Faculty of Science
School of Biological, Earth and Environmental Sciences

BIOS3091
Marine and aquatic ecology
Session 2, 2018

Contributions from:
A/ Prof Adriana Vergés, A/ Prof Alistair Poore, Prof Peter Steinberg, Prof Emma Johnston
BIOS3091

Marine and aquatic ecology

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# Course information

**Year of Delivery** | 2018  
**Course Code** | BIOS3091  
**Course Name** | Marine and Aquatic Ecology  
**Academic Unit** | School of Biological, Earth and Environmental Sciences  
**Level of Course** | 3rd year, undergraduate  
**Units of Credit** | 6 UOC  
**Session(s) Offered** | Session 2  
**Assumed Knowledge, Prerequisites or Co-requisites** | MSCI2001 or BEES2041  
**Hours per Week** | 5  
**Number of Weeks** | 12  
**Commencement Date** | Monday 30th July, 2018

### Summary of Course Structure (for details see 'Course Schedule')

<table>
<thead>
<tr>
<th>Component</th>
<th>HPW</th>
<th>Time</th>
<th>Day</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture 1</td>
<td>1</td>
<td>10–11 am</td>
<td>Monday</td>
<td>Mathews D</td>
</tr>
<tr>
<td>Lecture 2</td>
<td>1</td>
<td>1–2 pm</td>
<td>Tuesday</td>
<td>Mathews D</td>
</tr>
<tr>
<td>Laboratory</td>
<td>3</td>
<td>2 pm – 5 pm</td>
<td>Thursday</td>
<td>E26 TL4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


### Staff Involved in the course

<table>
<thead>
<tr>
<th>Staff</th>
<th>Role</th>
<th>Name</th>
<th>Contact Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Course Convenor</strong></td>
<td>A/Prof Adriana Vergés</td>
<td><a href="mailto:a.verges@unsw.edu.au">a.verges@unsw.edu.au</a></td>
<td>Ph: 9385 2110</td>
</tr>
<tr>
<td><strong>Additional Teaching Staff</strong></td>
<td>Lecturers &amp; Facilitators</td>
<td>Prof Peter Steinberg</td>
<td><a href="mailto:p.steinberg@unsw.edu.au">p.steinberg@unsw.edu.au</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A/Prof Alistair Poore</td>
<td><a href="mailto:a.poore@unsw.edu.au">a.poore@unsw.edu.au</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A/Prof Paul Gribben</td>
<td><a href="mailto:p.gribben@unsw.edu.au">p.gribben@unsw.edu.au</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A/Prof Tracy Ainsworth</td>
<td><a href="mailto:tracy.ainsworth@unsw.edu.au">tracy.ainsworth@unsw.edu.au</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A/Prof Suheilen Egan</td>
<td><a href="mailto:s.egan@unsw.edu.au">s.egan@unsw.edu.au</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dr Torsten Thomas</td>
<td><a href="mailto:t.thomas@unsw.edu.au">t.thomas@unsw.edu.au</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dr Ziggy Marzinelli</td>
<td><a href="mailto:e.marzinelli@unsw.edu.au">e.marzinelli@unsw.edu.au</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prof Tracey Rogers</td>
<td><a href="mailto:tracey.rogers@unsw.edu.au">tracey.rogers@unsw.edu.au</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prof Richard Kingsford</td>
<td><a href="mailto:richard.kingsford@unsw.edu.au">richard.kingsford@unsw.edu.au</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dr Kate Brandis</td>
<td><a href="mailto:kate.brandis@unsw.edu.au">kate.brandis@unsw.edu.au</a></td>
</tr>
<tr>
<td><strong>Tutors &amp; Demonstrators</strong></td>
<td>Ruby Garthwin</td>
<td><a href="mailto:r.garthwin@unsw.edu.au">r.garthwin@unsw.edu.au</a></td>
<td></td>
</tr>
<tr>
<td><strong>Technical &amp; Laboratory Staff</strong></td>
<td>Dr Suzy Evans</td>
<td><a href="mailto:s.evans@unsw.edu.au">s.evans@unsw.edu.au</a></td>
<td>Room G004</td>
</tr>
<tr>
<td><strong>Other Support Staff</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Course details

| **Course Description** | Ecology of marine and freshwater systems, emphasising benthic communities. Population and community dynamics of these systems. Evolution of life histories in the light of constraints of aquatic systems. Emphasis on experimental approaches to aquatic ecology. Special topics considered include chemical ecology, plant/herbivore ecology, and applied aspects of the topic such as mariculture. A section on the biology and taxonomy of marine algae (seaweeds) is included. Fieldwork is an important component of the course. |
| **Course Aims** | The course is aimed to provide an understanding of the processes that govern the ecology of aquatic habitats with a major emphasis on the ecology of marine coastal systems, and particularly the experimental analysis of benthic communities. Marine systems are then compared to streams and both freshwater and saline lakes. |
| **Student Learning Outcomes** | At the end of the course, students should be able to discuss the relative importance of the major ecological processes structuring marine and freshwater communities. They will have experience in each of the steps involved in the ecological research that has given rise to such knowledge. These are: 1) the careful formulation of hypotheses, 2) the design of field experiments and sampling, 3) collection of data, 4) data analysis, and interpretation, and 5) communication of results via scientific reports. Students should be familiar with the application of ecological data to applied problems in marine and freshwater habitats (pollution, habitat loss, overfishing, flow regulation, marine reserves). |

### Graduate Attributes Developed in this Course

<table>
<thead>
<tr>
<th>Science Graduate Attributes</th>
<th>The level of FOCUS</th>
<th>Activities / Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research, inquiry and analytical thinking abilities</td>
<td>3</td>
<td>Class research projects, Independent research projects (all assessed)</td>
</tr>
<tr>
<td>Capability and motivation for intellectual development</td>
<td>3</td>
<td>Students design their own research project (assessed). Links in course materials to current research activities at UNSW</td>
</tr>
<tr>
<td>Ethical, social and professional understanding</td>
<td>2</td>
<td>Links in course material to applied problems in marine and aquatic habitats. Recognition that a diverse range of views are held on ecological issues.</td>
</tr>
<tr>
<td>Communication</td>
<td>3</td>
<td>Written reports (for scientific audiences), Oral presentations</td>
</tr>
<tr>
<td>Teamwork, collaborative and management skills</td>
<td>3</td>
<td>Independent group research project &amp; oral presentations (assessed as report)</td>
</tr>
<tr>
<td>Information literacy</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

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2 Learning and Teaching Unit: [http://www.ltu.unsw.edu.au](http://www.ltu.unsw.edu.au)  
3 Access the contextualised Science Graduate Attributes and your mapped courses: [http://www2.science.unsw.edu.au/guide/slatig/sciga.html](http://www2.science.unsw.edu.au/guide/slatig/sciga.html)  
(Mapped courses are available at this site)
Major Topics (Syllabus Outline)

Major topics to be covered include:

- experimental marine ecology of rocky shores, kelp forests, soft sediment communities, coral reefs and seagrass beds
- ecology of streams and lakes
- life histories of marine invertebrates and algae
- marine chemical ecology
- marine microbiology
- applied aspects of marine and freshwater ecology (pollution, disturbance, overfishing, biotechnology and biofouling, marine reserves and flow regulation).
- marine conservation biology

Relationship to Other Courses within the Program

BIOS3091 shares its lectures and some assessments with MSCI9001 Conservation in aquatic ecosystems.

BIOS3091 is intended to complement BIOS3081 Ocean to Estuarine Ecosystems as third year offerings in marine biology.

Study of ecological processes and field experimentation also form part of BIOS3601 Advanced Field Biology, BIOS3671 Conservation Biology and Biodiversity, BIOS2011 Evolutionary & Physiological Ecology, and BEES2041 Data Analysis for Life and Earth Sciences.

Many honours and postgraduate projects conducted within the school involve research in marine ecology.

Rationale and strategies underpinning the course

Teaching Strategies

The lectures are organised around key ecological processes that shape different marine and aquatic habitats (rocky shores, kelp forests, coral reefs, etc) and also focus on current marine conservation issues. Lectures provide the key theoretical concepts and examples of experiments conducted to test hypotheses about the functioning of aquatic habitats.

The practical sessions and field trips provide an opportunity to gain experience in the design, conduct and communication of ecological experiments in the field. The class will conduct one experiment that has already been designed, and groups of students will design their own sampling programs in independent research projects.

Rationale for learning and teaching in this course

The focus on experimental ecology in the lecture and practical material was chosen as it this approach that has been most powerful in advancing our understanding of marine and aquatic ecology.

The ability to design and conduct rigorous experiments, analyse the resultant data, and communicate the results in written and oral form are skills essential for graduates seeking employment in this field.
Course schedule 2018

**Lectures**  Monday 10:00–11:00, Mathews Theatre D  
Tuesday 13:00–14:00, Mathews Theatre D

**Practicals**  Thursday 14:00-17:00h, E26 TL4, in the field or in computer labs.

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Lectures</th>
<th>Practicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Mon 30th Jul</td>
<td>Introductory Lecture</td>
<td>Deconstructing Science &amp;</td>
</tr>
<tr>
<td></td>
<td>Tue 31st Jul</td>
<td>Species interactions: predation &amp; herbivory (AV)</td>
<td>(TL4)</td>
</tr>
<tr>
<td>3</td>
<td>Mon 6th Aug</td>
<td>Natural disturbances (AV)</td>
<td>Plant-herbivore experiment set-up (low tide 1pm)</td>
</tr>
<tr>
<td></td>
<td>Tue 7th Aug</td>
<td>Species interactions: competition &amp; facilitation (PG)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Mon 13th Aug</td>
<td>Larval and supply-side ecology 1 (PS)</td>
<td>Deconstructing Science &amp;</td>
</tr>
<tr>
<td></td>
<td>Tue 14th Aug</td>
<td>Larval and supply-side ecology 2 (PS)</td>
<td>Independent field projects: planning 1 (TL4)</td>
</tr>
<tr>
<td>5</td>
<td>Mon 20th Aug</td>
<td>Kelp forests (PS)</td>
<td>Independent field projects: planning 2 (TL4)</td>
</tr>
<tr>
<td></td>
<td>Tue 21st Aug</td>
<td>Coral reefs (TA)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Mon 27th Aug</td>
<td>Seagrass meadows (AV)</td>
<td><em>Independent field projects</em></td>
</tr>
<tr>
<td></td>
<td>Tue 28th Aug</td>
<td>Rocky shores (TBC)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Mon 3rd Sep</td>
<td>Marine invaders: establishment to impact (PG)</td>
<td>Algal diversity (TL4)</td>
</tr>
<tr>
<td></td>
<td>Tue 4th Sep</td>
<td>Algal diversity (AP)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Mon 10th Sep</td>
<td>Conservation of marine megafauna (TR)</td>
<td><em>Independent field projects</em></td>
</tr>
<tr>
<td></td>
<td>Tue 11th Sep</td>
<td>Marine reserves (AV)</td>
<td></td>
</tr>
<tr>
<td>Week</td>
<td>Date</td>
<td>Lectures</td>
<td>Practicals</td>
</tr>
<tr>
<td>------</td>
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<td>----------------------------------------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>9</td>
<td>Mon 17th Sep</td>
<td>Threats to marine populations (AV)</td>
<td>Independent field projects</td>
</tr>
<tr>
<td></td>
<td>Tue 18th Sep</td>
<td>Impacts of climate change (AV)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Break</td>
<td>22nd Sep – 1st October</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Mon 1st Oct</td>
<td>NO LECTURE</td>
<td>Plant-herbivore experiment: data analysis (Computer lab TBC) &amp; Deconstructing Science</td>
</tr>
<tr>
<td></td>
<td>Tue 2nd Oct</td>
<td>Detecting human impacts (ZM)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Mon 8th Oct</td>
<td>Microbial diversity (TT)</td>
<td>Marine microbiology (TL4)</td>
</tr>
<tr>
<td></td>
<td>Tue 9th Oct</td>
<td>Marine holobionts (SE)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Mon 15th Oct</td>
<td>Desert rivers (RK)</td>
<td>Marine microbiology (TL4)</td>
</tr>
<tr>
<td></td>
<td>Tue 16th Oct</td>
<td>Freshwater management: solutions (RK)</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Mon 22nd Oct</td>
<td>Freshwater management: solutions (RK)</td>
<td>Independent field project presentations</td>
</tr>
<tr>
<td></td>
<td>Tue 23rd Oct</td>
<td>Waterbird breeding and environmental flows (KB)</td>
<td></td>
</tr>
</tbody>
</table>

AV: Associate Professor Adriana Vergés  
PS: Professor Peter Steinberg  
PG: Associate Professor Paul Gribben  
TA: Associate Professor Tracy Ainsworth  
AP: Associate Professor Alistair Poore  
SE: Associate Professor Suhelen Egan  
TT: Professor Torsten Thomas  
ZM: Dr Ziggy Marzinelli  
TR: Professor Tracey Rogers  
RK: Professor Richard Kingsford  
KB: Dr Kate Brandis
## Assessment

<table>
<thead>
<tr>
<th>Task</th>
<th>Knowledge &amp; abilities assessed</th>
<th>Assessment Criteria</th>
<th>% of total mark</th>
<th>Date of Feedback</th>
<th>WHO</th>
<th>WHEN</th>
<th>HOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class participation</td>
<td>Ability to engage with content delivered during lectures and interact with lecturers during practical classes.</td>
<td>Effective communication with peers and lecturers during deconstructing science activities and general class participation.</td>
<td>5</td>
<td>30th Jul</td>
<td>A/Prof Adriana Vergés and demonstrators</td>
<td>Throughout the semester</td>
<td>Upon direct request from students</td>
</tr>
<tr>
<td>Opinions in ecology</td>
<td>Ability to read ecological literature critically. Ability to write a persuasive argument.</td>
<td>Extent of research. Effective communication of scientific controversy to a wide audience.</td>
<td>10</td>
<td>30th Jul</td>
<td>A/Prof Adriana Vergés and demonstrators</td>
<td>Two weeks after submission</td>
<td>Marks &amp; written comments</td>
</tr>
<tr>
<td>Plant-herbivore report</td>
<td>An understanding of the hypotheses being tested. The ability to analyse ecological data. Ability to prepare scientific report</td>
<td>Correct interpretation of experimental results. Effective communication of results as a scientific paper.</td>
<td>20</td>
<td>30th Jul</td>
<td>A/Prof Adriana Vergés and demonstrators</td>
<td>One week after submission</td>
<td>Marks &amp; written comments</td>
</tr>
<tr>
<td>Independent field project report</td>
<td>Ability to design a sampling program able to test specific hypothesis. Ability to conduct ecological research in the field. Ability to prepare scientific report</td>
<td>Completion of tasks, correct analysis and presentation of results. Effective communication of results to a scientific audience</td>
<td>25</td>
<td>30th Jul</td>
<td>A/Prof Adriana Vergés and demonstrators</td>
<td>Two weeks after submission</td>
<td>Marks &amp; written comments</td>
</tr>
<tr>
<td>Final exam*</td>
<td>Knowledge of the ecological processes structuring marine and freshwater habitats. Ability to contrast functioning of ecosystems across habitats studied.</td>
<td>Comprehension of all material covered in lectures and practical classes</td>
<td>40</td>
<td>Date set by exam office</td>
<td>A/Prof Adriana Vergés and demonstrators</td>
<td>Two weeks after submission</td>
<td>Marks &amp; written comments</td>
</tr>
</tbody>
</table>

*Attendance at exams is expected. We do not know the final exam date until later in the session, but it is expected between 4th to 22nd Nov. Booking an overseas trip during that period is not considered a valid excuse for missing an exam.*
## Resources for students

Availability: UNSW bookshop, UNSW library, Open Reserve |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Manual</td>
<td>You are reading it! (also available as pdf from Moodle)</td>
</tr>
</tbody>
</table>
| Required Readings | Lecture notes for each section of the course will suggest recommended readings from the text and other sources of information.  
Reference to studies in the primary literature (i.e. original studies in journal articles rather than textbooks) will form an important part of the course.  
The following list includes the most important general ecology journals and the major journals that are devoted entirely, or in large part, to marine ecology, freshwater ecology, or marine botany:  
| Additional Readings | The following is a list of useful texts in marine and freshwater ecology, where possible within an Australian context:  
Resources


**Recommended Internet Sites**

Course web page (Moodle)

Lecture outlines, data sets from practicals, instructions for assessment and other useful resources will be posted throughout the session on the BIOS3091 web page. You will need to log on (using your student number and zPass) to Moodle:

http://moodle.telt.unsw.edu.au/

Required Equipment, Training and Enabling Skills

<table>
<thead>
<tr>
<th>Equipment Required</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enabling Skills Training Required to Complete this Course</td>
<td>Students are required to observe OHS regulations during the fieldtrip and practicals. Safety should be your top priority during fieldtrips and lab classes. If you are unsure of any procedures, please consult with staff. During the Microbiology practical sessions held in the laboratory it is compulsory to wear laboratory coats and covered shoes. Students cannot be admitted to these classes without these items. Additional safety requirements will be announced at the start of each practical. During field trips, it is essential to wear non-slip shoes that you are prepared to get wet. Extra care must be taken on the rocky shore due to wave action.</td>
</tr>
</tbody>
</table>

Course evaluation and development

Student feedback is gathered periodically by various means. Such feedback is considered carefully with a view to acting on it constructively wherever possible. This course outline conveys how feedback has helped to shape and develop this course.

<table>
<thead>
<tr>
<th>Mechanisms of Review</th>
<th>Last Review Date</th>
<th>Comments or Changes Resulting from Reviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Course Review</td>
<td>2010</td>
<td>Revision of lecture material with greater focus on marine conservation issues (given lecture material is shared with MSCI9001 Conservation in aquatic ecosystems)</td>
</tr>
<tr>
<td></td>
<td>2008</td>
<td>The change from 14 week to 12 week sessions has involved the removal of one of the written reports with assessment of practical exercise being moved to the final exam.</td>
</tr>
<tr>
<td></td>
<td>2006</td>
<td>Course revised to add independent group research projects and replace oral debates with written Opinions in Ecology essays.</td>
</tr>
<tr>
<td>CATEI(^4)</td>
<td></td>
<td>The course was evaluated with CATEI in 2006, 2008 and 2009. While the responses were overwhelmingly positive (100% of the respondents satisfied with the quality of the course), several changes resulting from these evaluations have been implemented from 2009-2010. The most important of these is the reduction in the number of written reports, more time allocated to the independent research projects, more help to be available on the preparation of written reports, and a reduced value for the final exam.</td>
</tr>
</tbody>
</table>

## Administration matters

<table>
<thead>
<tr>
<th>Expectations of Students</th>
<th>Attendance at practicals is compulsory – this material will not be available at other times.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignment Submissions</td>
<td>Submitted assignments are to be uploaded to Moodle. Assignments must fulfil conditions of the BEES Assignment cover sheet, which must be attached (see <a href="http://www.bees.unsw.edu.au/current">http://www.bees.unsw.edu.au/current</a>). The cover sheet lists penalties for late submission, and there is a declaration stating that you have kept a copy and that the report is your own and has not been previously submitted for assessment. <strong>School policy for late report submission</strong> For reports submitted up to seven (7) days late, a 10% per day penalty applies. Reports submitted more than seven (7) days late will not be marked. If medical grounds preclude submission of a report by the due date, contact should be made with the course convenor as quickly as possible. A medical certificate will be required for Special Consideration and late submissions based on medical grounds and must be appropriate for extension period. <strong>Assignment extensions will not be considered under any other circumstances.</strong></td>
</tr>
<tr>
<td>Health and Safety$^5$</td>
<td>Information on relevant Health and Safety policies and expectations at UNSW can be accessed online <a href="http://www.safety.unsw.edu.au/staff-student-resources/students">http://www.safety.unsw.edu.au/staff-student-resources/students</a></td>
</tr>
<tr>
<td>Assessment Procedures</td>
<td>The final examination will be scheduled by the Examinations Office. Students should be available for examination throughout the entire UNSW end-of-session examination period. Supplementary examinations will only be granted to students who miss the final examination due to illness or other unexpected reasons outside their control. A student who wishes to apply for a supplementary examination should contact the course coordinator as soon as the problem becomes apparent, and should apply for special consideration. Special consideration cannot be given for students who have planned or wish to plan any holiday trips or return flights home before the end of the examination period. If a supplementary examination is granted, it will normally be held before the beginning of the next session. Until then, you should maintain a current address with SIS, and be available for contact and assessment. For information on examinations see <a href="https://my.unsw.edu.au/student/academiclife/assessment/examinations/examinations.html">https://my.unsw.edu.au/student/academiclife/assessment/examinations/examinations.html</a>. If illness or misadventure intervenes to prevent a student meeting an assessment deadline or class meeting then he/she should contact the lecturer in charge of the assessment. The conditions for special consideration are given at <a href="https://student.unsw.edu.au/special-consideration">https://student.unsw.edu.au/special-consideration</a>.</td>
</tr>
<tr>
<td>Equity and Diversity</td>
<td>Those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the Damon prior to, or at the commencement of, their course, and with the Equity Officer (Disability) in the Equity and Diversity Unit (9385 4734 or <a href="http://www.studentequity.unsw.edu.au/">http://www.studentequity.unsw.edu.au/</a>). Issues to be discussed may include access to materials, signers or notetakers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.</td>
</tr>
</tbody>
</table>

### Student Complaint Procedure

In all cases you should first try to resolve any issues with the course convenor. If this is unsatisfactory, you should contact the School Student Ethics Officer (A/Prof Stephen Bonser, s.bonser@unsw.edu.au) or the Deputy Head of School (A/Prof Scott Mooney s.mooney@unsw.edu.au) who is the School’s Grievance Officer and Designated Officer under the UNSW Plagiarism Procedure.

UNSW has formal policies about the resolution of complaints that are available online for review (see [https://student.unsw.edu.au/complaints](https://student.unsw.edu.au/complaints)).

<table>
<thead>
<tr>
<th>School Contact</th>
<th>Faculty Contact</th>
<th>University Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr S Mooney</td>
<td>Dr Chris Tisdell Associate Dean (Education)</td>
<td>Student Administration in the Office of the Pro-ViceChancellor (Students).</td>
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⁷ University Counselling and Psychological Services: [https://student.unsw.edu.au/counselling](https://student.unsw.edu.au/counselling)
**UNSW academic honesty and plagiarism**

**What is Plagiarism?**

Plagiarism is the presentation of the thoughts or work of another as one's own.
*Examples include:

- direct duplication of the thoughts or work of another, including by copying material, ideas or concepts from a book, article, report or other written document (whether published or unpublished), composition, artwork, design, drawing, circuitry, computer program or software, web site, Internet, other electronic resource, or another person's assignment without appropriate acknowledgement;
- paraphrasing another person's work with very minor changes keeping the meaning, form and/or progression of ideas of the original;
- piecing together sections of the work of others into a new whole;
- presenting an assessment item as independent work when it has been produced in whole or part in collusion with other people, for example, another student or a tutor; and
- claiming credit for a proportion a work contributed to a group assessment item that is greater than that actually contributed.†

For the purposes of this policy, submitting an assessment item that has already been submitted for academic credit elsewhere may be considered plagiarism.

Knowingly permitting your work to be copied by another student may also be considered to be plagiarism.

Note that an assessment item produced in oral, not written, form, or involving live presentation, may similarly contain plagiarised material.

The inclusion of the thoughts or work of another with attribution appropriate to the academic discipline does not amount to plagiarism.

The Learning Centre website is main repository for resources for staff and students on plagiarism and academic honesty. These resources can be located via:

[www.lc.unsw.edu.au/plagiarism](http://www.lc.unsw.edu.au/plagiarism)

The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:

- correct referencing practices;
- paraphrasing, summarising, essay writing, and time management;
- appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.

Individual assistance is available on request from The Learning Centre.

Students are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting, and the proper referencing of sources in preparing all assessment items.

* Based on that proposed to the University of Newcastle by the St James Ethics Centre. Used with kind permission from the University of Newcastle
† Adapted with kind permission from the University of Melbourne
Further study in marine and freshwater ecology

A wide variety of marine and freshwater research is conducted by staff and students at UNSW. This includes the School of Biological, Earth and Environmental Sciences (BEES), the School of Mathematics, School of Biotechnology & Biomolecular Sciences (BABS), the Evolution & Ecology Research Centre (E&ERC), the Centre for Marine Bio-Innovation (CMB), the Climate Change Research Centre (CCRC) and the Centre for Ecosystem Science (CES).

We will expose you to a broad range of current research projects within BEES via the lectures series.

Students interested in further study via Honours should familiarise themselves with the research activities of the various laboratories and talk to relevant staff, their research fellows and their students. The formal requirements for entry into Honours and postgraduate programs and further details on research activities can be found on the BEES web page (www.bees.unsw.edu.au). Here’s a list of the BEES academics that work in the marine realm.

Professor Tracy Ainsworth is a microbial ecologist based at the School of BEES whose research largely focuses on coral reef ecosystems and climate change impacts. Her research has re-evaluated the role of bacterial communities in coral bleaching and she has developed novel methods for analysis of coral bacterial communities. She has ongoing projects in both the Great Barrier Reef and the NSW coastline.

Associate Professor Rob Brander is a coastal geomorphologist in the School of BEES. His research focuses on the morphodynamics of coastal nearshore systems including the interaction between wave action and beach morphology and related coastal management issues. Recent projects include relating physical measurements of rip current flow on beaches around Australia to beachgoers’ perception, understanding and response to the rip current hazard. He also has ongoing projects related to the vulnerability of coral reef-islands in the Great Barrier Reef and Maldives.

Associate Professor Suhelen Egan is a microbial ecologist based at the School of BEES who specializes on host-microbe interactions, marine biotechnology, molecular biology, -omics technologies and ecology. Much of her recent research has focused on understanding the diversity and function of the seaweed microbiome.

Associate Professor Paul Gribben’s research investigates the processes driving marine biodiversity. His interdisciplinary approach combines fundamental life-history theory, behavioural ecology and community ecology to better our understanding of the response of marine communities to global change. His research is conducted in a wide range of ecosystems including mangrove forests, seagrasses, intertidal sand flats, rocky shores and kelp forests. Current research projects include: 1) factors determining the spread and impacts of marine invaders, 2) processes structuring intertidal marine communities across continents, 3) role of sediment microbes in estuarine plant interactions, and 4) understanding how habitat-forming species facilitate biodiversity. PhD and Honours students in his group conduct research throughout Australia and internationally.

Professor Emma Johnston's research combines the disciplines of ecotoxicology and subtidal ecology in an original research program that both progresses our understanding of fundamental ecology, and provides insights and recommendations for the management of marine systems. Her research is conducted in the laboratory and in such diverse field environments as Antarctica, the Great Barrier Reef and temperate...
Further study

Australian estuaries. Emma’s group includes postdocs, research assistants and students at all levels (PhD, Masters, Honours and undergraduates). They approach research from both an ecological and ecotoxicological perspective using field experimentation wherever possible. Recent projects include: 1) Determining the major drivers of marine invasion, 2) Developing a system for assessing estuarine health and 3) Comparing the vulnerability of Antarctic assemblages to those of other regions.

Professor Richard Kingsford is the director of the Centre for Ecosystem Science (CES). His research group focuses on the ecology of inland rivers, their wetlands and dependent biota, particularly waterbirds. Recent projects include: 1) examining the distribution and extent of wetlands across New South Wales to determine representativeness in conservation reserves, 2) effects of diminishing river flows on the ecology of the Macquarie Marshes and Lowbidgee wetlands, and 3) changes in waterbird communities in relation hydrological regulation of floodplain lakes. Researchers studying aquatic ecology in the CES include Dr Nick Murray.

Associate Professor Alistair Poore conducts research into the ecology and evolution of species interactions among marine invertebrates, algae and seagrasses. Current research projects include: 1) the effects of herbivores on marine communities, 2) the ways in which consumers can tolerate plant chemical defences, 3) the evolution of host plant selection by marine herbivores, 4) effects of pollution on the invertebrate fauna inhabiting rocky reefs, and 5) tolerance of urchins and crustaceans to ocean warming and acidification.

Professor Tracey Rogers conducts multidisciplinary research to understand the ecology of marine mammals, particularly Antarctic seals. Current research projects examine the potential impacts of climate warming on the Southern Ocean ecosystem and how these changes will influence the pack-ice seals. The research uses a number of different techniques for studying foraging and spatial use behaviour of seals, including stable isotope analysis, stress and reproductive hormone analysis, satellite telemetry and acoustic surveying.

Associate Professor Jes Sammut conducts research involving sustainable aquaculture, coastal resource management, diseases of aquatic organisms and the aquatic impacts of coastal development. He is involved in aid and development work in Asia, particularly in the aquaculture and agriculture sectors. Recent projects include: 1) remediation and management of degraded earthen shrimp ponds in Indonesia and Australia, 2) identification of risk factors causing Sydney Rock Oyster production losses, 3) land capability assessment for land-based aquaculture, 4) planning tools for marine fin-fish cage culture, and 5) restoration of tsunami-impacted aquaculture ponds in Aceh.

Professor Peter Steinberg directs the Sydney Institute of Marine Sciences (SIMS). His research focuses on the chemical mediation of biological interactions and marine plant/herbivore ecology. Current basic research projects in the group include 1) the role of algal natural products in deterring fouling (epiphytism) of seaweeds, 2) chemical mediation of seaweed/bacterial interactions and larval settlement, 3) determining the costs and benefits of chemical defences, and 4) the effects of fish herbivory on algal communities. Applied projects include the development of a) novel antifouling technologies from natural antifoulants from marine organisms and b) strategies for the control of bacterial pathogens in aquaculture via inhibition of bacterial AHL regulatory systems.

Professor William Sherwin’s research group is focused on the conservation genetics of marine and terrestrial animals. Recent marine projects have included: 1)
understanding the evolution of group-formation, reproduction of bottlenose dolphins, 2) population viability of bottlenose dolphins and little penguins (penguins with Dr Jenny Sinclair; BEES), 3) understanding the connectivity among aquaculture and harvested prawn populations along the east Australian coast.

**Professor Iain Suthers** is head of the Fisheries and Environmental Research Facility at UNSW. His research group is interested in fish ecology, biological oceanography and human impacts on coastal environments. Recent projects have included 1) tracing nutrient pathways in coastal ecosystems using stable carbon and nitrogen isotopes, 2) determining the importance of physical mechanisms in blooms of plankton in coastal and estuarine systems, 3) the use of zooplankton size structure as an environmental monitoring tool, and 4) restocking of harvested fish in estuaries.

**Professor Torsten Thomas** is the Director of the Centre for Marine Bio-Innovation (CMB). His research focuses on the interaction of bacteria with their environment and aims to understand the function of the enormous diversity of bacteria in natural systems. He explores the microbial world, for example by high-throughput DNA sequencing and uses bioinformatics to make predictions about functional and ecological properties of bacterial communities. Current projects include 1) Bacteria-sponge symbiosis, 2) Microbial conversion of coal to methane, 3) Functional diversity and redundancy of marine communities, 4) Antibiotics and resistance in the marine environment and 5) Genomics of evolving, bacterial populations.

**Associate Professor Adriana Vergés** is a marine ecologist at the School of BEES and the Sydney Institute of Marine Science. Her research focuses on the ecology and conservation of coastal marine communities such as algal forests, coral reefs and seagrass meadows. Much of her recent work focuses on understanding the effects of climate change on marine communities. She has recently developed a novel line of research centred on shifting species interactions and the tropicalisation of temperate reefs in the Mediterranean, Australia and Japan. Adriana is also part of the Operation Crayweed and Operation Posidonia teams, which seek to restore underwater forests and meadows in Sydney and beyond. She is very interested in science communication.

An Honours research project in marine or freshwater ecology needs not be restricted to these topics, and joint projects with other staff members, and external supervisors (e.g., at NSW Fisheries, Australian Museum, EPA) can be considered.
Opinions in ecology

"Marine ecology has long ceased being a spectator sport"
Stephen Palumbi, Stanford University

While ecologists are usually a mild-mannered and reasonably friendly bunch, there are occasions when practicing scientists disagree strongly on various issues. It is quite common for different researchers to hold different views on the importance of different processes in marine and aquatic ecology, and what sort of research should be done. Such debate is often healthy for the science, but can leave new students confused as to what we know in ecology. Such confusion proves a particular problem when we need to communicate ecological knowledge to environmental managers or politicians.

In this exercise, students will select a topic that has been contentious and write an article that argues for one side of the debate (rather than reviews both sides of the debate). In doing so, you will need to acknowledge the criticisms of the concept you are supporting, and then argue against those criticisms. To do this successfully, you will need to read the literature critically, and select arguments and examples that support your side of the debate. The article should be written in the style of a popular science article, and may be illustrated with figures and tables.

The topics will emphasise those issues that link marine and aquatic ecology to practical problems in conservation and management of coastal environments. It is in these areas that scientists need to be able to clearly argue their point of view.

Ensure you make it clear whether you are arguing for or against a particular point. Please include a reference list in this assignment. You need to include in-text citations throughout and a list of references at the end. Word limit: 1000 words (not including references). Due date: Thursday 30th August 2018 (5pm). This report represents 10% of your mark.

Finding references. Don't rely on Google and Wikipedia! Comment pieces in journals such as Science and Nature can often point towards appropriate literature, and websites like The Conversation can also offer useful starting points. While your arguments may be guided by these popular science articles, your arguments need to be based and supported by scientific papers. The best databases for finding scientific literature are Google Scholar, Scopus and the ISI Web of Knowledge. Use the general search for finding papers on given topics or by certain authors. Use the cited reference search to find recent papers that have cited a given paper. This allows you to go forward in time from the introductory references given below.

Topics

1. We need ‘assisted evolution’ to save the world’s coral reefs

2. **World fishery stocks are lower than we think because catches are severely underestimated by official methods**  
Pauly, D., and D. Zeller. 2018. Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. *Nature Communications* 7:10244


3. **Ocean catastrophes are oversold**  

4. **We should stop fishing the high seas**  

5. **The role of sharks as apex predators in coral reefs needs to be re-assessed**  


6. **Ecologists have a duty to be environmental activists**  

7. **Coral reefs can adapt to climate change**  


8. **Marine reserves have no positive impacts on fishery catches in the Great Barrier Reef**  

9. **There are too many studies on dolphins**  

10. **Bioprospecting will harm, not save, marine environments**
Bioprospecting of genetic resources in the deep sea. United Nations University report available at

https://www.cbd.int/financial/bensharing/g-ubsseabed.pdf

11. **It is impossible to study natural marine ecosystems**

12. **There are no general laws in ecology**


13. **Introduced species in marine environments are mostly harmless**

14. **The keystone predator concept is useful for conservation biology**


15. **Reserves are essential for conservation of marine habitats**


16. **We will never be able to stop the spread of introduced marine species**

17. **It doesn’t matter how many species we lose, only which species are lost**

18. **Aquaculture has a positive effect on marine biodiversity, conservation and food security**

19. Long term monitoring of marine habitats is essential to detect environmental change

20. Introduced species enhance local biodiversity

21. Experimental marine ecology does not contribute to coastal management

22. Terrestrial ecologists don’t learn enough from marine ecologists


23. Grazing is unimportant in seagrass meadows

24. We should prioritise the conservation of the most endangered species

25. Is adaptive management of ecosystems a hopeless cause?

26. Marine renewable energy can greatly benefit biodiversity
Field projects

**Plant-herbivore field experiment**

**Practical classes in weeks 3, 4 and 10 (plus an additional week for each group)**

**Background**

Herbivores have a dramatic effect on the distribution and abundance of plants in both terrestrial and marine ecosystems. They can cause changes in the characteristics of individual plants (e.g. their morphology), in species composition of plant communities (consider the effects of sheep and rabbits on the Australian flora), and in the global distribution (biogeography) of plant taxa. As a single dramatic example, it is generally accepted that the deserts of Saharan and sub-Saharan Africa are the result of 10,000 years of grazing by sheep and goats.

Intertidal marine ecology is justifiably famous for popularising the notion that one can do ecological experiments *in the field*. However, for many years both experiments and research in general on plant-herbivore interactions along rocky intertidal shores were largely ignored. Because marine algae were studied by phycologists, and marine herbivores (snails, echinoids, fishes) by zoologists, both groups avoided each other’s alien organisms. The distribution of algae on the shore was thought to be largely a response to physical factors such as height on the shore, which has obvious effects on desiccation, nutrient levels, etc.

As scientists began to work simultaneously on both plants and animals, it became obvious that marine herbivores have a major impact on marine algae. The purpose of this practical is to determine whether local herbivores affect the distribution and/or abundance of algae on our local shores. We will do this using the powerful ecological technique of the field experiment. A secondary purpose of the practical is to introduce or (hopefully) remind you of some techniques of experimental design and analysis.

**General aims**

Looking at a typical local rocky shore at low tide one is struck by the difference in the communities low vs. higher on the shore. Near the water line the rocks are covered in algae (seaweeds) and various sessile invertebrates. Higher up the most conspicuous features of the shore are the scarcity of algae, and the abundance of grazing gastropods such as *Cellana*, *Bembicium*, *Austrocochlea*, *Nodolittorina* and *Nerita*. The major hypothesis we will test in this practical is as follows: **Herbivorous gastropods decrease the abundance of algae at mid-high levels on the shore.**

We will test this hypothesis by excluding herbivores from marked plots on the shore, and measuring changes in algal abundance within these plots over approximately 6-8 weeks. These experimental plots will be compared to un-manipulated control plots that contain natural densities of herbivores. If herbivores are having an effect, then the abundance of algae in plots without herbivores should ultimately be much greater than in control plots with herbivores.

We will also test a slightly more subtle aspect of the interaction. Changes in the abundance of algae in our plots may occur as growth of existing, very small plants, or by settlement of algal propagules and subsequent growth of these new individuals. We will test this idea by scraping some plots (both experimental and control) clear of all existing plants. Any subsequent increase in the abundance of algae in these scraped plots will then be due to new colonists.
Finally, an additional goal for this practical is to familiarise yourself with the animals and plants present on the shore. Field guides are available to help with identification.

In this experiment you need to complete the following five tasks:

1. **Experiment set-up** - this will happen on Thursday 9th of August at 1pm (i.e. low tide; please note this is earlier than the 2pm scheduled practical time)

2. **Media collection** - each group needs to upload a media collection that illustrates the main research question, the experimental design used to test our two hypotheses and that identifies the main 'actors' in the experiment. This needs to include appropriate captions. This collection will be graded as part of the assignment and needs to be completed by 4th October 2018 at 2pm (i.e. before the data analysis practical).

3. **Data collection and upload** - each group will be assigned a different week for sampling. Please upload your group name, group members and assigned sampling date ASAP after experimental set-up.

4. **Data analysis and report write-up** - the group data will be analysed during the lab session on Thursday 4th October, and after that each student will write an individual report.

5. **Experiment clean-up** - this will happen on a date to be confirmed

**1. Experimental set-up**

**Directions for fieldwork set-up: Maroubra Beach (Thursday 9th August 2018, 1pm)**

**WHERE:** Rock Platform at South Maroubra Beach. Meet in the southern corner of the far car park at the Arthur Byrne Reserve located off Fitzgerald Avenue at 12.45pm. If you are late, walk onto the beach and you will see us on the rocky platform to the south.

**WEAR:**
- Sensible clothing for seaside conditions;
- sturdy shoes for clambering over rocks (you will get your feet wet); **no thongs**
- hat and sunscreen – even on cloudy days you will get sunburnt;
- rain jacket if weather conditions vary.
- You might also like to bring something to drink if it’s likely to be hot.

**HOW:** You are expected to make your own way to the meeting point by the appropriate time. There is ample car parking if you are driving.

State Transit Bus Route 376 and 377 leaves from Belmore road southbound to South Maroubra. Phone 131 500 or visit [http://www.sydneybuses.info/](http://www.sydneybuses.info/) for times.
Notes on the Experimental Design:

An experimental design is simply an explicit description of the organisation of an experiment. Thus a proper experimental design will include a description of the different categories of data you will collect, and the number of samples within each category. Often experiments are designed with particular statistical analyses in mind, so that the results obtained at the end of the experiment can be analysed easily and powerfully. Our experiment will be designed so that the resulting data can be analysed by analysis of variance (ANOVA).

In our experiment, we are testing two main hypotheses:
1. Herbivores decrease algal abundance, and;
2. The strength of this effect is a function of whether there is some algae already in a plot.

Hypothesis 1 will be tested by comparing plots with herbivores to those without herbivores. Hypothesis 2 will be tested by comparing plots that have been scraped to those that are unscraped, especially in the absence of herbivores. Thus there are four different kinds of plots in our experiment, which can be represented in a 2 X 2 table:

<table>
<thead>
<tr>
<th>Herbivore treatment</th>
<th>Present (+)</th>
<th>Removed (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaping treatment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scraped (+)</td>
<td>H+S+</td>
<td>H-S+</td>
</tr>
<tr>
<td>Unscraped (-)</td>
<td>H+S-</td>
<td>H-S-</td>
</tr>
</tbody>
</table>
Note that H+S- are our pure control plots (completely un-manipulated).

A number of results are possible from this experiment. For example, herbivores may have a strong effect on algal abundance, but this effect may not depend on the amount of algae present in a plot when the herbivores are removed. If this is true, then algal abundance in scraped plots without herbivores should ultimately equal the abundance in unscraped plots without herbivores, and abundance in both these plots should be greater than in plots with herbivores (scraped or unscraped). However, if algae do not recruit into the plots, then algal abundance should only increase in unscraped plots in which herbivores have been removed.

If this is confusing, the best thing you can do is to consider the four combinations of treatments (experimental conditions):
1. herbivores present, scraped (H+S+);
2. herbivores present, unscraped (H+S-);
3. herbivores absent, scraped (H-S+);
4. herbivores absent, unscraped (H-S-).

Then ask yourself the following question. If herbivores do/don't have an effect, or scraping does/doesn't have an effect, what should the relative abundance of algae be like in each plot? This is far and away the best way to understand the logic of such experiments.

Procedural controls. It is possible that the copper-based paint that we will use to exclude limpets (see below) could affect the abundance the algae. To test for effects of copper other than that on herbivores, we will half paint some plots so that herbivores can move freely in and out of the plots, but any algae in the plots will still be subject to the effects of the paint. This block of plots will be treated separately from the main 2X2 design of the experiment.

Two further steps complete our experimental design:

Replication. Variation is a part of life and ecology. Although any two plots may share the same combination of treatments (e.g., H+S- or whatever), the abundance of algae or herbivores will rarely if ever be exactly the same in the two plots. This is due to differences in the location of plots, slight differences in their topography, etc. To account for this variation we must have replicate plots for each of our treatments, and in fact in the absence of replication it is impossible to meaningfully compare differences among treatments, no matter how large those differences appear.

For this experiment we will establish four separate plots for each treatment combination (H,S). Thus our experimental design is:

<table>
<thead>
<tr>
<th></th>
<th>+H</th>
<th>-H</th>
</tr>
</thead>
<tbody>
<tr>
<td>+S</td>
<td>4 replicates</td>
<td>4 replicates</td>
</tr>
<tr>
<td>-S</td>
<td>4 replicates</td>
<td>4 replicates</td>
</tr>
</tbody>
</table>

In addition, there will be four half painted plots.

Random allocation of replicates to treatments. Finally, replicate plots must be randomly assigned to each of the four treatments, otherwise we might bias the
Field projects

outcome of our experiment (for example, we might decide to put all our +H+S plots on one side of our experimental area, which may be subject to high sand scour). We have randomly assigned plots for you, with the following treatments:
H+S+ (scraped only): Plots 4, 9, 11, 19;
H+S- (unmanipulated): Plots 1, 13, 16, 20;
H-S+ (herbivores excluded, scraped): Plots 5, 8, 10, 14;
H-S- (herbivores excluded, unscraped): Plots 3, 7, 12, 18;
Half painted, unscraped: Plots 2, 6, 15, 17.

Experimental methods

i) Set-up and assignment of plots

Marking plots. Twenty 0.35 x 0.35 m² square plots will be marked out on the shore with bolts in opposite corners and numbered 1-20.

Herbivore exclusion. Herbivorous gastropods will be excluded from some plots by removing all the herbivores from selected plots and painting a border of antifouling paint which contains copper around these plots. Gastropods (there are no other taxa of important herbivores at this level on the shore) are deterred from crossing such barriers. Half painted plots will have half of each edge of the plot painted.

Scraping. Existing algae will be scraped off appropriate plots with paint scrapers, metal brushes, and a blowtorch.

ii) Sampling methods

Initial data will be collected during the set-up. Every week for at least 6 weeks, a group of students will go back to the shore and sample the experimental plots. Numbers of herbivores in the plots will be counted, and algal abundance measured. Data sheets will be available. The specific methodology is as follows:

Herbivore abundance. The numbers of herbivorous gastropods will be counted in all plots.
Algal abundance. It is often impossible to count individual algal thalli in densely packed algal "turfs". Thus algal abundance will be measured by "percent cover", in which we estimate abundance by measuring the amount of area covered in each plot by a particular organism or group of organisms. This will be done with perspex sheets with holes drilled in them, cut to fit on top of the plots. When you place the plastic on top of the plots, the holes will intersect with some organism. The number of holes which intersect with each kind of organism (primarily algae in this case) will provide an estimate of the percent cover of that organism, and hence its abundance. This is also the way in which we will measure the "abundance" of bare rock. Note that there are only fifty holes drilled in each sheet - therefore all estimates of percent cover = # holes intersected by that organism(s) x 2.

2. Media collection

Each group needs to upload a media collection that illustrates the experiment. This should consist of either a video or between 5 and 10 illustrations or photographs. The essential information that needs to be illustrated by this Media Collection is:
- Zonation patterns on the coastline, pointing towards the research question (i.e. why are there no algae in the lower intertidal?)
- The experimental design used to test our two hypotheses
Field projects

- Natural History: who are the main 'actors' in the experiment? What species are the main habitat-forming organisms in the different zones? Who are the main herbivores? Are there any obvious predators?
- What happened during the week when you sampled? Include some photographs of what the plots looked like on your sampling week.

You will need to include appropriate captions so that the images can be understood appropriately.

This group activity will be graded as part of your assignment and needs to be completed by 4th October 2018, i.e. just before the data analysis session.

3. Data collection and upload

Each group will be assigned a different week for sampling.

Please upload your group name, group members and assigned sampling date through Moodle database entitled: ‘Plant-Herbivory Experiment Groups Database: Instructions and Data upload’. Please enter your group name and add all group members by the end of Friday August 10th 2018.

Once your group goes sampling, use this database to upload your data, relevant photographs rom the field as well as to detail any maintenance performed (e.g. if you had to re-paint any plots, or if you had to remove any limpets/ gastropods from the exclusion plots).

4a. Data analysis

During the practical class on October 4th we will explain the way in which we will present and analyse the data from our field experiments. Excel files with the data will be available on the BIOS3091 Moodle site.

This experiment is designed so that results from the 16 main plots can be analysed by a two-factor (= two treatment) analysis of variance (ANOVA), where the two treatments are +/- Herbivores and +/- Scraping. This technique provides a methodology for statistically assessing differences among the four kinds of plots in the experiment. A two-way ANOVA of the data from this experiment should be included in your report. Half painted plots will be compared to +H-S plots in a separate analysis (t-test).

We will use the statistics package R to conduct the ANOVA, drawing on the material taught through Data Analysis for Life and Earth Sciences - BEES2041.

You should use the tutorials posted through the ‘Environmental Computing’ website to remind yourself of how to get started with R, enter data and plot it and how to run the ANOVA analyses and understand interactions.

The sequence of tasks you need to run through during the practical is as follows:

1. Plot the data, so that you understand what is happening. Have a think about what variable(s) you are most interested in, and what type of graph will best illustrate the results. One way to present data of this sort is to graph number or percent cover of a given organism against time, and show different treatments as different lines on the one graph.
2. Run the analyses, check assumptions, transform data if necessary.

**4b. Report on the plant-herbivore experiment**

Word limit: 1500 words + graphs and tables as needed.

Due date is **Friday, 12th October, 2018 (5 pm)**. This report represents **20% of your mark**.

The report on this experiment should be presented as a scientific report in a format as if this was to be submitted to the marine ecological journal *Marine Ecology-Progress Series* (MEPS) – formatting requirements are detailed online [here](#) through the Inter-Research Science Centre website (keep word limit to 1500 words, not 6000 as stated in this page). Thus your report should have the following sections: Title page, Abstract, Keywords, Text (Introduction, Materials and Methods, Results, Discussion), Figures and Tables, Acknowledgements and Literature Cited.

The hypotheses being tested should be clearly stated in the Introduction.

The Methods section may be kept brief and must include a section on the statistical tests used to analyse the data (but do tell us generally what you did, and include any changes in technique from the description above, do not cite this manual!).

The Results section is where you present your data as text, figures and tables, including any statistical analyses. The Results section must have text describing the results.

The Discussion section is where you place your results in the context of previous work and where you discuss the implications of your data. Do not repeat the Results in this section! Given that the two primary hypotheses tested by this experiment were:

1. herbivores limit the abundance of algae at mid-levels on the shore, and;
2. scraping the substratum reduces the rate of increase of algal abundance in the absence of herbivores;

your report should focus on these two hypotheses. Were they supported or refuted? Why? What organisms or data are most appropriate to test these hypotheses? Was our test of these hypotheses valid? That is, did our treatments work? Was our data collection accurate? What organisms other than algae and herbivores were important to our results (Hint: how do barnacles interact with algae?). In your report, relate our results to the discussion of intertidal zonation in the lectures. More specifically, I strongly suggest reading, and incorporating into your Discussion, the recommended references listed below, as well as any later papers on similar topics. Of course, address any other issues which you think are relevant as well.

**5. Experiment clean-up**

On a date to be confirmed we will need to return to the shore to clean up the experiment and remove all bolts and paint, leaving the rocky shore as we found it.

**Useful references**


---

**Plant-herbivore report: marking scheme**

The marks will be allocated to sections of the report as follows:

- Media Collection (5)
- Abstract (3)
- Introduction (10)
- Materials and methods (5)
- Results
  - Text (4)
  - Figures (4)
  - Analyses (4)
- Discussion (15)

Total (50)

*NOTE:* The five marks belonging to the Media Collection section will come from the group activity, all other components are INDIVIDUAL – i.e. each student submits their own report.
Independent field projects

Practical classes in weeks 4-5 and 13, plus time allocated independently by each group

Introduction

Understanding the ecology of organisms in field conditions, and the subsequent communication of results involves the following steps:

1) the careful formulation of hypotheses,
2) the design of field experiments and/or sampling,
3) collection of data
4) data analysis and interpretation
5) communication of results via scientific reports.

In the plant-herbivore experiment, you will gain experience in steps 3-5, but we had already provided the hypotheses and experimental designs to test these hypotheses. In this exercise, small groups of students will gain experience in all of these steps, including the formulation of your own hypotheses and sampling designs.

Planning 1 (Thursday 16th August – TL4)

Groups of students will sign up for research topics that can be addressed through field work in local marine and freshwater habitats. A list of topics will be made available through Moodle and will be discussed at this practical.

By the end of the practical, each group should:
- have formed groups and swapped contact details
- know specific hypotheses being tested
- know explicit sampling or experimental design (i.e., how many sites, times, replicates need to be collected etc.)
- know what data will be collected from each experimental or sampling unit
- know what statistical methods will be used to analyse the data
- know what equipment they will need to carry out the field work and provide list of requested materials to technical support officer (Suzy Evans)

A useful general reference for field sampling of marine habitats is:

Occupational Health and Safety

Groups will also need to identify potential risks to be incorporated into a risk assessment that will cover the class activities.
Field projects

Field work

Each group will conduct the field work at sites and times convenient to all group members. For intertidal projects, you will need to check tide times. See www.bom.gov.au/oceanography/tides/ for tide predictions.

For those of you collecting organisms from the marine environment, please remember to bring a copy of the SCIENTIFIC COLLECTION PERMIT, and to notify the relevant Fisheries Officer in the area of the activity. For contacts see: http://www.dpi.nsw.gov.au/fisheries/recreational/contact

For collections around Sydney South areas you can email: fisheries.southsydney@dpi.nsw.gov.au

Presentations (Thursday 25th October – TL4)

Each group is required to present a short talk on their field project. The aim is to educate the rest of the class on what was done and what was found.

Your presentation should include no more than 6 PowerPoint slides:

- Some background information on your project (i.e., what's your knowledge gap) – one slide
- The specific hypotheses you aimed to test – one slide
- The methods used to test the hypotheses – one slide
- Your results and their interpretation – 3 slides

Your challenge is to do all that within 10 minutes. Every student is expected to speak.

Please bring your presentation file on a USB memory stick or CD.

Report on field projects

Word limit: 1500 words of text + tables and graphs as needed. Due date is Wednesday 23rd October 2018. This report is worth 25% of your mark.

The report should be in the format of MEPS (see instructions for the plant-herbivore report).

Field project marking scheme

The marks will be allocated as follows:

- Abstract (4)
- Introduction (10)
- Materials and methods (5)
- Results
  - text (5)
  - figures (5)
  - analyses (5)
- Discussion (11)
- Oral presentation (5)

Total (50)
Algal diversity

Practical class on Thursday 6th September

Background

Algae are the dominant primary producers in aquatic environments. Consequently, understanding their distribution and abundance is of great importance to ecologists working in marine and freshwater environments. While they share some characteristics with higher plants (e.g., their photosynthetic ability), they also differ in many fundamental ways that are important to recognise if we are to understand the ecology of marine and freshwater habitats.

Aims

This practical aims to be an introduction to:

- the diversity of algae in local marine and freshwater environments,
- algal morphology, and,
- algal life histories.

A) Major algal taxa

Algae are not a single taxonomic group but a large collection of unrelated taxa. Representative specimens of common local species will be available.

Examine specimens of each of the three taxa of macroalgae; Phaeophyta (brown algae), Chlorophyta (green algae), Rhodophyta (red algae).

Make drawings and note of the characteristic features of species in the following orders:

- Fucales, Laminariales, Dictyotales, Ectocarpales (Phaeophyta)
- Ulvales, Caulerpales, Codiales (Chlorophyta)
- Corallinales (Rhodophyta)

B) Morphology

Algal morphology is very diverse and there are no obvious patterns with respect to taxonomy. Make a habit sketch of specimens whose morphology fits into each of the following categories:

1. Unicellular
2. Colonial
3. Filamentous
4. Sheet-like
5. Parenchymatous
6. Pseudoparenchymatous
7. Coenocytic

Make note the species that use calcium carbonate as a structural element.
C) Reproduction

Algae have an enormous diversity of life histories, many of considerable complexity. Using the live material, and the available literature, make life cycle diagrams of the following life histories. Ensure that you know the meaning of all the terms in italics.

1. The vegetative part of life cycle is diploid (gametic meiosis)

This life history is found in humans, most animals and some algae. A diploid zygote divides by mitosis to form a multicellular diploid organism. Eventually some of the diploid cells of this organism divide by meiosis to produce haploid cells that act as gametes. Gametes fuse to form the diploid zygote. The name refers to the fact that the organism is mostly diploid and meiosis produces gametes.

Examples: Hormosira, Sargassum

![Diagram of life cycle](image_url)
2. The vegetative part of life cycle as haploid (zygotic meiosis)

This type of life history is very common in freshwater green algae, but is also found in marine algae. In this life history, meiosis occurs right after syngamy and the resulting haploid cells divide by mitosis to form a multicellular haploid organism or many unicellular organisms. Eventually some of the haploid cells of this organism produce gametes, by mitosis, which fuse to produce the zygote (the only diploid cell), which again immediately divides by meiosis and the cycle continues. The name refers to the fact that the organism is mostly haploid and meiosis occurs in the zygote. In freshwater greens the zygote is also regularly a dormant resistant stage.

Examples: Spirogyra, Chlamydomonas
3. Both haploid and diploid phases occur (sporic meiosis, alternation of generations)

This type of life history is found in many algae and also in all terrestrial plants. In this life history, there is multicellular development of both diploid and haploid stages. Diploid individuals produce haploid spores (not gametes) by meiosis. The haploid spores germinate and develop into a multicellular haploid generation (male or female). This haploid generation produces haploid gametes by mitosis. The gametes fuse to form a diploid zygote, which in turn develops into a diploid organism. In angiosperms the haploid generation is limited to a few cells in the seed and pollen, but in many algae (also ferns and mosses) the haploid generation is an independent, free-living organism.

The multicellular diploid organism or tissue in plants, which produces spores by meiosis, is called the sporophyte (literally 'spore plant'). The multicellular haploid organism or tissue in plants which produces gametes is called the gametophyte. The alternation of these two stages in the life cycle of most plants is referred to as the alternation of generations. A sporophyte generation is followed by a gametophyte generation which is followed by a sporophyte generation etc.

These life histories may be isomorphic, with both haploid and diploid generations morphologically similar, or heteromorphic, with the haploid and diploid generations being dissimilar.

Examples: Ecklonia, Zonaria, Dictyota, Padina
4. Triphasic life histories in the Rhodophyta

The red algae have some of the most complex life histories of any known organisms. Many have a triphasic life history with two distinct diploid phases and one haploid phase. It resembles life cycle 3 (above) with the addition of a diploid phase known as the *carposporophyte*. The female gamete (*carpogonium*) is not shed into the water column and after fertilisation develops into a diploid phase (*carposporophyte*) that remains attached to the female gametophyte. This diploid tissue then develops diploid spores (*carpospores*) via mitosis which are shed into the water column. These germinate and develop into the diploid phase known as the *tetrasporophyte*. The tetrasporophyte produces haploid spores (*tetraspores*) via meiosis which develop into the haploid phase.

Examples: *Polysiphonia, Delisea*
5. Vegetative reproduction

Many algae have the capacity to increase in abundance without sexual reproduction. Vegetative reproduction may include:

- simple cell division, e.g., diatoms
- colony separation
- fragmentation
- production of mitotically derived spores
- adventitious thalli, e.g., *Dictyota*
- bulbils and other specialised vegetative structures, e.g., *Sphacelaria* propagules

D) Identification

Marine ecological research often involves the need to identify algae to species level. This usually involves using a combination of anatomical and reproductive characters. To provide some experience in identifying macroalgae, we will identify specimens from the brown algal order Dictyotales.

Members of this order occur worldwide in tropical and temperate regions. Most contain secondary compounds that are deterrent to many marine herbivores. They are recognised by a flattened, parenchymatic thallus and apical growth (either a single apical cell or a row of apical cells). Twenty-two species from 13 genera have been recognised from the New South Wales coast.

Using the key to genera of the Dictyotales on page 31 of the field guide provided, identify to genus and species each of the available specimens. Write down each of the steps taken in the key.
Microbial diversity

Microbial diversity in the marine environment

Practical class on Thursday 11th and 18th October – TL4)

Remember that a lab coat and closed shoes are essential for these two labs!

Learning Outcomes:
After successful completion of this laboratory exercise the student will be familiar with some basic microbiology techniques (microscopy, culturing, biochemical assays) and will be able to demonstrate an appreciation of microbial numbers, diversity and physiology in the environment.

Background:
Microorganisms in the environment exhibit a large functional diversity, which can be described by a range of microbiological techniques. Microscopy is a basic technique that is often employed to get a first impression of the microbial composition in a sample. Microscopy allows you to measure basic parameters, like cell numbers (population/community size), taxonomy (e.g. small (~ 1 um) bacteria versus larger (>3 um) protozoans) and diversity (e.g. shape of bacteria). Further characterization of microorganism then requires culturing onto solid media. These media are designed to facilitate the growth of a single cell into a large, clonal population (a so-called colony) that can be visually characterized (in terms of colony morphology). In addition, culturing can generate enough cell material to perform further biochemical or physiological tests.

Aims:
1. Prepare an environmental sample using sterile techniques for subsequent microbiological analysis
2. Perform a microscopic observation of a mixed microbial sample and on single isolates
3. Culture microorganisms from an environmental sample on different media
4. Assess catalase activity in individually cultured microorganisms from environmental samples.
5. Use 16S rRNA gene sequencing data and bioinformatics to identify microorganisms

Materials:
Seawater (provided for the entire class)
Green algae Ulva lactuca (provided for the entire class)
Sediment (provided for the entire class)
Scissors (metal) (one per group)
Forceps (metal) (one per group)
Spatula (metal) (one per group)
Bunsen burner (one per group)
 Pipettors plus sterile tips (1 ml and 0.1 ml) (one each per group)
Vortexer (one per bench)
Sterile Eppendorf tubes (1.5 ml) (>20 per group)
Tube rack
Sterile artificial seawater or seawater (one 100 ml bottle per group)
Microscope glass slide (one pack per group)
Staining racks
Diluted carbol fuchsin (one bottle per sink)
MA 2216 plates (3 per student)
MSSM + glucose plates (3 per student)
Single-use hockey stick/spreader
Sterile toothpicks (one jar per group)
Plates of *Staphylococcus* (catalase positive) and *Lactobacillus* (catalase negative)
10% fresh hydrogen peroxide solution
Anaerobic jars

**Procedure:**

Students should work for AIM 1-4 in teams of 3, with each student looking after one sample type. For AIM 5 students should perform their own analysis. Results should be shared and compared.

**AIM 1: Prepare an environmental sample using sterile techniques for subsequent microbiological analysis (Week 1).**

1. Sterilise the scissors, forceps and spatula by exposing the ends to the blue flame of the Bunsen burner. Move the end around in the flame for appr. 10 sec and then cool down by sitting it on the bench without touching the end (use a tip box or similar to keep the end off the bench)

2. Transfer the sample type (i.e. seawater, alga or sediment) to a sterile Eppendorf tube
   a. For seawater: pipette 1 ml from the bottle provided into the Eppendorf tube
   b. For the algal sample: using the sterilised scissors and forceps cut appr. 1 cm² of the algal thallus and transfer to tube. Add 1 ml of sterile seawater to the tube
   c. For the sediment: use the sterilised spatula to transfer approx 100 mg (0.1 ml) sediment to the tube. Use the marking on the tube to judge the amount. Then add 1 ml of sterile seawater to the tube

3. Vortex each tube for at least 1 min. Then let it stand for 1-2 min for the sediment and alga to settle. This sample solution will be used for microscopy and plating as outlined below (AIM 3).

**AIM 2: Perform a microscopic observation of a mixed microbial sample (week 1) and of single isolates (week 2)**

In this part the sample will be fixed on a slide, then stained and visualized under a 1000x magnification.

1. Transfer 10 µl of the sample (without alga or sediment) onto a glass slide and smear over an area of about 1 cm² with the pipette tip. Let the liquid air dry.

2. When smear has completely dried, heat fix by passing underside of slide rapidly through the Bunsen flame two or three times. Use forceps to hold the slide.

3. Allow to completely cool before applying any stains, then place slide on rack located over sink.

4. Add diluted carbol fuchsin to the slide enough to completely cover the area with the air-dried sample. Let sit for 1-2 min.
5. Wash the slide under a gentle water stream, blot dry and examine under light microscope.

6. Set up your microscope correctly as demonstrated by your tutor (information can also be found in the appendix).

7. Examine the microorganisms in the sample using low (10x), medium (40x) and high power (100x) objectives. After focusing on an organism, reduce the condenser diaphragm to the position where you see the clearest image. NB: The high power objective (100x) will require oil (see appendix), please ask a demonstrator if you are unsure of how this is used.

8. Observe the overall appearance of the microorganism. Note the effect of microscope adjustment on the resolution. Make a diagram (in the space below), noting the shapes and sizes, which can be resolved with the 100x objectives.

AIM 3: Culture microorganisms from an environmental sample on different media (Week 1)

1. Make serial dilution of your samples as shown in Figure 1. Transfer 900 ul of sterile seawater into two tubes and label them “1:10” and “1:100”. Transfer 100 ul from your sample tube to the “1:10” tube using a sterile pipette. Vortex the “1:10” tube well and transfer from it 100 ul to the “1:100” tube using a fresh, sterile pipette. Vortex the “1:100 tube” well.
2. Label the base (not the lid) of three MA 2216 plates and three MSSM + glucose plates (see appendix for recipe) with your name, date, sample type (ie. seawater, alga, sediment) and either “undiluted”, “1:10” or “1:100” and either “aerobic” or “anaerobic”. The simple scheme is illustrated here:

<table>
<thead>
<tr>
<th>Plate</th>
<th>Media</th>
<th>Dilution</th>
<th>Aerobic/anaerobic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MA 2216</td>
<td>Undiluted</td>
<td>Aerobic</td>
</tr>
<tr>
<td>2</td>
<td>MA 2216</td>
<td>1:10</td>
<td>Anaerobic</td>
</tr>
<tr>
<td>3</td>
<td>MA 2216</td>
<td>1:100</td>
<td>Aerobic</td>
</tr>
<tr>
<td>4</td>
<td>MA 2216</td>
<td>Undiluted</td>
<td>Anaerobic</td>
</tr>
<tr>
<td>5</td>
<td>MA 2216</td>
<td>1:10</td>
<td>Aerobic</td>
</tr>
<tr>
<td>6</td>
<td>MA 2216</td>
<td>1:100</td>
<td>Anaerobic</td>
</tr>
<tr>
<td>7</td>
<td>MSSM + glucose</td>
<td>Undiluted</td>
<td>Aerobic</td>
</tr>
<tr>
<td>8</td>
<td>MSSM + glucose</td>
<td>1:10</td>
<td>Anaerobic</td>
</tr>
<tr>
<td>9</td>
<td>MSSM + glucose</td>
<td>1:100</td>
<td>Aerobic</td>
</tr>
<tr>
<td>10</td>
<td>MSSM + glucose</td>
<td>Undiluted</td>
<td>Anaerobic</td>
</tr>
<tr>
<td>11</td>
<td>MSSM + glucose</td>
<td>1:10</td>
<td>Aerobic</td>
</tr>
<tr>
<td>12</td>
<td>MSSM + glucose</td>
<td>1:100</td>
<td>Anaerobic</td>
</tr>
</tbody>
</table>

3. Drop 100 ul with a pipettor onto the centre of the corresponding agar plate.

4. Use a single-use hockey stick/ spreader to evenly distribute the liquid over the whole area of the agar plate. Wait for sample to dry and then place with the lid down into the sample box provided. The anaerobic plates will be put by your demonstrator into an anaerobic jar. The plates will be incubated until next week at 20°C.
AIM 3: Culture microorganisms from an environmental sample.....continued
(Week 2)

1. Look at your agar plates and count the number of colonies found on each plate. Please also describe the colony morphology in terms of colour, size and structure (see appendix) for the 5-10 most frequently observed colonies. Note these results in the table below and work as a team to compare your observations:

<table>
<thead>
<tr>
<th>Sample</th>
<th># colonies</th>
<th>Morphotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seawater</td>
<td></td>
<td></td>
</tr>
<tr>
<td>undiluted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alga</td>
<td></td>
<td></td>
</tr>
<tr>
<td>undiluted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sediment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>undiluted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Observation of anaerobic MA 2216 plates

<table>
<thead>
<tr>
<th>Sample</th>
<th># colonies</th>
<th>Morphotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seawater</strong></td>
<td>undiluted</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:100</td>
<td></td>
</tr>
<tr>
<td><strong>Alga</strong></td>
<td>undiluted</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:100</td>
<td></td>
</tr>
<tr>
<td><strong>Sediment</strong></td>
<td>undiluted</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:100</td>
<td></td>
</tr>
</tbody>
</table>

### Observation of aerobic MSSM + glucose plates

<table>
<thead>
<tr>
<th>Sample</th>
<th># colonies</th>
<th>Morphotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seawater</strong></td>
<td>undiluted</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:10</td>
<td></td>
</tr>
</tbody>
</table>
### Observation of anaerobic MSSM + glucose plates

<table>
<thead>
<tr>
<th>Sample</th>
<th># colonies</th>
<th>Morphotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seawater</strong></td>
<td>undiluted</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:100</td>
<td></td>
</tr>
<tr>
<td><strong>Alga</strong></td>
<td>undiluted</td>
<td></td>
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<tr>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Compare the amount and types of colonies and morphotypes you found in each sample for the two different types of plates and aerobic/anaerobic conditions. Consider that MA 2216 is a nutrient-rich media (see recipe in appendix), which would support the growth of copiotrophic bacteria, while MSSM + glucose is low in nutrients and is therefore more suitable for the growth of oligotrophic bacteria. How do your observations relate to the anticipated nutrient availability of your samples (e.g., seawater v. sediment)? Did you see microbial colonies on the anaerobic plates? If yes, what type of sample would have anaerobic conditions (even on the micro- or milli-metre scale) that would support the growth of anaerobic microorganisms?

Please discuss your thoughts with your colleagues and demonstrator and write them down here:
AIM 3: Perform a microscopic observation of a mixed microbial sample and of single isolates.....continued

1. Perform a microscopic observation of at four different colony types. For this drop 10 µl of sterile seawater onto a glass slide. Then use a sterile toothpick to collect a small amount of the colony you want to observe and smear it in the drop on the glass slide. Mix thoroughly to create a suspension and spread over an area of about 1 cm². Let the liquid air dry.

2. Fix, stain and visualise as described in 2-8 in the “Microscopy” section (Aim 2).

3. Please note your observation in terms of cell shape, size and other features, below:

<table>
<thead>
<tr>
<th>Colony description</th>
<th>Cell description</th>
<th>Drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Do colonies with similar/identical morphology contain similar or different cell types?

Do different colonies have similar cell types?

AIM 4: Assess catalase activity in individually cultured microorganisms from environmental samples (Week 2)

This assay will determine if a microorganism has catalase activity. The enzyme catalase converts hydrogen peroxide (H₂O₂) to water and molecular oxygen. The production of molecular oxygen is visible through the formation of bubbles in the assay. Hydrogen peroxide is produced as a defense chemical by many marine algae and during aerobic growth and can cause damage to cellular proteins, lipids and nucleic
acids. Microorganisms produce catalase to reduce this damaging effect.

1. Two control microorganisms will be provided: *Staphylococcus* (catalase positive) and *Lactobacillus* (catalase negative).

2. Place four times three drops (20 ul) of 10% hydrogen peroxide solution onto glass slides (i.e. three drops per glass slide = 12 drops).

3. Using a sterile toothpick, transfer the two controls and 10 of your colonies separately to a drop (please take 5 colonies from each medium, if available). Once you add the colonies to the solution, mix quickly and thoroughly with the toothpick and look for bubbles. The positive and negative control should represent bubble and non-bubble formation, respectively.

4. Note observation in the attached table and compare with your group members:

<table>
<thead>
<tr>
<th>Organisms</th>
<th>Bubble (yes/ no)</th>
<th>Catalase (+/-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seawater</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Staphylococcus</em></td>
<td>Colony 1 (aerobic)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colony 2 (aerobic)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colony 3 (aerobic)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colony 4 (aerobic)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colony 5 (aerobic)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colony 6 (anaerobic)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colony 7 (anaerobic)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colony 8 (anaerobic)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colony 9 (anaerobic)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colony 10 (anaerobic)</td>
<td></td>
</tr>
<tr>
<td>Alga</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colony 1 (aerobic)</td>
<td></td>
<td></td>
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<tr>
<td>Colony 2 (aerobic)</td>
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<tr>
<td>Colony 3 (aerobic)</td>
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<td></td>
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<tr>
<td>Colony 4 (aerobic)</td>
<td></td>
<td></td>
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<tr>
<td>Colony 5 (aerobic)</td>
<td></td>
<td></td>
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<tr>
<td>Colony 6 (anaerobic)</td>
<td></td>
<td></td>
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<tr>
<td>Colony 7 (anaerobic)</td>
<td></td>
<td></td>
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<tr>
<td>Colony 8 (anaerobic)</td>
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<tr>
<td>Colony 9 (anaerobic)</td>
<td></td>
<td></td>
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<tr>
<td>Colony 10 (anaerobic)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sediment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colony 1 (aerobic)</td>
<td></td>
<td></td>
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<tr>
<td>Colony 2 (aerobic)</td>
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<td>Colony 3 (aerobic)</td>
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<td></td>
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<tr>
<td>Colony 9 (anaerobic)</td>
<td></td>
<td></td>
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<tr>
<td>Colony 10 (anaerobic)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Microbial diversity

Do you find more catalase-positive colonies on any sample type, medium and growth condition (i.e. aerobic versus anaerobic)? How might this be related to growth properties or habitat of the microorganism?

**AIM 5: Use 16S rRNA gene sequencing data and bioinformatics to identify a microorganism (Week 1 and 2)**

This aim will be fulfilled by “home-work” after week 1 and discussion in week 2. In this aim you will first analyse the 16S rRNA gene sequence of a bacterial isolate in order to taxonomically classify the bacterium. Once you know what kind of bacterium you have, you will then learn more about it through a brief literature search.

1. Go to the Moodle page of BIOS3091 and download the file “16S_rRNA_gene_sequence_marine_isolate.fna”. This file contains the 16S rRNA gene sequence of a bacterial isolate.
2. If you open the file in a text editor (e.g. notepad), then the first few lines will look like this:

```
> bacterial_isolate_BIOD3091_16S_rRNA_gene_sequence
AGAGTTTGATCATGGCTCAGATTGAACGCTGGCGGCAGGCCTAACACAT
G
CAAGTCGAGCGGAAACGACTTAACTGAACCTTCGGGGAACGTTAAGGGC
G
```

   This is called a fasta format, where the text after the “>” give the sequence name and the next lines give the sequence of the gene.
3. This sequence will be classified by comparing it to the Ribosomal Database Project (RDP), a comprehensive database of 16S rRNA gene sequence and taxonomic information. You can learn more about RDP in the following citation: Wang et al. Applied and Environmental Microbiology 2007, 73(16) 5261-5267 (http://aem.asm.org/content/73/16/5261)
4. Go to the following weblink to access the classification tool of the RDP database: https://rdp.cme.msu.edu/classifier/classifier.jsp.
5. Paste the 16S rRNA gene sequence including in line with the ‘>’ into the field “Cut and paste sequence(s) (in Fasta, GenBank, or EMBL format)”. Then hit submit.
6. The classification tool will return a result showing the taxonomic assignment of your sequence from the phylum down to the genus level. Take note of the full taxonomic classification. What is the genus level assignment of your sequence?
7. Do a literature research on this genus using available database, such as Google Scholar and Pubmed. On the following page address the following questions:
Result of literature search for the genus of a bacterial isolate

Genus:

Name three species that belong to the genus:

What did you find out about the physiology of the genus? E.g. is it aerobic or anaerobic? Is it copiotrophic or oligotrophic?

What are the ecological functions of some of the species belonging to the genus? Are any involved in marine, microbial disease? Are any of the symbiotic?

Please discuss your finding in week 2 with your colleagues and demonstrator.
Appendix

MICROSCOPY

1.1 Parts of the light microscope

There are many makes and models of light microscope. However, all light microscopes are fundamentally the same, have similar controls and functions. The microscope illustrated below is typical of the light microscope used in UNSW teaching.
1.2 Setting up the light microscope

1. Switching on microscope

Turn the power switch ✶ on.

Rotate the voltage control ✶ clockwise to reduce light intensity or counter clockwise to increase intensity.

2. Specimen placement

Open the spring-loaded finger of the specimen holder ✶ and insert the slide.

3. Focus

Swing in the 10x objective ✶.

Bring the specimen into focus using the course and fine adjustment knobs ✶.

4. Interpupillary distance

Looking through the binocular tube, move the knurled dovetail slides ✶ until a suitable binocular vision is obtained.
5. **Diopter adjustment**

Look at the image through the right eyepiece with your right eye, and focus on the specimen with the fine focus adjustment.

Looking at the image through the left eyepiece with your left eye, rotate the diopter adjustment ring \* to focus on the specimen without using the focus adjustment knobs.

6. **Centration of field iris diaphragm**

Rotate the diaphragm ring \* counter clockwise to stop down the iris diaphragm to minimum.

Rotate the condenser height adjustment knob \* in either direction until the image of the field diaphragm is visible sharply in the field of view.

7. **Objective change**

Swing in the desired objective for use.

Ensure that the nosepiece is clicked into position.

8. **Aperture iris diaphragm adjustment**

Turn the diaphragm lever \* counter clockwise to reduce diaphragm opening.
1.3 Resolution

A lens magnifies by bending light. Optical microscopes are restricted in their ability to resolve features by a phenomenon called diffraction which, based on the numerical aperture (NA or $A_N$) of the optical system and the wavelengths of light used ($\lambda$), sets a definite limit ($d$) to the optical resolution. Assuming that optical aberrations are negligible, the resolution ($d$) is given by:

$$d = \frac{\lambda}{A_N}$$

Usually, a wavelength of 550 nm is assumed, corresponding to green light. With air as medium, the highest practical $A_N$ is 0.95, and with oil, up to 1.5.

Due to diffraction, even the best optical microscope is limited to a resolution of 0.2 micrometers.

1.4 Oil immersion

The oil immersion lens (100X), when used with a drop of oil, prevents refraction or deflection of angled light from its straight path that would occur if the light were to pass at an angle from glass into air. The degree to which the light is refracted or bent by a substance is formulated as its refractive index. As you might expect, the numerical aperture of a lens, the light-function constant you used to calculate the resolution, is determined in part by the refractive index of the glass.

To prevent the light from being bent away on an angled path from the objective lens, allowing the maximum amount of light from the specimen to be gathered by the objective, a drop of immersion oil may be placed on the specimen and the oil immersion objective then lowered into the oil.

Immersion oil has the same refractive index as the glass so light travelling up through the slide, the oil and the objective lens is not refracted again until it passes from the convex upper surface of the lens into the air above. That bending, however, is what the lens is designed to do, sending the rays which left the specimen at angles up the tube at new coherent angles to be resolved and magnified by the ocular lens.

As light strikes the specimen the qualities of the light are changed in several ways that give the visual image we perceive. It may be scattered or reflected away from a path leading to the objective, darkening the image; it may be completely occluded by solid structures that appear black to the observer; specific wavelengths of the light may be partially absorbed by certain substances (including stains), giving a characteristic colour to structures containing them.

1.5 Microscopy trouble shooting

Occasionally you may have trouble with working your microscope. The following are some common problems and solutions.
Microbial diversity

- Image is too dark!
  *Adjust the diaphragm, make sure your light source is on.*

- There's a spot in the viewing field, even when I move the slide the spot stays in the same place!
  *Your lens is dirty. Use lens paper, and only lens paper to carefully clean the objective and ocular lens. The ocular lens can be removed to clean the inside.*

- Can't see anything under high power!
  *Remember the steps, if you can't focus low power, you won't be able to focus anything under high power.*

- Only half of the viewing field is lit, it looks like there's a half-moon in there!
  *You probably don't have your objective fully clicked into place*

<table>
<thead>
<tr>
<th>Apparent fault</th>
<th>Possible cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field dark</td>
<td>Power (lamp) not on or turned down too low</td>
<td>Turn power on &amp; check voltage</td>
</tr>
<tr>
<td></td>
<td>Condenser diaphragm closed</td>
<td>Open diaphragm</td>
</tr>
<tr>
<td></td>
<td>Lamp filament burnt out</td>
<td>Replace lamp</td>
</tr>
<tr>
<td>Colour of objects indistinct</td>
<td>Condenser diaphragm closed too far</td>
<td>Open diaphragm</td>
</tr>
<tr>
<td>Poor resolution</td>
<td>Condenser either too far open or too far closed</td>
<td>Adjust condenser diaphragm</td>
</tr>
<tr>
<td>Unable to focus on object</td>
<td>Cover-slip too thick</td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td>Slide up-side down</td>
<td>Invert slide</td>
</tr>
<tr>
<td></td>
<td>Focusing attempts too rapid</td>
<td>Use fine focus and adjust more slowly</td>
</tr>
<tr>
<td></td>
<td>Objective has insufficient resolving power</td>
<td>Use higher power</td>
</tr>
<tr>
<td></td>
<td>Objective covered with dried immersion oil from previous use</td>
<td>Clean with lens tissue and solvent</td>
</tr>
<tr>
<td>Specks in field of view</td>
<td>Dirt on eye lens of ocular</td>
<td>Clean with lens tissue</td>
</tr>
<tr>
<td></td>
<td>Dirt on condenser lens</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dirt on filter</td>
<td></td>
</tr>
<tr>
<td>Moving shadows in field</td>
<td>Air and/or water bubbles in immersion oil</td>
<td>Remove oil with lens tissue. Re-apply</td>
</tr>
<tr>
<td>Light suddenly reduced</td>
<td>No oil contact between oil immersion objective and slide</td>
<td>Adjust with course /fine focus control</td>
</tr>
</tbody>
</table>
BACTERIAL COLONIAL DESCRIPTION

4.1 Edges of bacterial colonies

- Entire
- Radially striated & lobate
- Undulate
- Fimbriate
- Lobate
- Rhizoid
- Crenated

4.2 Elevation of bacterial colonies

- Flat
- Raised
- Low convex
- Dome
- Umbonate
- Convex papillate
Microbial diversity

**Marine agar (MA) 2216**

**Description:** For the isolation and enumeration of marine heterotrophic bacteria. The medium has high nutrient concentrations and is therefore particular suitable for the isolation of copiotrophic bacteria.

**Formulation (g/L):**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peptone, Bacteriological</td>
<td>15.0</td>
</tr>
<tr>
<td>Sodium Chloride</td>
<td>19.4</td>
</tr>
<tr>
<td>Sodium Sulfate</td>
<td>3.24</td>
</tr>
<tr>
<td>Potassium Chloride</td>
<td>0.55</td>
</tr>
<tr>
<td>Ferric Citrate</td>
<td>0.10</td>
</tr>
<tr>
<td>Strontium Chloride</td>
<td>0.034</td>
</tr>
<tr>
<td>Ammonium Nitrate</td>
<td>0.0016</td>
</tr>
<tr>
<td>Agar</td>
<td>15.0</td>
</tr>
<tr>
<td>Yeast Extract</td>
<td>1.0</td>
</tr>
<tr>
<td>Magnesium Chloride</td>
<td>8.8</td>
</tr>
<tr>
<td>Calcium Chloride</td>
<td>1.8</td>
</tr>
<tr>
<td>Sodium Bicarbonate</td>
<td>0.16</td>
</tr>
<tr>
<td>Potassium Bromide</td>
<td>0.08</td>
</tr>
<tr>
<td>Boric Acid</td>
<td>0.022</td>
</tr>
<tr>
<td>Sodium Fluoride</td>
<td>0.0024</td>
</tr>
<tr>
<td>Disodium Phosphate</td>
<td>0.008</td>
</tr>
<tr>
<td>Sodium Fluoride</td>
<td>0.0024</td>
</tr>
</tbody>
</table>

*Final pH 7.6 ± 0.2*

**Preparation:**

Suspend 55.1 g of the medium in one litre of deionized or distilled water. Mix well. Heat to boiling until solution is complete. Dispense and sterilize at 121°C (15 lbs psi) for 15 minutes. The medium is amber, clear, slightly opalescent and may have a slight precipitate. Cool to 45°C. Swirl gently before pouring into Petri dishes.
Marine Simple Salt Medium (MSSM) agar with glucose

**Description:** Medium has a defined and low concentration of glucose. This medium is therefore suitable for growing oligotrophic organisms that can use glucose as a carbon and energy source.

**Formulation (g/L):**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Concentration (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Chloride</td>
<td>19.4</td>
</tr>
<tr>
<td>Sodium Sulfate</td>
<td>3.24</td>
</tr>
<tr>
<td>Potassium Chloride</td>
<td>0.55</td>
</tr>
<tr>
<td>Iron sulfate</td>
<td>0.002</td>
</tr>
<tr>
<td>Strontium Chloride</td>
<td>0.034</td>
</tr>
<tr>
<td>Sodium Silicate</td>
<td>0.004</td>
</tr>
<tr>
<td>Ammonium sulfate</td>
<td>1</td>
</tr>
<tr>
<td>Agar</td>
<td>15.0</td>
</tr>
<tr>
<td>Magnesium Chloride</td>
<td>8.8</td>
</tr>
<tr>
<td>Calcium Chloride</td>
<td>1.8</td>
</tr>
<tr>
<td>Sodium Bicarbonate</td>
<td>0.16</td>
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<tr>
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<tr>
<td>Sodium Fluoride</td>
<td>0.0024</td>
</tr>
<tr>
<td>Disodium Phosphate</td>
<td>0.08</td>
</tr>
<tr>
<td>Glucose</td>
<td>1</td>
</tr>
</tbody>
</table>

- dissolve each compound separately before adding the next
- adjust pH to pH 7.6 ± 0.2
SPECIAL CONSIDERATION AND FURTHER ASSESSMENT
SEMESTER 2 2018

Students who believe that their performance, either during the session or in the end of session exams, may have been affected by illness or other circumstances may apply for special consideration. Applications can be made for compulsory class absences such as (laboratories and tutorials), in-session assessments tasks, and final examinations. **Students must make a formal application for Special Consideration** for the course/s affected as soon as practicable after the problem occurs and **within three working days of the assessment to which it refers.**

Students should consult the “Special Consideration” section of the UNSW current students’ website for further information [https://student.unsw.edu.au/special-consideration](https://student.unsw.edu.au/special-consideration).

HOW TO APPLY FOR SPECIAL CONSIDERATION
Applications must be made via Online Services in myUNSW. **You must obtain and attach Third Party documentation before submitting the application.** Failure to do so will result in the application being rejected. Log into myUNSW and go to **My Student Profile tab > My Student Services channel > Online Services > Special Consideration.** After applying online, students must also verify supporting their documentation by submitting to **UNSW Student Central:**

- Originals or certified copies of your **supporting documentation** (Student Central can certify your original documents), and
- A completed **Professional Authority form (pdf - download here).**

The supporting documentation must be submitted to Student Central for verification **within three working days** of the assessment or the period covered by the supporting documentation. Applications which are not verified will be rejected.

Students will be contacted via the online special consideration system as to the outcome of their application. Students will be notified via their official university email once an outcome has been recorded.

SUPPLEMENTARY EXAMINATIONS:
The University does not give deferred examinations. However, further assessment exams may be given to those students who were absent from the final exams through illness or misadventure. Special Consideration applications for final examinations and in-session tests will only be considered after the final examination period when lists of students sitting supplementary exams/tests for each course are determined at School Assessment Review Group Meetings. Students will be notified via the online special consideration system as to the outcome of their application. **It is the responsibility of all students to regularly consult their official student email accounts and myUNSW in order to ascertain whether or not they have been granted further assessment.**

For Semester 2 2018, BEES Supplementary Exams will be scheduled on:

**Saturday 8 December - Saturday 15 December**

**Further assessment exams will be offered on these days ONLY and failure to sit for the appropriate exam may result in an overall failure for the course. Further assessment will NOT be offered on any alternative dates.**