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OCEANWATCH

AWARE - Coral Reef Conservation

PROJECT AWARE™

PADI®

Specialty Course Instructor Guide

Product No. 70242 (Rev. 11/07) Version 2.0

AWARE - Coral Reef Conservation Specialty Course Instructor Guide

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Visit projectaware.org for information about the Protect the Living Reef campaign and other conservation efforts

Introduction

This section includes suggestions on how to use this guide, an overview of course philosophy and goals, a flow chart to show you how course components and materials work together for success, and ways you can organize and integrate student diver learning.

How to Use this Guide

This guide speaks to *you,* the PADI Specialty Instructor. The guide contains two sections – the first contains standards specific to this course and the second contains knowledge development presentations. All required standards, learning objectives, activities, and performance requirements specific to the AWARE - Coral Reef Conservation course appear in **boldface** print. **The boldface assists you in easily identifying those requirements that you *must* adhere to when you conduct the course.** Items not in boldface print are recommendations for your information and consideration. General course standards applicable to *all* PADI courses are located in the General Standards and Procedures section of your PADI *Instructor Manual.*

Course Philosophy

The AWARE – Coral Reef Conservation Specialty Course allows PADI Instructors and Assistant Instructors to inform divers and nondivers about the plight of the world's coral reefs. The course describes how coral reefs function and why they are so important. It also reviews why many reefs are in serious trouble and what individuals can do to prevent further decline.

Most divers, snorkelers and environmental enthusiasts have already visited or plan to visit a coral reef. The AWARE – Coral Reef Conservation Specialty course provides the knowledge base for proper interaction while touring a reef.

Course Flow Options

Conduct the AWARE – Coral Reef Conservation Specialty course as follows:

- Ask participants to read Chapter Four in the *A.W.A.R.E. – Our World, Our Water* manual.
- Have participants watch, either on their own or with you, the *Protect the Living Reef* video – diver and/or snorkeler version (depending on their interests).
- Provide participants with an AWARE – Coral Reef Conservation Knowledge Review and ask them to look for answers to the questions as you elaborate.
- Use the AWARE – Coral Reef Conservation Lesson Guides and presentation notes to teach participants about coral reef ecology, threats and preservation. Involve participants in the discussion.
- Conclude by going over the completed Knowledge Reviews. Clarify information as necessary for understanding.
- Recognize participant achievement by completing a PIC envelope for specialty certification or issue Project AWARE Recognition Certificates as appropriate.
- If combining the course with another PADI diving or snorkeling program, explain how participants will apply their coral reef conservation knowledge and skills. (Refer to Links to other courses for options and suggestions)
- Incorporate CoralWatch monitoring dive/snorkel as an optional inwater activity. Find out more on Project AWARE website – projectaware.org
- Encourage participants to get involved in local conservation efforts and learn more about the aquatic environment.

Section One:
Course Standards

This section includes the course standards, recommendations, and suggestions for conducting the AWARE - Coral Reef Conservation course.

Standards at a Glance

Topic	Course Standard	
Minimum Instructor Rating	**PADI Instructor or Assistant Instructor**	
Prerequisites	Interest in the aquatic world	
Minimum Age	None	
Ratios	Not applicable	
Hours	Recommended: 2	
Materials	Instructor: • ***AWARE - Coral Reef Conservation Specialty Course Instructor Guide*** • **Coral Reef Conservation Instructional CD-ROM**	Student Diver: • *AWARE - Our World, Our Water* manual

Instructor Prerequisites

To qualify to teach the AWARE - Coral Reef Conservation course, an individual must be a Teaching status PADI Assistant Instructor, Open Water Scuba Instructor or higher.

Participant Prerequisites

Participants only need to have an interest in the aquatic world to enroll in the course. There is no minimum age or experience requirement.

Materials

Instructor Materials

Use the AWARE - Coral Reef Conservation course materials prescriptively to accommodate various sequencing preferences and teaching and learning styles.

Required

- ***AWARE - Coral Reef Conservation Specialty Course Instructor Guide***
- ***AWARE - Coral Reef Conservation Instructional CD-ROM*** which includes course lesson guides and the *Protect the Living Reef* video - diver and snorkeler versions.

Recommended

- Project AWARE Recognition Certificate
- Project AWARE decal
- Protect the Living Reef brochure
- Protect the Living Reef poster
- Project AWARE CoralWatch Kit
- Tens Ways a Diver Can Help Protect the Aquatic Environment brochure
- Ten Tips for Underwater Photographers
- Project AWARE Foundation Brochure
- *Discover the Underwater World – Snorkeler's Field Guide*
- *Peak Performance Buoyancy* video and booklet
- *The Encyclopedia of Recreational Diving*
- Mooring Buoy Planning Guide
- Project AWARE Public Service Announcements DVD

Participant Materials.

Recommended

- *A.W.A.R.E. – Our World, Our Water* manual

Assessment Standards

To assess knowledge you may review the AWARE - Coral Reef Conservation Knowledge Reviews with participants.

Certification and Recognition Procedures

Participants may receive either AWARE - Coral Reef Conservation Specialty certification card or a Project AWARE Certificate of Recognition or both. It's recommended that you encourage participants to obtain a Project AWARE card (rather than the standard certification card) by donating to the Project AWARE Foundation.

Links to Other Courses

Other PADI programs teach the skills and emphasize practical application of environmentally sound diving and snorkeling techniques. Although you may offer the AWARE – Coral Reef Conservation Specialty course as a stand-alone program it's strongly recommended that you combine it with another PADI program based on participant needs and desires. Here are a few suggestions:

- **Peak Performance Buoyancy Specialty Diver Course**

  For certified divers – have participants watch the *Peak Performance Buoyancy* video and read the associated booklet. Incorporate a review of their completed Peak Performance Buoyancy Knowledge Reviews with the AWARE – Coral Reef Conservation knowledge development session. During the Peak Performance Buoyancy specialty dives, emphasize streamlining equipment and body awareness around sensitive environments, such as coral reefs. This allows divers to apply knowledge and skills while earning two specialty certifications – AWARE – Coral Reef Conservation and Peak Performance Buoyancy.

- **Peak Performance Buoyancy Clinic**

  For certified divers, when completing open water dives is not practical – Have participants watch the *Peak Performance Buoyancy* video. After completing the AWARE – Coral Reef Conservation knowledge development session, schedule a confined water dive. Use the Peak Performance Buoyancy Specialty outline – Dive One guidelines for conducting a buoyancy clinic. Emphasize streamlining equipment and body awareness around sensitive environments, such as coral reefs. In addition to their AWARE – Coral Reef Conservation specialty certification, recognize divers who complete the clinic with a Project AWARE certificate.

- **AWARE – Fish Identification, Underwater Naturalist or Digital Underwater Photographer Specialty Diver Courses**

  For certified divers, especially when dives will occur on coral reefs – integrate the AWARE – Coral Reef Conservation knowledge development session into the specialty diver course. During specialty dives, emphasize proper buoyancy control, streamlining equipment and body awareness around sensitive environments, such as coral reefs. This allows divers to apply knowledge and skills while earning two specialty certifications.

- **PADI Skin Diver Course and Discover Snorkeling**

  For skin divers and snorkelers, especially when dives will occur on coral reefs – As appropriate, integrate the AWARE – Coral Reef Conservation knowledge development session into the program. Emphasize the skills and suggestions presented in the *Protect the Living Reef* video – snorkeler version. Skin diver students may earn a PADI Skin Diver certification and AWARE – Coral Reef

Conservation specialty certification. In addition to their AWARE – Coral Reef Conservation specialty certification, recognize Discover Snorkeling participants who complete a reef tour with a Project AWARE certificate.

- **PADI Seal Team – AquaMission: Inner Space**

  For PADI Seal Team members – To enhance the AquaMission: Inner Space, integrate the AWARE – Coral Reef Conservation knowledge development into an extended predive session. During the AquaMission, emphasize that their careful interaction with the underwater space station is how they should interact with a coral reef. This allows PADI Seal Team members to apply knowledge and skills while earning the AWARE – Coral Reef Conservation specialty certification and AquaMission: Inner Space decal.

- **Project AWARE Specialty Program**

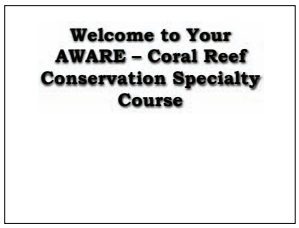
  For all environmental enthusiasts – Integrate the AWARE – Coral Reef Conservation knowledge development session into the Project AWARE Specialty program when discussing coral reefs. Encourage participants to apply their knowledge by participating in coral reef monitoring, shoreline and underwater cleanups and other environmental activities, and by getting involved with conservation organizations. This promotes awareness and encourages ongoing participation by allowing participants to earn two nondiving specialty certifications.

Section Two:
Knowledge Development

During a knowledge development session, you'll use these presentation notes along with the AWARE – Coral Reef Conservation Lesson Guides to cover the course material. This course contains six main topics as listed on the Overview slide. Each topic has several learning objectives that are written as questions and bolded in the outline. The Summary section includes a complete list of course learning objectives.

Miniature copies of the lesson guides appear next to the related information to help guide your presentation. This outline may be used for direct presentation to your students, however, you'll want to customize it as appropriate to meet participant needs and cover local information.

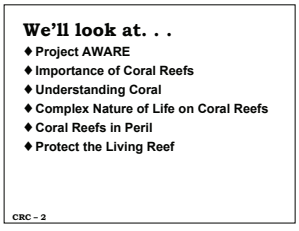
Presentation Notes



I. Welcome to Your AWARE – Coral Reef Conservation Course

A. [Introductions]

B. [Administration – review schedule, course requirements, costs, materials, equipment and paperwork, etc.]



II. Overview

A. Project AWARE

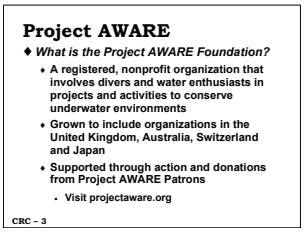
B. Importance of Coral Reefs

C. Understanding Coral

D. Complex Nature of Life on the Coral Reef

E. Coral Reefs in Peril

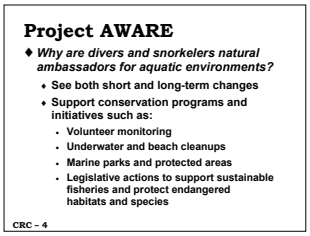
F. Protect the Living Reef



III. Project AWARE

A. Why are divers and snorkelers the natural ambassadors for the aquatic environment?

1. Noticing both short and long term changes in the aquatic realm, be it marine or freshwater, is unavoidable for people who regularly put on masks and venture underwater.
2. Because of intimate familiarity with the underwater world, divers and snorkelers are the natural ambassadors for the aquatic environment. Today they are some of the strongest supporters of programs and initiatives such as:
   a. Volunteer monitoring.
   b. Underwater and beach cleanups.
   c Marine parks and protected areas.
   d. Legislative actions to support sustainable fisheries and protect endangered habitats and species.
3. To harness each diver's potential as an advocate and protector of the aquatic environment, PADI introduced Project AWARE (Aquatic World Awareness, Responsibility and Education) in 1989.



B. What is the Project AWARE Foundation?

1. What began as an environmental ethic quickly formed into the Project AWARE Foundation, a 501(c)(3) nonprofit organization that involves divers and water enthusiasts in projects and activities to conserve underwater environments. The Foundation also supports research, education and conservation projects through its established grant program.
2. Since the nonprofit designation in 1992, Project AWARE has created an international presence with offices in the United Kingdom, Australia, Switzerland and Japan.
3. You can join the team of environmental divers and contribute to conservation by becoming a Project AWARE Patron.
   a. Project AWARE Patrons take action for the underwater environment and their donations support conservation and data collection initiatives.
   b. All patrons receive a subscription to Project AWARE's email newsletter containing information about conservation activities and action alerts from around the world related to the underwater environment.
4. Through Project AWARE, each year nearly a million people worldwide are exposed to environmental awareness through interactions with PADI Professionals. For up-to-date information, visit Project AWARE Foundation online at projectaware.org

C. What is Project AWARE's purpose and mission?

1. Project AWARE is dedicated to conserving underwater environments through education, advocacy and action.
2. Project AWARE partners with divers and water enthusiasts to protect aquatic environments around the world.
3. Project AWARE involves divers in environmental projects, activities and campaigns working toward global conservation solutions.

Project AWARE
- *What is Project AWARE's purpose and mission?*
  - Conserving underwater environments through education, advocacy and action
  - Partnering with divers and water enthusiasts to protect aquatic environments around the world
  - Involving divers in environmental projects, activities and campaigns working toward global conservation solutions

CRC – 5

D. What steps is the Project AWARE Foundation taking in partnership with PADI to protect the aquatic world?

1. Emphasizing environmentally sound approaches to dive practices, dive operations and dive skills. These include: mooring buoy use, responsible boating practices, buoyancy control, proper techniques and equipment placement for underwater photography, responsible wreck diving guidelines and dive training programs including this course.
2. Implementing initiatives to expand diver participation in conservation activities and data collection including global underwater cleanups, coral reef monitoring, shark sightings and identification, environmental education and advocacy.
3. Empowering children to get involved in environmental solutions through its AWARE Kids program.
4. Increasing implementation of sustainable business practices and expanding financial support for aquatic environmental projects, public education and outreach programs, and research.

Project AWARE
- *What steps is Project AWARE taking in partnership with PADI to protect the aquatic world?*
  - Emphasizing environmentally sound approaches to dive practices including:
    - Mooring buoy use
    - Responsible boating practices
    - Buoyancy control
    - Proper underwater photography techniques
    - Responsible wreck diving guidelines
    - Dive training programs

CRC – 6

Project AWARE
- *Protecting the aquatic world...*
  - Implementing initiatives to expand participation in underwater cleanups, coral reef monitoring, shark identification and sightings, education and advocacy
  - Empowering children to get involved through the AWARE Kids program
  - Increasing implementation of sustainable business practices and expanding financial support for projects and research

CRC – 7

IV. Importance of Coral Reefs

A. Why are coral reef ecosystems important and how do they maintain biological diversity?

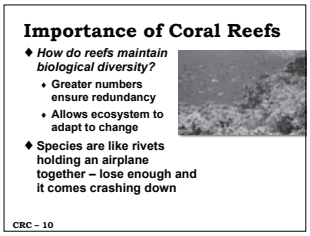
1. Coral reefs cover around 284,300 square kilometres/110,000 square miles, which is less than one tenth of a percent of the sea bottom (an area about the size of Ecuador or Nevada), yet are vital because they are:
   a. Nursery grounds to 25 percent of all known marine species.
   b. Home to nearly 33 percent of all known fish species.
2. The Atlantic Ocean contains about 8 percent of the world's coral reefs, with about 70 coral species and 500 fish species.
3. The Indo-Pacific (which includes the Indian and Pacific Oceans) contains about 92 percent of the world's coral reefs, with about 700 coral species and 4000 fish species.
   a. Of the 107 known genera of coral, the Atlantic and Pacific share only eight.
4. Scientists have identified about 80,000 species on coral reefs, but estimates range from 600,000 to 9 million species.
5. This abundance of life means that reefs help maintain biological diversity – Earth's inventory of functioning parts.

Importance of Coral Reefs
- *Why are coral reef ecosystems important and how do they maintain biological diversity?*
- Coral reefs are:
  - Less than 0.1% of the sea bottom
  - Nursery grounds to 25% of known marine species
  - Home to nearly 33% of all known fish species

CRC – 8

Importance of Coral Reefs
- *Important ecosystems. . .*
  - Atlantic – contains about 8% of reefs with 70 coral species and 500 fish species
  - Indo-Pacific – contains about 92% of reefs with 700 coral species and 4000 fish species
    - 80,000 species identified on reefs, but may contain more than 9 million

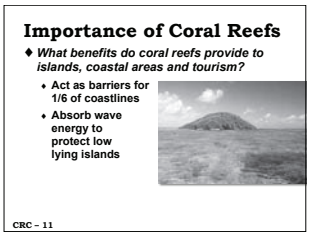
CRC – 9



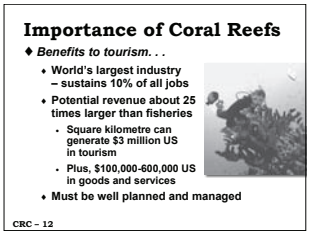
a. Marine biodiversity is important because greater numbers ensure redundancy. If one species is lost, vital functions can be covered by other species. This redundancy allows an ecosystem to persist as environmental conditions change.

b. Coral reef biodiversity can be likened to an airplane held together by rivets.
   - Each species on earth is like one rivet.
   - When a species is lost, it's like a rivet popping out of the frame.
   - Lose enough rivets and the airplane (or earth's biosphere) comes crashing down.
   - This analogy fails considering that we know the function of all the rivets in a real airplane, but in the biosphere we haven't even identified all species, nor fully understand the function of all identified species.

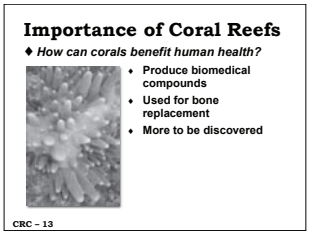
B. What benefits do coral reefs provide to islands, coastal areas and tourism?



1. Coral reefs act as coastal barriers protecting islands and coastal communities from storms, wave damage and erosion.
   a. One-sixth of the world's coastlines are protected by coral reefs.
   b. Low islands in the Caribbean owe their existence to coral reefs that absorb incoming wave energy. Corals and mangroves absorb up to 90 percent of the wave energy.
   c. Estimated costs of installing artificial breakwater around the Male, Maldives, following the degradation of the natural reef, was $10,000 US per square metre/yard. Estimated costs of protecting coral reefs through management of marine protected areas, is only $0.77 US per square metre/yard per year.
2. Coral reefs attract tourists which boosts local economies.
   a. Tourism is the world's largest industry and sustains 10 percent of all jobs.
   b. The economic potential of tourism greatly overshadows that of fishing. One year of world tourism revenue is around 25 times greater than *all* the world's marine fisheries revenue.
   c. In some areas, a single square kilometre of coral reef can generate nearly three million dollars in tourism revenue, and between a $100,000- 600,000 US in goods and services a year. In comparison, the destructive practice of dynamite fishing in the same area would yield a one-time income of $15,000 US.
   d. Coral reef tourism can bring benefits to the local area but it must be well planned and well managed to ensure the sustained health of the reef.



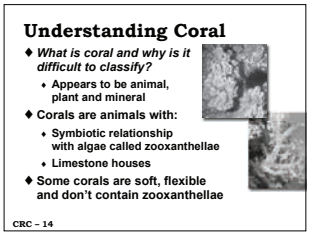
C. How can coral reefs benefit human health?



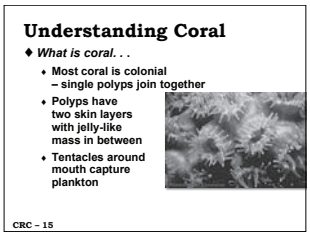
1. Pharmacologists find coral reefs contain many biomedical compounds including anti-cancer agents, anti-HIV agents and antibiotics.
2. Coral is used to experimentally repair and replace human bones. Certain corals, such as finger coral (*Porities)* and kidney coral (*Goniopora*), have a skeletal porosity close to human bone so vessels and nerves grow into the coral.
3. Coral reefs probably hold more beneficial undiscovered compounds. Humans will benefit only as long as healthy coral reefs exist.

V. Understanding Coral

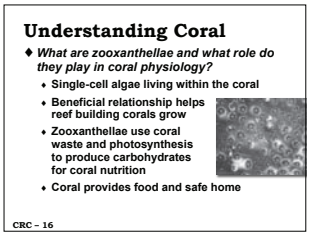
A. What is coral and why is it difficult to classify?



1. Scientists have had a difficult time classifying coral because it appears to be a unique combination of animal, plant and mineral. In the past, coral has been classified as either lithophytes (stone-plants) or zoophytes (animal-plants)
2. Corals are animals (Cnidarians) and are related to both jellyfish and anemones.
   a. They are simple animals without a brain, eyes, specialized internal organs or anus.
   b. Their plant nature comes from the single-cell alga – zooxanthellae – housed deep within their tissues. Zooxanthellae are the key to most coral reef success. (More about this relationship in a minute.)
   c. Their mineral nature comes from their limestone (calcium carbonate) content, manufactured in cooperation with their resident plants from the calcium and carbonate that's abundant in seawater.
3. Keep in mind that not all corals are hard corals, and not all contain zooxanthellae. Soft corals manufacture the flexible protein gorgonin.
4. Although some corals are a single animal, or polyp, most are colonial where individual polyps occupy small cups called corallites.
   a. Each corallite has a series of sharp, blade-like structures, or septa, rising from the base.
   b. Septa patterns differentiate coral species.
   c. Each polyp is composed of two skin layers with a jelly-like mass in between.
   d. Connective membrane joins the polyps and transports both nutrients and nerve impulses from polyp to polyp.
   e. A series of tentacles around the mouth contains stinging cells, or cnidocytes, that capture plankton. Corals can also absorb

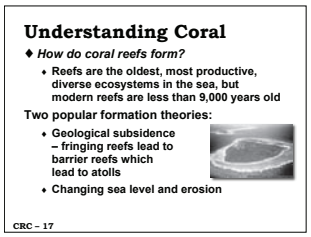


nutrients directly from the seawater. However, to obtain a more balanced diet, corals must capture plankton for protein.



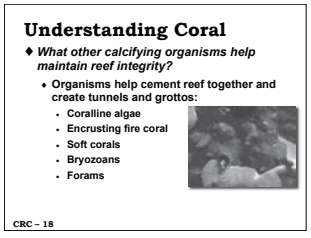
B. What are zooxanthellae and what role do they play in coral physiology?

1. Zooxanthellae are single-cell algae that live deep within the tissues of reef building corals. This mutually beneficial relationship makes it possible for these corals to grow to their large size. Corals that do not contain zooxanthellae cannot produce massive coral reefs.
2. Zooxanthellae provide corals with their primary food source.
   a. Zooxanthellae use polyp waste products, such as carbon dioxide, in combination with photosynthesis to produce carbohydrates.
   b. Zooxanthellae can supply up to 90 percent of the nutritional requirement for some coral species.
   c. Zooxanthellae benefit from this arrangement by getting food for their own growth and a safe home.



C. How do coral reefs form?

1. Coral reefs are the oldest, most productive and diverse ecosystems in the sea that existed 500 million years ago. However, all modern reefs formed since the last Ice Age less than 9,000 years ago.
2. No single theory completely explains reef formation. Reefs form differently depending upon local factors such as tectonic forces, glacial periods, climatic and oceanographic conditions. Two popular theories include:
   a. Reef formation by geological subsidence.
      - Over time, volcanic islands sink and fringing reefs form. Narrow, shallow lagoons separate these reefs from land.
      - Further sinking leads to barrier reefs, which are separated from land by very wide, sometime deep lagoons.
      - Further sinking leads to atoll development. Atolls are elliptical reefs with no nearby land.
      - As the island subsides, reef growth usually compensates for the rate at which it is sinking.
   b. Formation due to changing sea level and erosion. Similar to the subsidence theory, changing land structures and water levels allow reefs to grow. This is the case with most reefs in the Caribbean, around the Philippines, Indonesia, New Guinea, Fiji and Florida, USA.



D. What other calcifying organisms help maintain reef integrity?

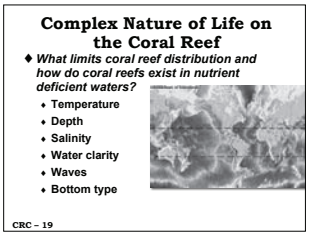
1. Reef organisms other than corals contribute to the reef's frame-

work. Like mortar between bricks, cementing organisms make the reef stronger and more wave-resistant.

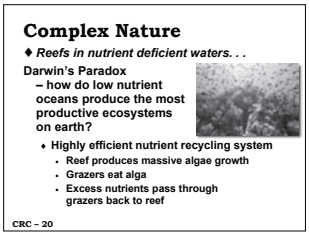
2. These organisms include coralline algae, encrusting fire coral, soft corals, bryozoans and forams. Without these organisms contributing to the reef's strength, it could not withstand storms or powerful waves.
3. Although coral reefs look like solid structures, 40-70 percent of a reef is made up of tunnels, grottoes and caves. This open space provides more habitat than a solid structure.

VI. Complex Nature of Life on the Coral Reef

A. What limits coral reef distribution and how do coral reefs exist in nutrient deficient waters?



1. Corals are found worldwide, but large coral reefs develop only in the tropics.
2. Several physical factors control and limit warm-water coral reef distribution.
   a. Temperature — Although some reef building corals can survive for short times in water temperatures below 20º Celsius (C)/68º Fahrenheit (F), warm-water coral reefs do not develop in water temperature below 18º C/64º F.
   b. Depth — Since zooxanthellae need light for photosynthesis, most reefs grow in water 25 metres/80 feet or shallower.
      - However, some corals thrive at depths. Often referred to as cold or deep-water corals these extremely slow growing corals form in cold, dark, and deep waters beyond the limits of scuba diving. They provide habitat for many commercially important fishes but, since they are very fragile, are threatened mostly by trawling as well as oil and gas exploration activities.
   c. Salinity — Corals cannot tolerate significant deviations from the normal sea water salinity of 32-36 parts per thousand.
   d. Water clarity — Heavy sedimentation smothers coral feeding structures and reduces the light needed for photosynthesis.
   e. Waves — Wave action provides constant oxygenated seawater, prevents sedimentation and renews the plankton supply of food. Reef development is usually greatest in areas subject to moderate wave action.
   f. Bottom type — Coral reef development requires consolidated bottom because coral larvae cannot settle on sandy or muddy bottoms.

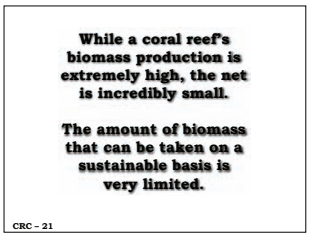


3. Unlike temperate oceans, tropical ocean waters are low in nutrients. Darwin's Paradox asks how coral reefs in these low nutrient oceans can be the most productive ecosystems on earth. It is

possible because of a highly efficient nutrient recycling system in which very few nutrients escape.

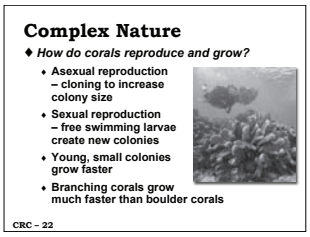
a. On a reef, there is massive algae production, including turf algae growing on dead coral and zooxanthellae within coral polyps.
b. Quick and massive consumption by grazers prevents algae from taking over.
c. Excess nutrients pass through grazers and this elimination allows algae to grow.
d. This cycle results in tight nutrient retention.

4. While a coral reef's gross biomass (total amount of living plant and animal tissue) production is extremely high, the net (what's left over after everything eats) is incredibly small – typically only a two to three percent surplus.
   a. This means that coral reefs can't produce large amounts of food beyond what's needed by the reef community itself.
   b. The amount of biomass that can be taken from a coral reef on a sustainable basis is very limited. This has serious fisheries implications.

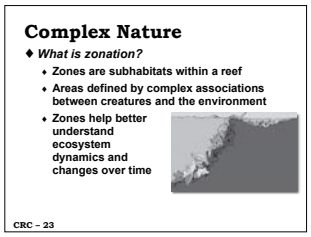


B. How do corals reproduce and grow?

1. Asexual reproduction is accomplished by budding (cloning) a genetically identical new individual from the parent.
   a. This increases the colony's size, but doesn't produce new colonies.
   b. Branching corals can also grow asexually through fragmentation when pieces are broken off.
2. Sexual reproduction produces free-swimming larvae called planula, which can settle to create new colonies.
   a. Most corals reach sexual maturity at 7-10 years of age, or when they are about 10 centimetres/4 inches.
   b. Coral colonies can be male, female or hermaphroditic – capable of producing both sperm and eggs.
3. Coral growth rates vary by species, the colony's age, the coral's position on the reef and if the coral contains zooxanthellae.
   a. Young, small colonies tend to grow more rapidly than older, larger colonies.
   b. Branching corals generally grow more rapidly than boulder corals. For example, a staghorn coral can grow 10-20 centimetres/2-8 inches in height per year, while a brain coral may grow only millimetres/a fraction of an inch per year.
   c. Coral longevity is unknown, but evidence suggests most colonies are ten years or younger although some massive corals may be hundreds of years old.

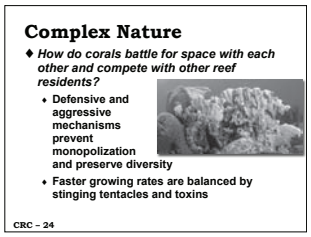


C. What is zonation?

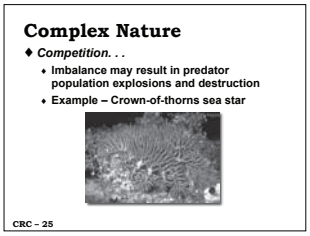


1. Coral reefs develop in patterns called zonation. Each zone, or subhabitat, within a reef contains complex associations between creatures and the environment.
   a. Access to resources such as light, oxygen and food primarily determine these zones.
   b. Physical conditions, such as depth, bottom composition and wave action, change when moving from shore to deeper water, thus creating these subhabitats within the reef.
   c. Each subhabitat has certain corals and other organisms that specialize in these conditions.
2. There are more than a dozen different zones within coral reefs, but the main zones are the back reef, reef crest and fore reef.
3. Studying the differences between zones helps scientists better understand reef ecosystems dynamics. Defining zones also provides a method to track changes to reef systems over time.

D. How do corals battle for space with each other and compete with other reef residents?

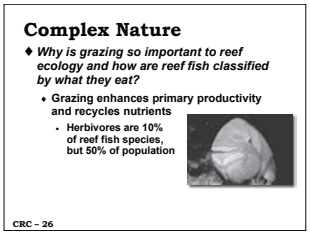


1. Corals are in a constant battle with other corals for living space.
   a. An aggressive pecking order often exists that prevents monopolization of space and preserves diversity. Corals also have a wide range of defensive and aggressive mechanisms.
   b. Branching corals grow more rapidly than encrusting or massive corals.
   c. Slower growing species survive due to their defensive stinging tentacles. This prevents faster-growing corals from overshadowing slower-growing species.
   d. Competition is not limited to hard corals. Soft corals and sponges have toxins that are used for both defense and aggressive competition.
2. Corals also compete with other small predators such as gastropods, nudibranchs, polychaete worms, barnacles and crustaceans. These creatures usually cause only minor damage when they remove small amounts of coral tissue and skeleton. This allows coral polyps to rejuvenate.
3. Some creatures bore into the reef creating small holes and tunnels for others to hide. However, boring into coral can weaken the foundation and make the colony susceptible to destruction from wave action.
   a. Some species of sponges enter the reef through dead areas using chemicals to dissolve the limestone.
   b. Other invertebrates such as crabs, mussels, polychaete worms, and sea urchins form burrows by eating the surface coral.

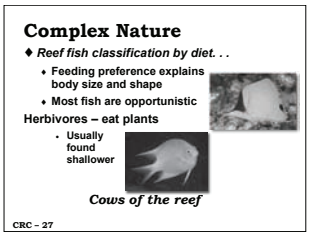


4. If a competitive imbalance occurs, population explosions may result. When numbers are too high, some organisms can destroy entire reefs, such as the crown-of-thorns sea star.
   a. The crown-of-thorns sea star is found only on Indo-Pacific reefs and feeds on the tissue of living coral.
   b. They prefer to eat fast-growing corals, so when their numbers are within normal range, they preserve coral diversity by keeping faster growing species in check.
   c. Under certain conditions, their numbers swell to tens of thousands on a single reef and they can consume nearly all corals.

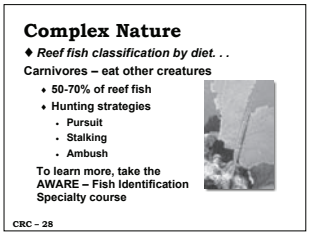
E. Why is grazing so important to reef ecology and how are reef fish classified by what they eat?



1. Grazing enhances primary productivity – the first step in the food chain – by promoting new algae growth and recycling nutrients back to the reef community.
   a. Driven to graze constantly, herbivores, fish that specialize in eating plants, make up 50 percent of reef fish by number, but represent only 10 percent of species present.
2. Coral reef fish may be classified by their diet. A fish's feeding preference often explains its anatomical features. Although they do have distinct preferences, most reef fish are opportunistic feeders — sometimes carnivores eat plants and herbivores eat fish.
3. Herbivores, *the cows of the reef,* include damselfish, surgeonfish and parrotfish.
   a. As a rule, above 10 metres/33 feet, most fish are herbivores because more light is available for photosynthesis, and therefore more plants are available. Below this depth, most fish are carnivores.
   b. Some herbivorous species reside on reefs during the day and feed in seagrass beds at night. Their fecal pellets bring nutrients from grass beds to the reef.
   c. Because plants have poor nutritional value and are difficult to break down, herbivores have long digestive tracks and feed continuously.



4. Carnivores make up 50-70 percent of reef fish species.
   a. Prey items tend to change as fish move through different stages of their lifecycles.
   b. Because animals have higher nutritional value than plants, carnivores have shorter digestive tracts and don't feed as often as herbivores.
   c. Pursuit hunters have a moving start from long range and include sharks, jacks and mackerel.



d. Stalking hunters make a stealthy attack from close range and include trumpetfish and barracuda.

e. Ambush hunters have no preliminary maneuvering and include scorpionfish, seabasses and lizardfish.

5. Other specialized feeding subgroups include:

a. Benthivores – an important group adapted to eating coral reef invertebrates. They have precise swimming and maneuvering skills, good close-up vision, mouths designed to pluck and crush prey, and good defense mechanisms. Examples include – blennies, wrasses, gobies, goatfish, drums, hogfish and trunkfish.

b. Planktivores – a few fish who are plankton feeders. Examples include chromis, Creole wrasses, juvenile yellowtail snapper, sergeant majors and the nocturnal cardinalfish and sweepers. Most hunt up in the water column, away from the reef on the seaward side, and are colored to avoid detection in open water.

c. Nocturnal feeders – these fish rely on touch, taste, smell and motion. Their mouths are adapted to quick sucking action. Some species, such as grunts and snappers, forage up to a mile away from the reef. Others, such as squirrelfish and bigeyes, remain closer to reef.

6. Although most reef fish are small, colorful and pose no risk to humans, there are a few that are venomous or toxic.

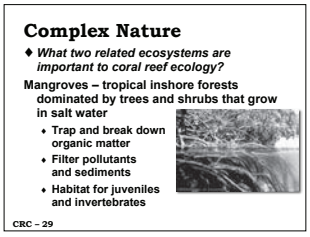
a. Venomous fish produce crinotoxin that is delivered through spines. These fish are relatively rare, confined mainly to the stonefish and scorpionfish.

b. Many species such as parrotfish, wrasses and surgeonfish have toxic secretions on their outer surfaces.

c. Some reef fish have toxic flesh or internal organs and are dangerous to humans when eaten.

7. To learn more about reef fish, take the AWARE – Fish Identification Specialty course.

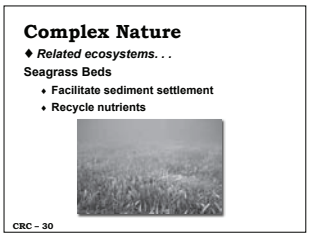
F. What two related ecosystems are important to coral reef ecology?

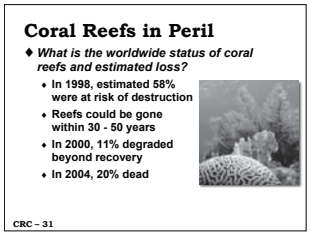


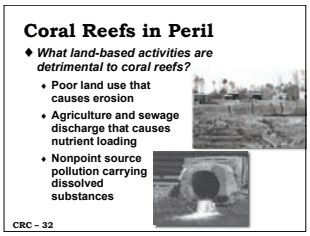
1. Mangroves are tropical inshore ecosystems dominated by several species of trees or shrubs that grow in salt water.

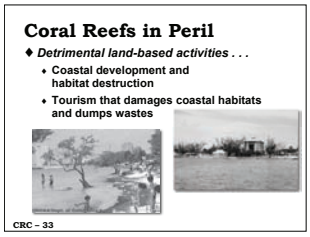
a. These trees have shallow, widely spread roots that extend from their trunk and branches to anchor them to the bottom. Some species send up snorkel roots, or pneumatophores, to the surface for oxygen from above the anoxic mud.

b. Their extensive root system traps and filters plant matter. This material is broken down into detritus, which forms the base of the food chain.









c. In many areas, mangroves act as coral reef wastewater treatment plants and help to maintain water quality. They trap excess nutrients and pollutants, and prevent sedimentation from reaching the reef.

d. The root system also provides habitat for invertebrates, such as mussels, sponges, tunicates, hydroids and oysters, as well as many juvenile fish species.

2. Seagrass beds facilitate sediment settlement, stabilize the bottom and recycle nutrients to the coral reef. Many reef fish depend on these highly productive beds to graze and hunt. Nutrients return to the reef through their fecal pellets.

VII. Coral Reefs in Peril

A. What is the worldwide status of coral reefs and estimated loss?

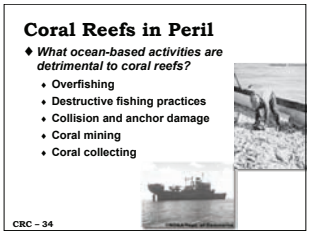
1. In 1998, World Resource Institute estimated that 58 percent of the remaining coral reefs were at immediate risk of destruction from human activities.
2. South and Southeast Asia, East Africa and Caribbean reefs are at the greatest risk. In places like the Philippines, Indonesia and Jamaica, the majority of the reefs are seriously damaged or dead.
3. Forecasts are that most reefs could be gone within the next 30-50 years.
4. In 2000, research showed that 11 percent of the world's coral reefs were degraded beyond recovery, by 2004, 20 percent of reefs were dead, in part due to raised sea surface temperatures causing major bleaching events.

B. What land-based activities are detrimental to coral reefs?

1. Deforestation, mining, over-grazing, and poor land uses cause erosion and sedimentation.
2. Agricultural activities and sewage discharge cause nutrient loading (eutrophication). This shifts the competitive balance in favor of algae, sponges and other organisms that erode coral.
3. Nonpoint source pollution is caused by construction of impervious surfaces, such as parking lots, that increase runoff rates and carry dissolved substances to the water. Even small amounts of oil can disrupt coral reproduction.
4. Coastal development and habitat destruction often affects mangroves and seagrasses, which normally act as filters for sediment. This has increased the sediments and nutrients reaching coral reefs.
5. Tourism— when viewed globally, comparatively little damage occurs to reefs from activities such as sport fishing, anchoring and

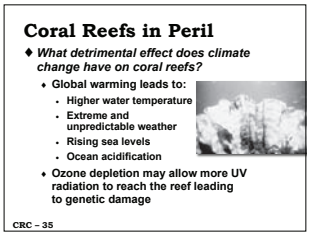
accidental contact by snorkelers and divers. Most damage from tourism is caused by building environmentally destructive facilities that damage coastal habitats such as mangrove forests and seagrass beds and allow sewage and other wastes to pollute reef areas.

C. What ocean-based activities are detrimental to coral reefs?



1. Overfishing causes reef decline, particularly by depleting spawning stock.
   a. Nearly half a billion people live within 100 kilometres/60 miles of coral reefs and rely on coral reef fish as their primary protein source.
   b. The overfishing of herbivores in many threatened reef areas is directly associated with the shift from coral dominated to algae dominated reef communities.
2. Destructive fishing practices such as blast fishing and cyanide fishing affect the entire reef, not just the target species.
3. Fortunately, collision damage caused by large ships is relatively rare. However, continual damage caused by small boats hitting reefs, props chipping away at corals and anchors crushing habitats is significant in some areas.
   a. When a large vessel, freighter or super-tanker runs aground on a reef, the immediate physical damage is extensive. The potential for damage caused by leaking oil and chemicals makes these accidents very destructive to the local environment.
   b. Often more damaging is the constant abuse some reefs endure from the poor operational practices of recreational or small commercial boats.
4. Coral mining for building material and cement causes massive destruction.
5. Collecting coral for souvenirs, or for any other purposes, severely alters a reef.

D. What detrimental effect does climate change have on coral reefs?

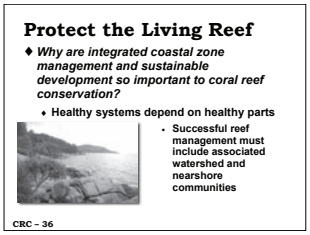


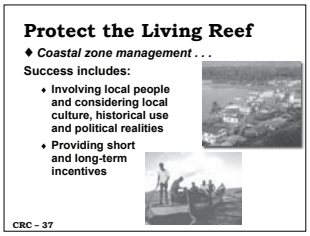
1. Global warming leads to several significant changes including:
   a. A rise in the sea surface temperature. Once past a critical temperature, coral polyps lose their zooxanthellae and turn white, or bleach. Coral bleaching events have increased in the last twenty years.
   b. More extreme and unpredictable weather that could cause extensive physical damage.
   c. Rising sea levels that threaten coral reefs and small island nations based on coral reef atolls.

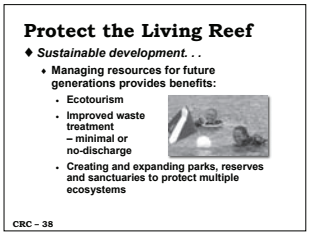
d. Increase in the acidity of the oceans' water may lead to ocean acidification slowing the development of coral reefs.

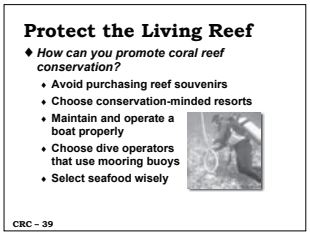
2. Ozone depletion may permit more potentially damaging UV radiation to reach the earth's surface. This could lead to genetic damage.

VIII. Protect the Living Reef









A. Why is integrated coastal zone management and sustainable development so important to coral reef conservation?

1. Coral reefs do not exist in isolation and cannot be managed as discrete patches within the sea. A healthy system depends on healthy parts. Successful reef management must include the associated watershed and nearshore communities, such as seagrass beds and mangrove forests.
2. Most coral reef management success stories prominently involve local stakeholders and account for the local culture, historical uses and political realities. Local communities must have both short-term and long-term incentives for protecting the reef.
3. Sustainable development means managing coral reef resources in ways that meet our needs today without compromising the ability of future generations to meet their own needs. These include:
   a. Ecotourism. Using reef resources to entertain visitors provides continual use versus consumptive uses, such as fishing.
   b. Improved waste treatment. Minimal or no-discharge systems are available for cost-effective treatment of sewage to protect water quality in coral reef areas.
   c. Marine Protected Areas. Creating a network of protected areas that protects multiple ecosystems and breeding grounds. However, for the network to be successful, all stakelholders must be included in its design and management.

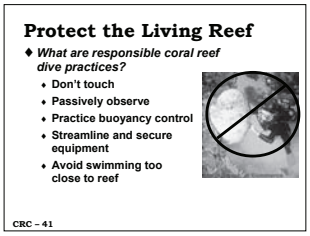
B. How can you promote coral reef conservation?

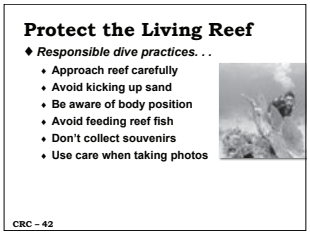
1. Avoid purchasing souvenirs made from coral or any threatened or endangered marine species.
2. While traveling, choose resorts and tour operators that properly treat all sewage and wastewater.
3. When operating a boat, avoid vulnerable ecosystems such as coral reefs or seagrass beds, and maintain equipment to prevent oil or fuel spills.
4. Whenever possible, choose dive or tour operators that use mooring buoys or drift diving techniques rather than anchors.
5. Select seafood wisely and avoid items that are caught or farmed using destructive or unsustainable practices, including poisons, explosives and illegal equipment. (See the *AWARE manual* and visit projectaware.org for the latest guide to sustainable seafood choices.)

6. Don't buy tropical hardwood furniture or products made from clear-cut tropical forests. These practices cause siltation damage to coral reefs.
7. Further your education through other PADI specialty courses, such as the Project AWARE Specialty, Underwater Naturalist Specialty, AWARE-Fish Identification Specialty and Peak Performance Buoyancy.
8. Volunteer to help and report all coral reef damage to dive operators, scientific or conservation organizations that monitor coral reef health.

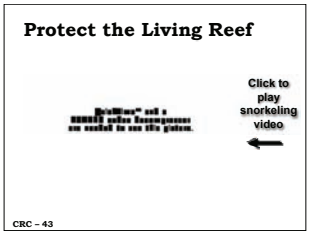
C. What are responsible coral reef dive practices?

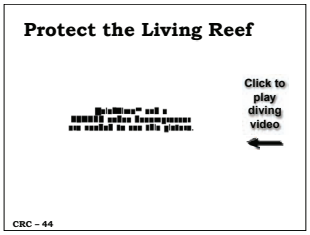
1. Coral tissue is very thin and easily damaged, so don't touch any coral and resist the temptation to touch other creatures. Some divers choose not to wear gloves so that they won't be tempted to grab the reef.
2. Passively observe organisms by floating in one spot and allowing fish to swim to you.
3. Practice buoyancy skills in a pool or sandy area before diving near a coral reef.
4. Secure your gauges and equipment to avoid accidental contact with the reef.
5. Avoid swimming over the top of reef areas and try to remain in the sand channels between coral heads, which makes contact with the reef much less likely.
6. Remain at least an arm's length from the reef unless you're looking at something very carefully.
7. Avoid kicking up sand because this smothers corals when it settles and is stressful to other reef animals.
8. Always be aware of your body's position in relation to the reef, especially your fins, and never stand on coral.
9. Avoid feeding reef fish. This may introduce unhealthy food items and disrupt their natural behavior.
10. Don't collect souvenirs, including dead shells and coral rock because everything on the reef has a function and anything removed affects the reef ecosystem.
11. Use a camera to bring back memories to share, but keep a safe distance from the reef while taking pictures. (See projectaware.org for 10 Tips for Underwater Photographers.)

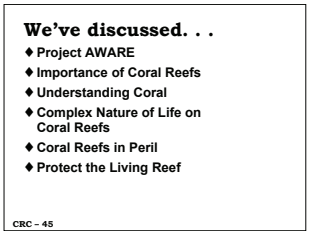




[Show the Protect the Living Reef video – diver version or snorkeler version, as appropriate.]







IX. Summary

A. Project AWARE

1. Why are divers and snorkelers the natural ambassadors for the aquatic environment?
2. What is the Project AWARE Foundation?
3. What is Project AWARE's purpose and mission?
4. What steps are PADI and Project AWARE taking to protect the aquatic world?

B. Importance of Coral Reefs

2. Why are coral reefs vital ecosystems and how do they maintain biological diversity?
3. What benefits do coral reefs provide to islands, coastal areas and tourism?
4. How can coral reefs benefit human health?

C. Understanding Coral

1. What is coral and why is it difficult to classify?
2. What are zooxanthellae and what role do they play in coral physiology?
3. How do coral reefs form?
4. What other calcifying organisms help maintain reef integrity?
5. What limits coral reef distribution and how do coral reefs exist in nutrient deficient waters?

D. Complex Nature of Life on the Coral Reef

1. How do corals reproduce and grow?
2. What is zonation?
3. How do corals battle for space with each other and compete with other reef residents?
4. Why is grazing so important to reef ecology and how are reef fish classified by what they eat?
5. What two related ecosystems are important to coral reef ecology?

E. Coral Reefs in Peril

1. What is the worldwide status of coral reefs and estimated loss?
2. What land-based activities are detrimental to coral reefs?
3. What ocean-based activities are detrimental to coral reefs?
4. What detrimental effect does climate change have on coral reefs?

F. Protect the Living Reef

1. Why is integrated coastal zone management and sustainable development so important to coral reef conservation?
2. How can you promote coral reef conservation?
3. What are responsible coral reef dive practices?

Appendix

Table of Contents

Knowledge Review
AWARE – Coral Reef Conservation

Answer the following questions. Your instructor will review your answers with you.

1. Why are divers and snorkelers the natural ambassadors for the aquatic environment?

2. Coral reefs are vital marine ecosystems because they:
   a. Are nursery grounds to 25 percent of known marine species.
   b. Are home to nearly 33 percent of all known fish species.
   c. Help maintain biological diversity.
   d. All of the above.

3. What benefits do coral reefs provide? (choose all that apply)
   a. Reefs act as coastal barriers protecting islands and coastal communities.
   b. Reefs attract tourists, which boosts local economies.
   c. Reefs contain many biomedical compounds including anti-cancer agents, anti-HIV agents and antibiotics.
   d. Reefs are navigational aids for large ships.

4. Corals are _____ that have a symbiotic relationship with _____ called zooxanthellae.

5. True or False. Reefs form differently depending upon local factors, however, the two popular theories include geological subsidence and formation due to changing sea level and erosion.

6. What physical factors control and limit coral reef distribution? (choose all that apply)
   a. Temperature
   b. Depth
   c. Rainfall
   d. Water clarity
   e. Waves
   f. Bottom type

7. True of False. Because coral reefs have a highly efficient nutrient recycling system, they produce large amounts of food beyond what's needed by the reef community itself.

8. Corals constantly _____ for space with each other and with other reef residents.

9. Why is grazing so important to reef?
   a. It enhances productivity by promoting new algae growth.
   b. It keeps algae growth in check.
   c. It recycles nutrients back to the reef community.
   d. All of the above.

10. True or False. By 2004, 50 percent of reefs were estimated to be dead, in part due to raised sea surface temperatures causing major bleaching events.

11. What activities may be detrimental to coral reefs? (choose all that apply)
   a. Dynamite or blast fishing
   b. Deforestation and overgrazing
   c. Sewage discharge
   d. Coral mining
   e. Destruction of mangroves
   f. Oily runoff from parking lots
   g. Overfishing

12. True or False. Atmospheric changes that lead to a rise in sea surface temperatures can cause coral polyps lose their zooxanthellae and turn white, or bleach.

13. To be successful, reef management must: (choose all that apply)
   a. Treat each reef as an separate, independent ecosystem.
   b. Include protection of associated watershed and nearshore communities.
   c. Involve all stakeholders.
   d. Account for the local culture, historical uses and political realities.

14. How can you promote coral reef conservation? (choose all that apply)
   a. Don't buy souvenirs made from coral.
   b. When operating a boat, avoid vulnerable ecosystems and maintain equipment to prevent oil or fuel spills.
   c. Choose dive or tour operators that use mooring buoys rather than anchors, whenever possible.
   d. Select seafood wisely.
   e. Further your education and volunteer to help conservation organizations that monitor coral reef health.

15. When snorkeling or diving, do not _____ coral and always be aware of your body's position in relation to the reef.

Knowledge Review – ANSWER KEY
AWARE – Coral Reef Conservation

Answer the following questions. Your instructor will review your answers with you.

1. Why are divers and snorkelers the natural ambassadors for the aquatic environment?
   Divers and snorkelers notice both short and long term changes in the aquatic realm. This intimate familiarity makes them the natural ambassadors for the aquatic environment.

2. Coral reefs are vital marine ecosystems because they:
   a. *Are nursery grounds to 25 percent of known marine species.*
   b. *Are home to nearly 33 percent of all known fish species.*
   c. *Help maintain biological diversity.*
   d. *All of the above.*

3. What benefits do coral reefs provide? (choose all that apply)
   a. *Reefs act as coastal barriers protecting islands and coastal communities.*
   b. *Reefs attract tourists which boosts local economies.*
   c. *Reefs contain many biomedical compounds including anti-cancer agents, anti-HIV agents and antibiotics.*
   d. *Reefs are navigational aids for large ships.*

4. Corals are *animals* that have a symbiotic relationship with *plants (algae)* called zooxanthellae.

5. True or False. Reefs form differently depending upon local factors, however, the two popular theories include geological subsidence and formation due to changing sea level and erosion.
   TRUE

6. What physical factors control and limit coral reef distribution? (choose all that apply)
   a. *Temperature*
   b. *Depth*
   c. *Rainfall*
   d. *Water clarity*
   e. *Waves*
   f. *Bottom type*

7. True of False. Because coral reefs have a highly efficient nutrient recycling system, they produce large amounts of food beyond what's needed by the reef community itself.
   FALSE – the amount of biomass that can be taken from a coral reef on a sustainable basis is very limited.

8. Corals constantly *compete (battle)* for space with each other and with other reef residents.

9. Why is grazing so important to reef?

a. *It enhances productivity by promoting new algae growth.*
b. *It keeps algae growth in check.*
c. *It recycles nutrients back to the reef community.*
d. *All of the above.*

10. True or False. By 2004, 50 percent of reefs were estimated to be dead, in part due to raised sea surface temperatures causing major bleaching events.
FALSE – estimates are closer to 20 percent

11. What activities may be detrimental to coral reefs? (choose all that apply)
a. *Dynamite or blast fishing*
b. *Deforestation and overgrazing*
c. *Sewage discharge*
d. *Coral mining*
e. *Destruction of mangroves*
f. *Oily runoff from parking lots*
g. *Overfishing*

12. True or False. Atmospheric changes that lead to a rise in sea surface temperatures can cause coral polyps lose their zooxanthellae and turn white, or bleach.
TRUE

13. To be successful, reef management must: (choose all that apply)
a. *Treat each reef as a separate, independent ecosystem.*
b. *Include protection of associated watershed and nearshore communities.*
c. *Involve all stakeholders.*
d. *Account for the local culture, historical uses and political realities.*

14. How can you promote coral reef conservation? (choose all that apply)
a. *Don't buy souvenirs made from coral.*
b. *When operating a boat, avoid vulnerable ecosystems and maintain equipment to prevent oil or fuel spills.*
c. *Choose dive or tour operators that use mooring buoys rather than anchors, whenever possible.*
d. *Select seafood wisely.*
e. *Further your education and volunteer to help conservation organizations that monitor coral reef health.*

15. When snorkeling or diving, do not *touch* coral and always be aware of your body's position in relation to the reef.