Reef HQ Education

Teaching Unit

Reef Ecology

Middle School and Senior Secondary

In this Reef HQ Education Program students explore the ecology of the Great Barrier Reef ecosystem. Gain an appreciation for the diversity of life it contains, and the evolutionary processes that have shaped the plants and animals that exist there today.

Curriculum links

Completing this Reef HQ Education Program will develop students' ability to:

- Evaluate the contribution of environmental factors to change within populations and communities;
- Relate the patterns of distribution of organisms to their requirements;
- Identify or critically analyse various types of special associations that may occur between organisms within communities, such as symbiosis;
- Construct diagrammatic representations of food webs, on the basis of observed or inferred feeding relationships;
- Compare communities in terms of their biotic and abiotic characteristics;
- Describe the types of interactions that occur between living and non-living components of the ecosystem;
- Interpret data pertaining to the ways in which matter and energy move in an ecosystem;
- Predict the effects on the natural environment of activities associated with industrialised human societies;
- Evaluate modern scientific evidence for the process of biological evolution; and
- Analyse examples of evolutionary events.

The following unit includes suggestions for activities that can be completed before and after your Reef HQ visit.

Reef HQ Visit

This teacher resource is linked to a class visit to Reef HQ. The Reef HQ visit will enable students to:

- Explore the complexities of reef ecology within a closed system;
- Analyse the intimate associations that occur between species;
- Investigate the process of biological evolution and analyse examples of evolutionary events;
- Develop hypotheses linking adaptations of organisms to both biotic and abiotic components of their surroundings; and
- Gain an appreciation for the effects human activities may have on the ecology of communities.

Theme Overview

The Great Barrier Reef is under pressure and everything we do on the Great Barrier Reef, along the shore and even on the land, affects this diverse and fragile ecosystem. The plant and animal communities that make up the Great Barrier Reef need to be protected.

The Great Barrier Reef

The Great Barrier Reef World Heritage Area consists of the world's largest system of coral reefs together with lagoon, seagrass, mangrove and estuarine communities. Stretching over 2000km along Australia's north-east coastline and comprising more than 2900 reefs, some 940 islands and surrounding waters, the Great Barrier Reef is the largest natural feature on the earth. The Great Barrier Reef World Heritage Area covers more than 38 million hectares (equivalent to approximately 38 million football fields). It represents one of the most complex and biologically diverse systems on earth and contains critical habitats for a number of rare, threatened and endangered species.

The Great Barrier Reef World Heritage Area is the largest World Heritage Area in the world and one of just a few that meet all four natural World Heritage criteria:

1) An example of a major stage in the earth's evolutionary history;
2) An outstanding example of geological processes, biological evolution and people's interaction with their natural environment;
3) A place with unique, rare and superlative natural phenomena; and
4) A place that provides habitats for rare and endangered species of plants and animals.

What is the difference between the Great Barrier Reef Marine Park and the Great Barrier Reef World Heritage Area?

The northern, eastern and southern boundaries of theses two areas are the same. The major area of difference (and of some conjecture) exists along the western boundary. The Great Barrier Reef Marine Park's boundary ends at the low water mark, whereas the Great Barrier Reef World Heritage Area's boundary encompasses some areas of the Commonwealth's coastal zone.
The Great Barrier Reef Marine Park Authority was established in 1975 and is the principal adviser to the Commonwealth Government on the care and development of the Great Barrier Reef Marine Park. The Authority's fundamental obligation is to protect the Great Barrier Reef Marine Park and World Heritage Area. Guided by the principle of balancing conservation and wise use, the Great Barrier Reef Marine Park Authority has created a framework that allows for reasonable human use and ensures the healthy survival of important tropical marine ecosystems.
Certain managerial functions are carried out in conjunction with other Commonwealth and Queensland organisations. This includes the Queensland Environmental Protection Agency, which, through its Queensland Parks and Wildlife Service, has joint responsibility for day-to-day management of the Great Barrier Reef Marine Park subject to Great Barrier Reef Marine Park Authority guidelines.

Great Barrier Reef World Heritage Area (Area: 347 800 sq km)

Great Barrier Reef Marine Park (Area: 339 750 sq km)

The biological diversity of the Great Barrier Reef World Heritage Area is supported by:

- Continental islands;
- Coral cays;
- Deep ocean troughs;
- Algal and sponge gardens;
- Over 1/3 of the world's soft coral species;
- Six of the world's seven species of marine turtle;
- One of the world's most important dugong populations;
- Breeding area for humpback and other whale species.
- Low wooded islands;
- Bottom-dwelling communities;
- Mangrove estuaries - 54% of the world's mangrove diversity;
- Seagrass beds - > 3000 km2;
- Over 1500 species of fish;
- World's largest green turtle breeding area;
- Important seabird breeding islands;

Time scales:

The Great Barrier Reef we see today is about 8 000 years old. Some parts of the Great Barrier Reef date back 18 million years. Some species found on the Great Barrier Reef have links to the age of dinosaurs, and have evolved into the representations we see today. The first evidence of vertebrates dates back to approximately 500 million years ago.

Reef Ecology – Activity Ideas

Tuning In

Prior knowledge investigation
Provide students with time to respond to each of the following questions:

- Where is the Great Barrier Reef?
- How large is it?
- Is the Great Barrier Reef a biologically diverse ecosystem? Explain;
- List as many different specific groups of animals and plants inhabiting the Great Barrier Reef as you can;
- What are the major associations/relationships existing between animals on the Great Barrier Reef? and
- What are the major requirements for a coral reef community to exist and survive?

Mapping
Students create maps that show regional representations of the Great Barrier Reef Marine Park. Contact the Great Barrier Reef Marine Park Authority's Public Information Unit for the most up-to-date maps of the Great Barrier Reef Marine Park.

Teachers and students can download background information and maps reef and non-reef bioregions of the Great Barrier Reef World Heritage Area from the following web address:

http://www.gbrmpa.gov.au/corp_site/key_issues/conservation/rep_areas/consultation/bio_region_info_sheets/

Note: Differences between bioregions allows only a very crude recognition of the sorts of differences and similarities that occur between communities of organisms. Within bioregions there are both small- and large-scale patterns of variation in the structure of communities and in the organisms inhabiting them.

Preparing to find out

Essential knowledge development
To survive in any environment, an organism must be able to:
- Tolerate the physical conditions; and
- Satisfy its requirements for food, oxygen, water, shelter and space.

The Great Barrier Reef habitat is very different from terrestrial habitats. Consider the following abiotic conditions and the questions that pertain to them:

- **Oxygen**
  How do marine animals breathe under water?
  How are gills different from lungs?
  Are there any other ways that animals extract oxygen from the water?

- **Light**
  Not all light penetrates seawater so competition for light can be great.
  Which organisms need light?
  How deep do particular intensities of light and colours of the spectrum penetrate seawater?

- **Buoyancy**
  Water is more dense than air and exerts an upthrust on bodies in the water. This is the buoyancy you experience in seawater.
  Investigate the purpose of buoyancy control devices such as swim bladders in fish; oil-laden livers in sharks and the vests scuba divers wear.

- **Viscosity**
  Water offers greater resistance to movement than air because of its density.
  What adaptations have sea creatures undergone to maximise their efficiency in seawater?

- **Salinity**
  Seawater tends to dehydrate our bodies due to the process of osmosis if we are immersed for too long.
  What are some of the evolutionary adaptations that marine animals have to avoid this problem?

Cause and Effect Wheels

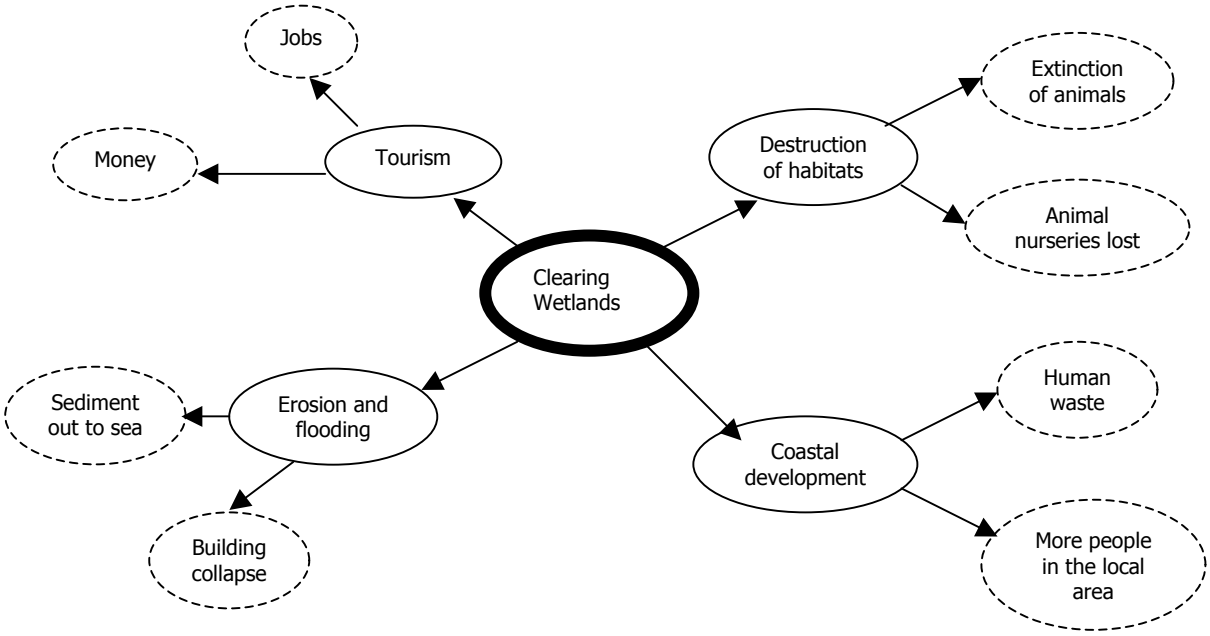
Create cause and effect wheels through student-centred class discussion evaluating the contribution of environmental factors to change within populations and communities on the Great Barrier Reef. These cause and effect wheels can be enlarged and displayed in the classroom.

Follow these steps to create a cause and effect wheel:

- **Step 1:**
  A key concept (problem or issue) is placed in the center of the diagram – as the hub of a wheel. This is called the **cause.**

- **Step 2:**
  A number of possible consequences or implications, arising from the cause given on the hub form a ring (as in a wheel) around the initial cause. These consequences or implications (real or potential) are called **effects.**

- **Step 3:**
  The wheel created in **Step 2** can be further extended, because each effect can be looked on as a new cause, with more consequences (effects) flowing from it. Thus, an extra ring is added to the wheel.



Finding Out

Visit Reef HQ and explore the reef up close. Encourage students to develop a list of questions they want answered about the Great Barrier Reef.

GBR Explorer

Use the Great Barrier Reef Marine Park Authority's reef education website

www.reefed.edu.au

The "GBR Explorer" is like an online encyclopaedia about the Great Barrier Reef.

Other useful websites have been listed in the **Websites** section of this unit.

Group Discussion

In groups, students discuss and record why they think it is important to find out about the Great Barrier Reef's ecosystem, inhabitants and their interrelationships. The following question could be used to stimulate discussions:

- Why do you think seeing the Great Barrier Reef up close could help you in this unit of work?
- What hypotheses can you develop which link adaptations of organisms to both biotic and abiotic components of their surroundings?
- What types of interactions and associations occur between living and non-living components of the Great Barrier Reef ecosystem?
- How could introduced species affect the Great Barrier Reef environment?
- What examples of biological evolution within marine species do you know of?
- How do activities associated with industrialised human societies effect the Great Barrier Reef environment? And
- Do you think the Great Barrier Reef will be used sustainability in the future?

Groups report back and record their findings. Students compare ideas, identifying similarities and differences and discussing differing opinions.

Sorting Out

Biological Diversity

The following table shows animal and plant phyla, the classes included within them and the characteristics of living organisms (biotic) that distinguish them from non-living matter (abiotic). Source as much specific information as you can to complete the table:

Phyla	*Reproduction*	*Respiration*	*Nutrition*	*Excretion*	*Growth*	*Responsiveness*	*Movement*
Chlorophyta (Green algae)							
Rhodophyta (Red algae)							
Phaeophyta (Brown algae)							
Cnidaria Class Anthozoa Class Scyphozoa Class Hydrozoa							
Mollusca Class Polyplacophora Class Gastropoda Class Pelycepoda Class Cephalopoda							
Arthropoda Subphylum Crustacea							
Echinodermata Class Asteroidea Class Ophiuroidea Class Echinodea Class Holothuroidea Class Crinoidea							
Chordata Class Chondrichthyes Class Osteichthyes Class Reptilia Class Aves Class Mammalia							

Evolution, natural selection and variation

The characteristics listed in the previous table are those traditionally ascribed to living organisms. However, it leaves out an important feature of living organisms, namely their potential to change or evolve over generations.

Are there any homogeneous environments in nature?
Challenge students to offer reasons and examples of why or why not.

Encourage students to consider a section of the water column in and around a tropical reef ecosystem. Make the statement *"Environments contain within them gradients of conditions or of available resources".* Challenge students to elaborate on what this statement means and to consider the question:
How could condition gradients and resource availability stimulate evolutionary processes or variations within species or communities?

In pairs or small groups, students can prepare either a play, multi-media presentation or report which conveys detailed information about the major condition and/or resource factors that have stimulated evolutionary processes or variations within a specific marine species or community.

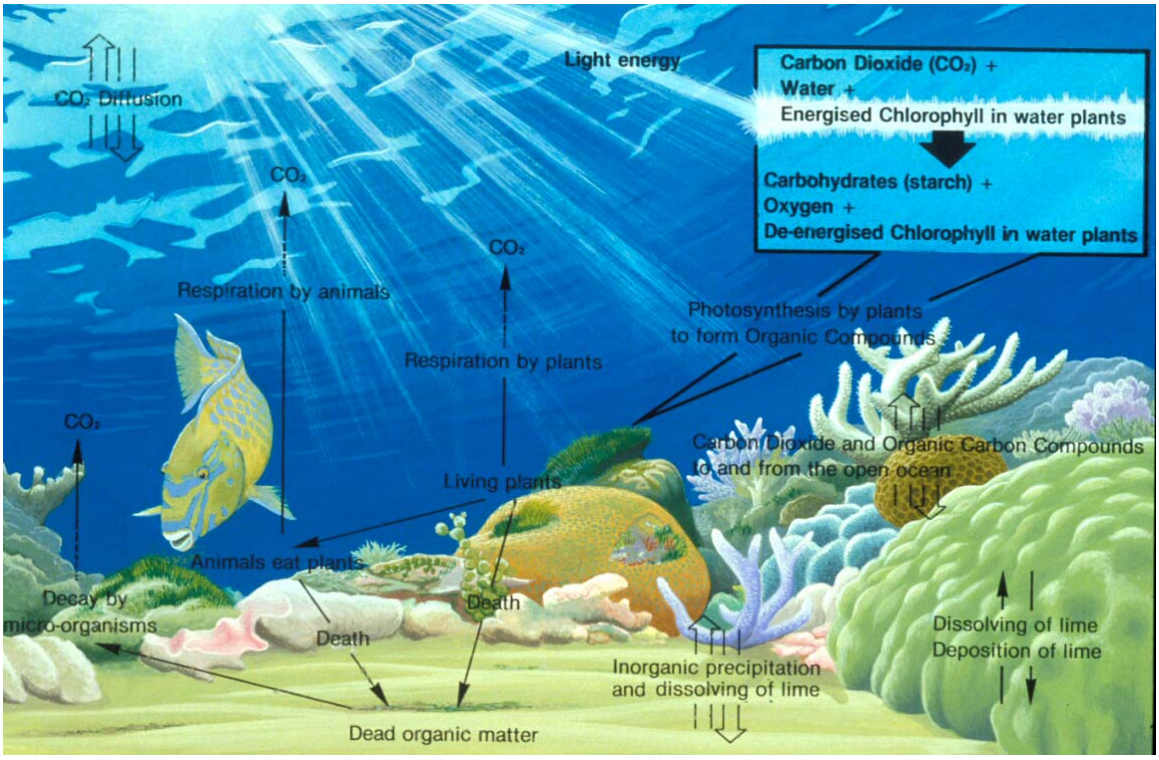
Going Further

Cycling of matter and flow of energy

In order for organisms to maintain themselves, and to grow and reproduce, they require a supply of the elements from which they are made. These elements are obtained through *biogeochemical cycles.*

Bio - how elements flow through living organisms
Geochemical - how elements cycle through rocks, water and atmosphere

Marine Carbon Cycle



Provide students with a copy of the marine carbon cycle. Ask students to research an additional essential element to the survival of the reef. Ask students to produce a diagrammatical representation of the biogeochemical cycle for reef survival.

Food Chains and Food Webs

In almost all ecosystems, the organisms fall into three nutritional groups:

- Producers;
- Consumers; and
- Decomposers.

Direct students to the Great Barrier Reef Marine Park Authority's online image collection:

http://www.gbrmpa.gov.au/corp_site/info_services/library/resources/image_collection/index.html

Students are to download images of a variety of Great Barrier Reef flora and fauna and group them into producers, consumers and decomposers. These images can then be formatted into a food web showing the feeding relations within a tropical reef community.

Construct 'futures' wheels to analyse the ecological consequences in tropical reefs if particular representatives within the food web are removed. Consider pyramids of energy and explain why it takes a smaller area of reef to provide food for a herbivore compared with a carnivore.

Class Debate

Divide students into debating teams and call upon them to debate topics such as:

- Oceans are for everybody. People should be able to take as much as they want from the ocean;
- Humans need energy to survive. We should mine the Great Barrier Reef for oil and natural gas;
- Tourism makes money. More tourists should be allowed to travel within the Great Barrier Reef World Heritage Area; and
- Biotechnology could lead to many useful and sometimes lifesaving materials and medicines being generated. Increased government funding should be given to reef biotechnology research.

Environmental Impact Assessments & Management Plans

Using one of the debate topics or a current issue relating to the Great Barrier Reef, complete an Environment Impact Assessment. Once you have completed your Environment Impact Assessment, follow up and design a Management Plan for the activity.

Environmental Impact Assessment

1. **Title**: Your activity needs a title so people will recognise the area you are assessing.

2. **Description of activity**: Briefly outline the activity and when the activity will take place. (Include diagrams of facilities/structures and their location).

3. **Need**: Why is the activity necessary?

4. **Impacts**: What are the likely impacts on the flora, fauna and ecological processes?
   What will be the impacts on water, air or surface quality?
   What are the likely impacts on the heritage, wilderness and/or aesthetic value of the area?
   What wastes will be generated, how will they be handled and what are the impacts of handling them this way?
   What cumulative impacts could arise from this activity given other existing or planned activities?
   What is likely to be the most significant negative impact of this activity?
   Are there any impacts not addressed above and/or are there any other comments you wish to make?

5. **Mitigation measures**: What action, if any, will be taken to mitigate the impacts of the activity?

6. **Alternatives**: What alternatives to the activity would involve less environmental impact?

7. **Conformity with management plan**: How does the activity accord with any management plan prescriptions applicable to the location?

8. **Possible public concerns**: What public concerns could be expressed about this activity?

9. The Environment Impact Assessment must then be signed and dated.

10. The Assessment will receive a negative or positive recommendation.

11. Finally, the Assessment will receive a Determination stating whether or not the activity will be allowed.

Management Plan

- **Develop** a set of criteria, which could be used to evaluate a management plan;
- **Formulate** a management plan, that is, decide how and by whom the issue should be managed; and
- **Justify** your management plan using the criteria you initially developed.

Making Connections

Autecology Investigation

An autecology investigation is one that sets out to identify all the important aspects of the ecology of a single species.

For example, when studying the autecology of eucalyptus trees, the following ecological questions could be asked:

- What proportion of gum nuts germinate?
- What happens to gum nuts that do not germinate?
- What sort of soil is needed by gum nuts in order to germinate, grow into seedlings and eventually become young trees?
- What are the climatic factors that limit the distribution of eucalyptus?
- What are the light requirements of eucalyptus?
- Which organisms feed on eucalyptus?
- What proportion of eucalyptus seedlings go on to reproduce?
- What is the generation time of eucalyptus?
- What factors effect the flowering of eucalyptus trees?
- How is pollination achieved? and
- What factors effect the size and numbers of gum nuts produced?

Students select a reef marine animal or plant and outline how they might carry out an autecology investigation by devising their own questions like those above. Further research, experimentation and field study could generate answers to the predetermined investigation questions.

Associations between species

There are many situations in which individual organisms form close associations with one another. Such associations may occur within the same species **(intraspecific associations)** or between different species **(interspecific associations).**
The term used to describe associations between pairs of species is **symbiosis.** The three major categories of symbiosis distinguished by the consequences of the association to each individual are:

- Parasitism;
- Commensalism; and
- Mutualism.

Students choose a number of marine animals or plants that have intimate associations and outline how they might determine whether the relationship is parasitic, commensalistic or mutualistic.

Symbiotic organisms and their hosts seem to have evolved in response to each other, a process called **coevolution.** The survey of parasitism, commensalism and mutualism raises the interesting question of which came first? Pose the following question to students: "Can we assume that commensalism is the most primitive association and parasitism and mutualism followed later, or could the order be different?"

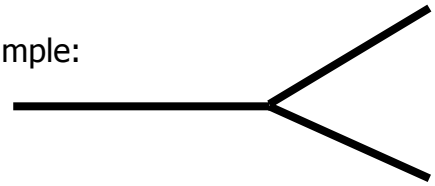
What are possible, probable and preferable futures for the Great Barrier Reef?

Working in small groups, students plot the significant events for the Great Barrier Reef to date on a timeline. Students distinguish between those they think local societies had some control over, and those over which they had little control.

Model the continuation of the futures timeline, encouraging students to consider the probable and preferable futures of the Great Barrier Reef. In groups, students discuss the types of decisions needed if these preferable futures were to eventuate.

Tip:
A timeline can be inclusive of probable and preferable futures by adding a < shape.

For example:



Students plot probable futures along the upper axis and preferable futures along the lower axis. Probable futures refer to how students expect the future to be, both in their own lives and in the wider world. Preferable futures refer to how students would like the future to be, both in their own lives and in the wider world.

Taking Action

Community Education

Students can help increase others awareness of reef ecology by designing a poster, brochure or information sheet. This project should detail the reefs ecological components, how and why these components are important for reef survival, what impacts result if the ecological balance is effected, what could or should be done to insure ecological balance continues. Display these posters on school notice boards, during school assemblies or in the school library.

Submission/Proposal

Take the information gathered during the completion of this unit and develop a formal submission or proposal to be sent to local, state or federal members with regard to the current ecological state of the Great Barrier Reef. Current state of the reef information can be found at:

http://www.gbrmpa.gov.au/corp_site/info_services/publications/sotr/

Creating Popular Culture

Students can develop slogans that encourage protection of the Great Barrier Reef. Screen print T-shirts or calico bags and sell them to raise money for field trip or school environment group.

Become a Reef Guardian School

This is an exciting, innovative program that encourages students, teachers, parents and friends to become involved in protecting our environment and the Great Barrier Reef. Reef Guardian Schools are environmentally active and participate in reef education through activities and environmentally friendly initiatives. Students and teachers promote best environmental practices and the importance of Reef protection to their communities. To find out more go to:

http://www.reefed.edu.au/guardians/

Websites

Queensland Studies Authority – Science Syllabus
http://www.qsa.qld.edu.au/yrs1to10/kla/science/docs/syllabus/syllabus.pdf

Queensland Studies Authority – SOSE Syllabus
http://www.qsa.qld.edu.au/yrs1to10/kla/sose/syllabus.html

Queensland Studies Authority – Biology Syllabus
http://www.qsa.qld.edu.au/yrs11_12/subjects/bio_science/syllabus.pdf

Queensland Studies Authority – Multi Strand Science Syllabus
http://www.qsa.qld.edu.au/yrs11_12/subjects/multi_science/syllabus.pdf

Reef ED
www.reefed.edu.au

Great Barrier Reef Marine Park Authority
http://www.gbrmpa.gov.au

Reef HQ
http://www.reefHQ.com.au

Australian Institute of Marine Science
http://www.aims.gov.au/

CRC Reef
http://www.reef.crc.org.au/

Department of Environment and Heritage
http://www.deh.gov.au/

Department of Primary Industries
http://www.dpi.qld.gov.au/home/default.html

National Geographic - Virtual World "Great Barrier Reef"
http://www.nationalgeographic.com/earthpulse/reef/reef1_flash.html

References & Resources

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Roberts, M. Reiss, M. & Monger, G. (1993) *BIOLOGY Principles and Processes.* South Melbourne: Thomas Nelson Australia.

Tyler Miller, G. (1994) *Living in the Environment: Principles, Connections, and Solutions 8th Edition.* United States of America: International Thomson Publishing.

Webber, H. & Thurman, H. (1991) *Marine Biology 2nd Edition*. New York: Harper Collins Publishers.