, each chromosome contains precisely one gene.
   E. Genetic differences can result from changes in the DNA called mutations.

6. Asexual reproduction and sexual reproduction are different in that;
   A. Individuals reproducing asexually transmit 100% of their genes to their progeny, whereas individuals reproducing sexually only transmit 50%.
   B. Asexual reproduction produces offspring that are genetically identical to the parents, whereas sexual reproduction gives rise to genetically distinct offspring.
   C. Asexual reproduction involves a single parent, whereas sexual reproduction involves two.
   D. asexual reproduction only requires mitosis, whereas sexual reproduction always involves meiosis.
   E. all of the above

7. Frequency of crossing over between any two linked genes is
   A. Higher if they are recessive.
   B. Different between males and females in sexually reproducing species.
   C. Determined by their evolutionary fitness levels.
   D. The same as if they were not linked.
   E. Proportional to the distance between them.

8. All of the following are directly involved in translation EXCEPT;
   A. mRNA
   B. tRNA
   C. ribosomes
   D. DNA
   E. amino acids

9. Which bonds are created during the formation of the primary structure of a protein?
   A. peptide bonds
   B. hydrogen bonds
   C. disulfide bonds
   D. phosphodiester bonds
   E. A, B, and C
10. Which of the following is/are true for alleles?
   A. They can be identical or different for any given gene in a somatic cell.
   B. They can be dominant or recessive.
   C. They can represent alternative forms of a gene.
   D. Only A and B are correct
   E. A, B, and C are correct

MARE 171/171L
11. Plankton can increase their buoyancy by:
   A. decreasing their surface area & increasing their mass
   B. increasing their surface area & rod-shaped body
   C. increasing their surface area & disk-shaped body
   D. increasing their surface area & increasing their mass
   E. decreasing their surface area & decreasing their mass

12. Cyanobacteria in the marine environment are:
   A. found in anoxic sediments
   B. nitrogen fixers
   C. undergoes photosynthesis
   D. form stromatolites
   E. all of the above

13. Red algae includes:
   A. coralline algae
   B. giant kelp
   C. Phylum Rhodophyta
   D. Phylum Phaeophyta
   E. Both a. and c.

14. Most molluscs have
   A. a tongue-like structure called a radula
   B. an endoskelton
   C. radial symmetry
   D. an external shell made of chitin
   E. all of the above

15. Exclusively marine phyla of invertebrates include:
   A. Annelida
   B. Arthropoda
   C. Pogonophora
   D. Platyhelminthes
   E. All of the above

16. Representative orders of marine mammals include:
   A. Sirenia
   B. Carnivora
   C. Cetacea
   D. All of the above
   E. None of the above

17. The trait(s) that define the chordates include:
   A. dorsal hollow nerve cord
   B. dorsal hollow nerve cord, pharyngeal gill slits
   C. dorsal hollow nerve cord, pharyngeal gill slits, notochord
   D. dorsal hollow nerve cord, pharyngeal gill slits, notochord, post-anal tail
   E. none of the above
18. Define the term germ layers.
   A. A layer of cells during embryonic development that all have similar fates
   B. Includes endoderm; lines digestive tract/cavity-forms digestive tract lining, lungs & liver
   C. Includes mesoderm; forms connective tissue, muscle, bone, & urogenital & circulatory systems develop
   D. Includes ectoderm; forms epidermal layers develop, & for some, nervous system
   E. All of the above

19. Name the group that DOES NOT represent a group of fishes.
   A. Class Myxini
   B. Class Chondrichthyes
   C. Class Sauropsida
   D. Class Actinopterygii
   E. Class Sarcopterygii

20. The following is true concerning cartilaginous and bony fishes:
   A. The only consistent difference between them is a mineralized skeleton in bony fish.
   B. Both have rows of teeth that serve as reserves to replace lost teeth.
   C. Bony, but not cartilaginous, fishes often have swimbladders, and have a bony operculum over the gills and bony fin rays to support the fins.
   D. Both groups have total solute concentrations in their blood much less than seawater
   E. Both groups accumulate high amounts of urea to equalize total solutes to that of seawater.

21. Sea cucumbers (holothuroidean Echinoderms) are
   A. carnivores, using modified tentacular tube feet to grasp animal prey
   B. deposit feeders ingesting sediment
   C. suspension feeders using oral tentacles
   D. a and c
   E. b and c

22. The term meroplankton refers to:
   A. spore stages of phytoplankton
   B. organisms that spend their whole life in the plankton
   C. organisms with planktonic larval stages
   D. planktivorous fish
   E. prokaryotic plankton

23. If the primary producers in a particular habitat contain 1 million calories of energy, about ________ calories would be expected to make it to the secondary consumers.
   A. 1,000,000
   B. 100,000
   C. 10,000
   D. 1000
   E. 100

24. Bioluminescence in mesopelagic and deep pelagic animals is thought to be used for
   A. distracting predators and luring prey
   B. blending an animal's body into the background light
   C. intraspecies communication
   D. counterillumination
   E. all of the above
25. The microbial loop refers to a food chain in which DOM from producers is processed
   A. first by bacteria, then by protozoa, then by zooplankton animals
   B. first by viruses, then by protozoa, then by zooplankton animals
   C. first by phytoplankton, then zooplankton, then lower level carnivorous fish
   D. first by cyanobacteria, then fungi, then by lower level carnivorous fish
   E. none of these

26. All of the following have bilateral symmetry EXCEPT:
   A. larval echinoderms
   B. flatworms
   C. tunicates
   D. sea anemones
   E. none of the above

27. Which of the following is NOT a characteristic of the class Chondrichthyes?
   A. They are active swimmers.
   B. They have flattened rays.
   C. They have a bony skeleton.
   D. Most are active predators.
   E. none of the above

28. The following is true concerning cartilaginous and bony fishes:
   A. The only consistent difference between them is a mineralized skeleton in bony fish.
   B. Both have rows of teeth that serve as reserves to replace lost teeth.
   C. Bony, but not cartilaginous, fishes often have swim bladders, and have a bony operculum over the gills and bony fin rays to support the fins.
   D. Both groups have total solute concentrations in their blood much less than seawater.
   E. Both groups accumulate high amounts of urea to equalize total solutes to that of seawater.

29. The following must return to land to breed:
   A. whales, manatees, and pinnipeds
   B. sea turtles, sea snakes, and seals
   C. seabirds, sea turtles, and pinnipeds
   D. cetaceans, sea otters and seabirds
   E. dugongs, crocodiles, and seasnakes

30. The average salinity of seawater in the open ocean in parts per thousand is:
   A. 30
   B. 32
   C. 35
   D. 40
   E. 42

MARE 201

31. Which of the following statements about the study of the interior of the Earth is incorrect?
   A. the earth’s interior has a very uniform density
   B. the velocity of seismic waves varies with the density of the material
   C. S-waves cannot pass through the liquid outer core
   D. Data from seismic waves can be used to produce 3-D tomographs
   E. The Moho indicates the boundary between the crust and the mantle
32. At a depth of water less than 1/20 the wavelength, the motion of the water particles of a passing wave
   A. will be in flattened ellipses
   B. form large circular orbits
   C. will be minimal or cease entirely
   D. is determined by the period of the wave
   E. will have surface tension as the restoring force

33. Oceanic ridges and rises are found at
   A. convergent plate boundaries
   B. shear plate boundaries
   C. divergent plate boundaries
   D. destructive plate boundaries
   E. transform plate boundaries

34. On the figure below, which one of these 5 positions of the earth, sun and moon would result in medium sized high tides and medium sized low tides? (Large circle = Sun; medium = Earth, small = moon; not to scale)

35. Which of the following is NOT a piece of evidence supporting plate tectonic theory?
   A. coastlines match along coastal contour lines
   B. diamonds and various minerals deposit are found on previously adjacent coasts
   C. magnetic stripes on the seafloor support that seafloors spread over time
   D. large tides pull gravitationally on continents
   E. sediment thickness increases with increasing distance from a spreading center

36. The major ionic constituents (salts) of seawater
   A. tend to have long residence times
   B. cause salinity to be a conservative property of seawater
   C. have the same ratio to each other even when diluted by rainwater
   D. all of the above are correct
   E. none of the above is correct
37. The sediments at the bottom of a deep ocean basin, in the middle of the ocean, would most likely consist mostly of which of the following sediments?
   A. a diatom ooze
   B. tektites
   C. foraminiferan shells
   D. coral reefs
   E. red clay

38. The Coriolis effect arises primarily from the
   A. difference between the supplied and required forces
   B. latitudinal differences in the speed of rotation or Earth around its axis
   C. rotation of the Earth around the sun
   D. effect of winds high in the atmosphere
   E. motion of the oceans in their basins

39. The dependable surface winds which are located at approximately 0-30 degrees north and 0-30 degrees south latitudes are called
   A. the doldrums
   B. the ITCZ winds
   C. the westerlies
   D. the trade winds
   E. the horse latitude winds

40. When geostrophic flow if achieved, the ________ force is balanced by the ___________ force.
   A. centrifugal; centripetal
   B. Coriolis; centrifugal
   C. Coriolis; gravitational
   D. Gravitational; centrifugal
   E. Centripetal; centrifugal
41. In the graph above, the salinity shows the following relationship with distance along the transect:
   A. It decreases
   B. It increases
   C. It doesn’t change
   D. It shifts erratically
   E. It is in an inverse relationship with dissolved oxygen concentration

42. What is the most likely explanation for the salinity relationship in the graph?
   A. Input of fresh water near Station 1 mixes with sea water along transect
   B. Input of fresh water all along the transect increases in volume with distance from Station 1
   C. Input of ultra high salinity water near Station 4
   D. Evaporation of water along transect from Station 1 to Station 4
   E. None of the above

43. How would bottom water salinity compare to surface water salinity along the transect?
   A. Similar surface and bottom water at all stations
   B. Higher bottom water salinity at every station with difference between surface and bottom water increasing from Station 1 to 4
   C. Higher bottom water salinity at every station with difference between surface and bottom water decreasing from Station 1 to 4
   D. Lower bottom water salinity at all stations
   E. None of the above

44. In the graph, bottom dissolved oxygen values show the following relationship with distance along the transect from Station 1:
   A. It decreases
   B. It increases
   C. It doesn’t change
   D. It shifts erratically
   E. It is in an inverse relationship with salinity

45. What is the most likely explanation for the dissolved oxygen relationship (fill in all correct answers)
   A. Low dissolved oxygen in surface water input at Station 1
   B. High biological oxygen demand at the bottom near Stations 1 to 4
   C. Little surface to bottom mixing due to density stratification near Stations 1 to 4
   D. Thermo-haline circulation transporting bottom water with higher dissolved oxygen near higher stations
   E. There is no relationship
46. What would a graph of surface water dissolved oxygen look like?
   A. Low values of dissolved oxygen near station 1, increasing toward station 4
   B. High values of dissolved oxygen near station 1 due to low salinity and temperature
   C. Similar to bottom dissolved oxygen values
   D. Constant along transect due to slow circulation of bottom water
   E. Completely unpredictable

MARE 250

47. Which of the following is a not part of the scientific method?
   A. biological interpretation
   B. collecting data
   C. proving your hypothesis is true
   D. testing the null hypothesis
   E. none of the above

48. If you wanted to measure the extent of variation among data the most appropriate statistic would be the:
   A. mean
   B. P-value
   C. sample size
   D. standard deviation
   E. median

49. In statistical analysis we assume a 5% chance of:
   A. accepting the null hypothesis
   B. achieving the normal distribution
   C. saying samples are different when they are not
   D. saying samples are similar when they are different
   E. sampling more than 95% of the total population of data

50. Means testing includes:
   A. t-tests
   B. Analysis of variance
   C. Mann-Whitney U
   D. Kruskal-Wallace
   E. All of the above

51. Correlations:
   A. test for the difference between/among means
   B. predict the value of the response variable for any value of the predictor variable
   C. measures the extent of a linear relationship between two continuous response variables
   D. measures the extent of a linear relationship between two discrete factors
   E. none of the above

52. R²:
   A. is the test statistic for a Pearson’s correlation test
   B. is typically between 200 and 300 in marine systems
   C. describes the amount of variation in the observed response values that is explained by the predictor(s)
   D. the probability that your sample could have been drawn from the population(s) being tested given the assumption that the null hypothesis is true
   E. a resourceful, spunky and adventurous astromech droid from the Star Wars films
53. Given the null hypothesis H₀: µ₁ = µ₂, a correct alternative hypothesis would be:
   A. H₀: µ₁ ≠ µ₂
   B. H₀: µ₁ < µ₂
   C. Ha: µ₁ = µ₂
   D. Ha: µ₁ ≠ µ₂
   E. All of the above

54. Chi-square analysis is used to:
   A. statistically test the mean of one population to the mean of another
   B. can be used to predict the value of variable for any value of another variable
   C. involves independent and dependent variables
   D. all of the above
   E. none of the above

55. From the following set of output, select the most correct response:

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loc.</td>
<td>3</td>
<td>281.7</td>
<td>93.9</td>
<td>6.02</td>
<td>0.004</td>
</tr>
<tr>
<td>Error</td>
<td>20</td>
<td>312.1</td>
<td>15.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>593.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   A. reject the null hypothesis
   B. fail to reject the null hypothesis
   C. reject the alternative hypothesis
   D. none of the above
   E. all of the above

56. Select the most appropriate test from the following examples: Compare the mean number of urchins found at Onekahakaha using two different quadrant sizes (0.25, 0.5).
   A. 2 sample t-test
   B. Analysis of variance
   C. Pearson’s correlation
   D. Linear Regression
   E. Chi-square analysis

57. A species with characteristics of high fecundity, short generation time, high r, small body size are characteristics of
   A. natural selection
   B. artificial selection
   C. r selection
   D. K selection
   E. selective advantage

58. The type of species interaction in which both species benefits
   A. commensalism
   B. competition
   C. mutualism
   D. parasitism
   E. symbiosis

59. Ecosystems with high species richness
   A. recover from disturbance more readily
   B. may have greater substrate cover
   C. generally have greater production
   D. are more stable
   E. all the above
60. The amount of light energy converted to chemical energy by autotrophs (or new biomass accumulation) in a given area per unit time
   A. biomass conversion
   B. photosynthesis
   C. production
   D. productivity
   E. standing crop

61. A keystone species is
   A. important in community function because it is abundant
   B. has a greater effect on the community than you would expect based on its abundance/biomass
   C. a species that alters flows of materials to other species
   D. are the dominant primary producers
   E. are foundation species in an ecosystem

62. The average contribution of an allele to the next or succeeding generations is called:
   A. evolution
   B. fitness
   C. natural selection
   D. reproductive success
   E. mutation

63. All of the following are assumptions of Hardy-Weinberg Equilibrium except:
   A. mate choice is not random
   B. migration is not occurring
   C. mutation is not occurring
   D. selection is not occurring
   E. none of the above

64. A defining characteristic of allopatric speciation is
   A. asexually reproducing populations
   B. geographic isolation
   C. large populations
   D. the appearance of new species in the midst of existing ones
   E. overlap of distribution ranges

65. The feeding relationships among the species in a community determine the community's
   A. ecological niche
   B. species diversity
   C. species richness
   D. trophic structure
   E. geographical range

66. Which of the following is arranged in the correct order from least inclusive to most inclusive?
   A. Community, ecosystem, individual, population
   B. Individual, community, population, ecosystem
   C. Individual, population, community, ecosystem
   D. Population, ecosystem, individual, community
   E. Community, population, ecosystem, individual
Mare 350

67. Experimental design requires all of the following except
   A. randomization
   B. replication
   C. large sample size
   D. controls
   E. all are required

68. Environmental Assessment projects are difficult because
   A. adequate controls are difficult to locate
   B. before and after sampling is difficult to interpret
   C. environmental impacts are difficulty to predict
   D. costs may greatly restrict sampling
   E. all the above

69. If you complete your experiment and have non-normal data or unequal variances for your analysis of variance, you must
   A. repeat the experiment
   B. transform your data and on use analysis of variance
   C. transform your data and use a nonparametric test
   D. eliminate the non-normal or highly variable data
   E. use a nonparametric test if your data do not pass assumption tests

70. Experiments should be conducted with sufficient sample size that would be best determined by
   A. conducting a pilot study
   B. selecting from a similar published study
   C. modeling with simulated data
   D. best estimate
   E. none of these

71. Which of the following is not a section in a scientific paper?
   A. abstract
   B. table of contents
   C. methods
   D. results
   E. discussion

72. When you are calibrating an instrument, you are:
   A. turning it on
   B. checking its accuracy against a standard
   C. turning it off
   D. checking its precision against a standard
   E. none of the above

73. Which is not a step in experimental design?
   A. defining a question
   B. developing a hypothesis
   C. creating an experimental design
   D. conducting a pilot study
   E. all are steps in experimental design
74. Interpolation is:
   A. calculating an intermediate value in a series
   B. calculating a median value in a series
   C. calculating the mode in a series
   D. determining the way-point for a location
   E. determining the direction of a current

75. Precision is:
   A. the extent to which a measured value coincides with a standard
   B. the fineness of a measurement
   C. reproducibility of a measurement
   D. a & b
   E. b & c

76. What is a standard curve?
   A. a series of solutions with known solute concentrations
   B. a series of solids with different masses
   C. a statistical method used to assess the relationship between two parameters
   D. a statistical method used to predict the response of one parameter relative to another
   E. a method for determining the length of an organism

MARE425
77. Marcet’s principal states:
   A. Ratio between the amounts of the major ions in ocean water is nearly constant regardless of salinity
   B. Ratio between the amounts of all the ions in the ocean is nearly constant regardless of salinity
   C. Ratio between the amounts of all the major ions in coastal waters is nearly constant regardless of salinity
   D. Ratio between the amounts of all the ions in coastal waters is nearly constant regardless of salinity
   E. none of the above

78. Activity of a dissolved solute in seawater is:
   A. the ineffective concentration of the solute
   B. the total concentration of that solute
   C. the portion of the solute’s concentration that does not participate in a chemical reaction
   D. the portion of the solute’s concentration that does participate in a chemical reaction
   E. none of the above

79. Which type of sediment comprises the bulk of the pelagic sediments in the ocean?
   A. hydrogenous
   B. cosmogenous
   C. lithogenous
   D. biogenous
   E. neritic

80. What is the Redfield ratio?
   A. average ratio of phytoplankton to zooplankton in the ocean
   B. average ratio between photosynthesis to respiration in the ocean
   C. average elemental ratio of a plankton cell
   D. average elemental ratio of a phytoplankton cell
   E. average ratio between Na⁺ and Cl⁻ in the ocean
81. What is the order of the processes in the metabolic cascade from the most energy yielding to the least?
   A. methanogenesis > sulfate reduction > iron oxide reduction > manganese oxide reduction > denitrification > aerobic respiration
   B. aerobic respiration > denitrification > manganese oxide reduction > iron oxide reduction > sulfate reduction > methanogenesis
   C. denitrification > sulfate reduction > iron oxide reduction > methanogenesis > aerobic respiration > manganese oxide reduction
   D. sulfate reduction > aerobic respiration > denitrification > manganese oxide reduction > methanogenesis > iron oxide reduction
   E. photosynthesis > respiration

82. What are the vertical features of a nutrient-type profile in the ocean?
   A. surface water enrichment, deep water depletion
   B. mid-depth maximum
   C. constant concentration with depth
   D. surface water depletion, deep water enrichment
   E. higher concentrations in the Atlantic ocean and lower concentrations in the Pacific ocean

83. What element is thought to limit primary production in high nutrient, low chlorophyll (HNLC) regions of the ocean?
   A. Fe
   B. N
   C. P
   D. C
   E. Si

84. What is the lysocline?
   A. the depth in the water column where $CO_3^{2-}$ is saturated
   B. the depth in the water column where there is no longer CaCO$_3$ found in the sediment
   C. the depth in the water column where CaCO$_3$ starts to show signs of dissolution
   D. the depth in the water column where photosynthesis and respiration are equal
   E. the depth in the water column where light is completely attenuated

85. What form of CO$_2$ dominates at the pH of the ocean (8.2)?
   A. carbonic acid
   B. carbonate ion
   C. unhydrated CO$_2$
   D. bicarbonate ion
   E. hydrated CO$_2$

86. Which process is not part of the nitrogen cycle?
   A. denitrification
   B. nitrification
   C. nitrogen precipitation
   D. nitrogen fixation
   E. ammonium assimilation

MARE440
87. Circle the letters of 3 true statements about waves.
   A. There are circumstances where wave height affects crest speeds.
   B. The term “most probable extreme wave” refers to the highest wave a storm will probably create.
   C. In shallow water, crests don’t persist.
   D. You can find the energy of a fully developed sea if you know only the relevant wind speed.
   E. Dispersion helps form swells.
88. Circle the letters of 2 false statements about tides.
A. Tides are generally higher on the side of the earth closest to the moon.
B. Tide-generating forces arise from the moon’s motion and the earth’s daily rotation.
C. Coriolis force has an effect on tides.
D. The size of the diurnal inequality can vary throughout the month.
E. The angle between Earth’s axis and the ecliptic plane affects tides.

89. Circle the letters of all false statements about atmospheric circulation.
A. The average wind patterns are symmetric around the equator.
B. Average surface winds are weak at 30°N.
C. Knowledge of world-wide atmospheric convection cells is sufficient for approximate mapping of the major ocean currents.
D. Evaporation from the ocean makes overlying air more dense.
E. Coriolis force acting on atmospheric convection causes trade winds.

90. Circle the letters of all false statements about ocean currents.
A. The North Pacific Current flows toward the east at about 30°N.
B. The Antarctic Circumpolar Current has fairly consistent speeds from the surface to the bottom of
C. The Equatorial Countercurrents are located in the ITCZ.
D. Some of the Gulf Stream’s flow arrives in the Norwegian Sea.
E. One major ocean current has a greater transport rate than all the world’s rivers combined.

91. Circle the letters of all false statements about the Coriolis effect.
A. It deflects the paths of objects moving freely on a surface rotating around an axis perpendicular to the surface.
B. It causes measurable effects in the ocean.
C. It would not affect the path of a snail crawling at on a table at the north pole.
D. Its strength will depend on the direction an object is moving on the earth’s surface.
E. It may or may not appear - depending on one’s point of view.

92. Circle the letters of all false statements about hydrostatic pressure.
A. Hydrostatic pressure differences in the ocean produce forces.
B. It plays a part in causing the shape of the pycnocline to mirror the shape of the sea surface.
C. It plays only a minor role in the dynamics of most ocean currents.
D. It plays only a minor role in creating buoyancy.
E. It acts on horizontal submerged surfaces only.

93. Circle the letters of all true statements about geostrophic theory.
A. Almost all ocean currents are in approximate geostrophic balance.
B. Geostrophic balance is a balance between frictional and Coriolis forces.
C. Geostrophic theory explains the causes of most major ocean currents.
D. Geostrophic calculations are used to find surface currents from observations of sea surface topography.
E. Recently, satellite-monitored current meters have largely replaced geostrophic current calculations.

94. Circle the letters of all true statements concerning fluid dynamics.
A. Density stratification influences friction between layers of water.
B. Newton’s laws of motion don’t apply very well in the pycnocline.
C. Friction in the ocean leads to an outflow of water from subtropical gyres.
D. East-west winds, such as trades and westerlies, provide energy for north-south currents such as the Kuroshio and the California Current.
E. If all the earth’s winds stopped blowing, major ocean currents could continue flowing for over a year.
95. Circle the letters of all false statements about deep water movements.
   A. They are very slow, on the average.
   B. They differ between Atlantic and Pacific partly because the surface temperatures are different.
   C. Distributions of radioactive isotopes are the primary tool for studying deep water motions.
   D. They can sometimes attain speeds exceeding one meter per second.
   E. Surface currents can affect deep water formation.

96. Circle the letters of all true statements about environmental models based on rate budgets.
   A. They are normally used to calculate the time needed for completely replacing all the water in
      an aquatic system.
   B. They are not used until after field studies have provided data about the variables in the system.
   C. They are can provide predictions about the future behavior of the system.
   D. They are not very useful for modeling whole oceans.
   E. They can provide information about current speeds.