Coral Reef Ecosystems:
Habitats, processes and biodiversity
National Tropical Marine Network
Course coordinator: Prof Maria Byrne (USyd)
Lecturers: Dr Sophie Dove (UQ), Dr Lynne van Herwerden (JCU), Maria Byrne (USyd).

Overview of the course
This course aims to introduce the key organisms and the biological and non-biological processes that make up coral reef ecosystems. Students who attend the courses will build skills in the following areas: classification of coral reef organisms, observation and data collection, laboratory and field techniques. Delivery of the course will include lectures, laboratory sessions and fieldwork. A major focus of the second half of the course is student projects that aim to develop independent research skills. The course will be held at One Tree Island Research Station and will be delivered by a multidisciplinary team from the four institutions. Assessment is based on presentations and written work, essays, a project report and a written exam.

Specific course objectives
• To gain a comprehensive understanding of the diversity of coral reef organisms.
• To understand the biogeography and oceanography of coral reefs and the concept of biological connectivity.
• To understand the physiological processes underlying reef primary production and consumption.
• To appreciate the necessity for systematic studies of coral reef organisms.
• To understand the processes involved in management issues specific to the Great Barrier Reef and global tropical ecosystems.
• To appreciate the influence of climate change and other anthropogenic influences on the integrity of reef systems.
• To gain insight into the approaches involved with tropical marine research
• To develop the capacity to conceive and undertake an independent research project.

Curriculum details
In total there are 16 lectures delivered by different members of the teaching staff. The group research project will involve 2 days of intense group work in the laboratory, field or both depending on the nature of the project. Assistance in the conception, design and analysis of experiments will be provided in a lecture and tutorial session. **Students are warned to not exceed their "statistical comfort zone" as they, rather than either the lecturers or tutors, will be responsible for the analysis presented in the final project write-up**. Groups will give a presentation on their initial project findings. All students will be required to develop portfolios on 3 distinct organisms and give a short presentation (5 min) based on one of these organisms. For the first six days of the course, there are 3-4 presentations by staff, in the morning, afternoon and evening. Timing of the lectures during day-light hours varies from day to day to facilitate the field exercises that require working the high and low tide windows. The class is divided into 4 groups who rotate through the 4 field exercises and 4 laboratory exercises. The exam will be held post-lunch on day 7 with the morning set aside for exam revision. Daylight hours of day 8 and 9 are set aside

for group projects, with the evenings taken up for the most part by portfolio presentations.

A course manual of powerpoint lecture notes will be given to each student. Reading resources are also provided for each lecture. These are a set of recent publications, 3-5
per lecture, the Coral Reef Handbook and a number of library texts. Much of the lecture material is based on individual research of the instructors and so details may not be found in textbooks. In the non-contact hours students are encouraged to avail of the reading resources provided. This reading material will also be useful background when considering research projects.

Pre-course assignments
Students are required to do some reading prior to the course and prepare 2 short (1500 words) essays. Essay questions and resource references are on the course web site:
http://www.tmnonline.net/cre.html . Some older references are available on-line through the University of Sydney library home page. The selection of references for this on-line exercise is a valuable resource for the course and projects. Students are encouraged to become familiar with the topics covered in the papers provided. Essays are to be submitted to Maria Byrne (mbyrne@anatomy.usyd.edu.au) on the 13th of July, 2009. Students should also bring back-up printouts of essays to be handed in on arrival at HIRS. It is recommended that students devote at least 6 hours to this exercise.

Lectures (90 min each) (TBC)

Lecture 1: Biogeography: Fishes of the Great Barrier Reef (LvH)
This lecture presents the global patterns of coral reef biogeography and an introduction to the geomorphology and oceanography of the Great Barrier Reef (GBR). The factors correlating with the distribution and abundance of reef organisms and some of the underlying processes underlying formation of different types of reef. A general overview of the biogeography of the Indo-Pacific is presented.

Lecture 2: Oceanography of Australia and Great Barrier Reef (LvH)
The water column is inhabited by a diversity of organisms that are influenced to a varying degree by the oceanography of their habitat. The influence of oceanography on distribution patterns, feeding and survivorship, movement, reproduction and settlement patterns of coral reef organisms is presented. Some organisms are readily advected in prevailing water flow while others can avoid advection. This lecture covers the influence of oceanography in tropic regions from small scale at the level of planktonic organisms to the big picture created by the major currents. For the GBR, the East Australia Current (EAC) and El Nino Southern Oscillation (ENSO) are particularly important. Finally the link between oceanography and fisheries of the region is discussed.

Lecture 3: Vertebrates of coral reefs (LvH)
An overview of the vertebrates of tropical regions is presented with an emphasis on the fishes their taxonomy, morphology, trophic groups, reproduction and changes in biology with age. The link between ecology and behaviour is explored and how diet is influenced by time, space and the size and age of fishes. For the different groups of fishes, the significance of morphological specialisations on diet is explained as is the need to be cautious when only considering morphology when assessing the lifestyle of fishes.

Lecture 4: Reef invertebrates: overview of diversity and research (MB)
An overview of tropical marine invertebrates is presented with a link to areas of current research undertaken on species from the Capricorn-Bunker Group and elsewhere in the GBR and the Indo-Pacific. Invertebrates are in focus for a number of reasons ranging from marine chemistry and aquaculture to the outbreaks of crown-of-thorns starfish. As each invertebrate group are discussed current research emphasis is presented.

Lecture 5: Reproduction of reef invertebrates – complex life cycles (MB)
The lecture presents the diversity of reproductive strategies and life history traits of tropical marine invertebrates. It addresses the long-held paradigm that sexually reproduction in tropical regions should be continuous. We will assess under which circumstances and for which taxa this notion holds or does not hold. For many tropical invertebrates asexual or vegetative propagation is the norm and the importance of this is presented. For corals, the ongoing broadcast -vs- brooding debate is put into perspective for the Great Barrier Reef and other tropical regions. The complex life cycles of reef invertebrates and the connection between benthic adults and their planktonic propagules is presented.

Lecture 6: Benthos - Tropical lagoons and sandy reef flats (MB)
Sandy lagoons, mainly comprised of carbonate sands, occupy approximately 33% of the GBR. These lagoons play a major role as sinks for storage and release of nutrients. They are associated with a diversity of epifaunal and infaunal organisms that have a major influence on sediment turn over rates. The hypothesis that tropical sandy lagoons are detritus based is examined. Research from several lagoons in the GBR provides important insights into the importance of bioturbation and the organisms involved.

Lecture 7: Darwin's Paradox and nutrient cycles (SD)
This lecture presents the dilemma how such a high diversity of organisms exist in habitats what are essentially nutrient deserts. Tropical surface waters are generally depleted of nutrients but local biomass is large. How is this achieved and where do the nutrients to support this biomass come from? This lecture explores Darwin's Paradox and explains fundamentals of the nitrogen cycle, the phosphorous cycle and reef primary productivity. The reef fertilisation experiments at One Tree Reef lagoon are presented as a specific case study.

Lecture 8: Symbiosis and nutrient re-cycling (SD)
Symbiosis in tropical regions is expressed in plant-animal symbioses, a feature essential in the very existence of coral reefs. The range of other symbioses observed on coral reefs such as fish-cnidarian symbioses are also presented. A full appreciation of the diversity and taxonomy of organisms involved in symbioses in reef systems is key to our understanding of coral reef systems. The importance of symbiosis to nutrient recycling, a fundamental process in tropical reef habitats is presented.

Lecture 9: The ecology of Coral reef Macro-algae (SD)
Macroalgae play important roles in the ecology of coral reefs, including contributions to primary production, reef construction, and reef degradation. This lecture explains the ecological roles, describes the temporal and spatial pattern of distribution of algae and introduces the topic of coral-algal competition. The regulation of the abundance of macroalgae in response to environmental factors and conditions is discussed, as well as the impacts of global climate change on the reef algal

assemblages. The taxonomic classification and the classification into functional form groups is also presented.

Lecture 10: Photosynthesis and primary production on coral reefs (SD)
The photobiology of coral reef ecosystems is complex and a challenge to understand. In this lecture the physiological basis of the relationship between corals and their symbiotic dinoflagellates is explained. This included an overview of basic photosynthetic processes, the players involved and how best to quantify these processes.

Lecture 11: Energy flow on coral reefs (SD)
The pathways of energy flow on coral reefs are described. This involves primary producers, grazers, particulate feeders and predators. On coral reefs mucus loops and
bacterial decomposition are very important. Each link in the flow system from primary production to top consumers is described, as are all the feedback mechanisms.

Lecture 12: Calcification and the carbonate balance (SD)
Calcification is a major process underlying construction of coral reefs and is the ultimate source of the carbonate sands in lagoonal systems. This lecture describes calcification and the carbonate balance of reef systems. The various methods for measuring calcification are detailed. Research on the history of calcification of the world's reef systems through examination of cores provides important insights into reef growth patterns over geological time. This is important in putting the evolutionary history of the
GBR into perspective.

Lecture 13: Bioerosion and Ocean Acidification (SD)
On healthy reefs, reef growth is balanced by reef destruction. On damaged reefs, the rate of reef substrate destruction tends to exceed the rate of production. Destructive forces can be physical, chemical or biological. This lecture introduces the agents of reef bioerosion, and contrasts bioerosion processes as they occur on healthy and damaged reefs. The lecture ends with the potential effects of ocean acidification on reef balance.

Lecture 14: Human Impacts and reef futures (SD)
More than half of the world's coral reefs are threatened by human activity. This is serious not just for loss of biodiversity but for the very existence of coastal populations, both from an economic and habitat perspective. By their nature reefs have a long-term role in stabilising coastlines. Human impacts on the GBR are put in a historical perspective and our current understanding of the causes, mechanisms and consequences of coral bleaching is presented.

Lecture 15: Migration and connectivity of marine populations (LvH)
Understanding the movements of organisms on large and small scales is important to determine how reefs are connected and what are the sources and sinks of propagules for recruitment. Daily and annual migrations are features of many small planktonic animals and fishes. In this lecture the significance of migration in avoidance of predation, in feeding, reproduction and photoprotection is presented. What are the behavioural and physiological mechanisms underlying predictable migratory behaviour? The importance of understanding animal migrations to the structure and maintenance of marine populations is presented.

Lecture 16: Sampling design and analysis for Projects

This lecture will take the form of a discussion session. It is aimed at helping the student understand the process of constructing hypotheses, allocating sampling units in space and time, and appropriate analyses and graphical presentations. The staff on the course will provide examples of how design their experiments and analyse their data.

Field and Lab Exercises will be held

Group Projects (20 hr project research + 10 min presentation)
It is expected that students will work in groups of 4-5 people to achieve the group projects. A lecture (13a) and tutorial (13b) will assist students in sampling design, conceiving and designing a research project. Discussion of subject of the project will be undertaken with the relevant staff member who will provide support for the group as needed through the project activity. While the design of the project and the collection of data are group activities, it is expected that project reports are written up independently.

Each group will provide an overview of their project and findings in a presentation to the class followed by a short discussion. These presentations will be given on the last morning and depending on the number of projects will take 1-1.5 hrs. All students are required to attend this presentation session.

Assessed work
1. Two short-essays (1500 words each) - 20%
2. Exam (2 hours) - 50%
3. Project report (2,000 words; each individual is to complete a report) - 30%