

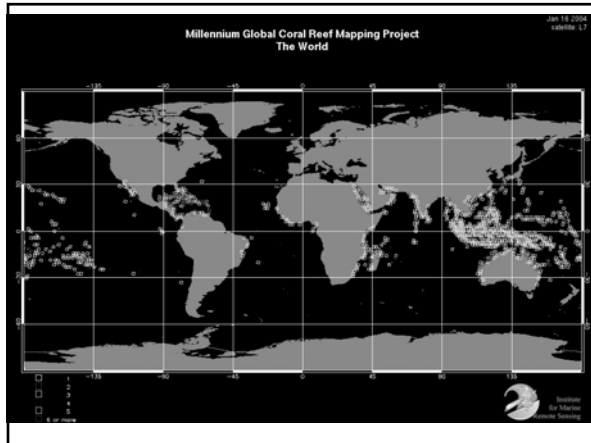
Remote Sensing of Coral Reef

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Geomorphic Types

-  **Drowned barrier reef:**
Récifs-barrières submergés : Barrière aréolaire submergida (38.57 km²)
-  **Fringing reef :**
Récifs frangeants : Aréolaire frontal (29.95 km²)
-  **Fringing reef around small islands:**
Récifs frangeants d'îlots : Aréolaire frontal bordando pequeñas islas (2.23 km²)
-  **Fringing reefs around barrier-reef islands (Pamandzi sector) :**
Récifs frangeants des îles de barrière (secteur Pamandzi) : Aréolaire frontal bordando islas de aréolles-barrière (Sector Pamandzi) (12.50 km²)
-  **Fringing reefs around barrier-reef islands (M'Zamboro sector):**
Récifs frangeants des îles de barrière (secteur M'Zamboro) : Aréolaire frontal bordando islas de aréolles-barrière (Sector M'Zamboro) (7.07 km²)
-  **Pinnacles and patches under terrestrial influence:**
Pináculos et patches proches de la terre : Pináculos y parches bajo influencia terrestre (6.85 km²)
-  **Shallow barrier reef**
Récifs-barrières peu profonds : Barrière de aréolles someros (157.26 km²)
-  **Deep reefs (detection limit in Landsat imagery):**
Récifs profonds (situés à la limite du brut dans les images) : Aréolles profundos (limite de detección en imágenes Landsat) (15.55 km²)



Typical Structures Of Coral Reef Atolls

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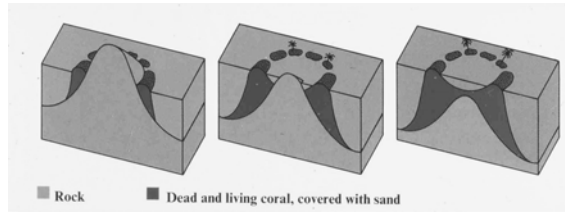
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Radar View Of Bora Bora

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Coral reefs and their associated communities cover an estimated 600,000 square kilometers, mostly between the Tropic of Capricorn and the Tropic of Cancer. Coral reefs represent less than 0.2 percent of the total area of oceans. They occur at depths of up to 30 feet, and cover about 30% of the earth's coastline.

Coral Reef Formation



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Blowing in the Wind "Our primary reason for this study is to address one of the old chestnuts in coral reef science," says Hatcher. He explains that one of the ways in which atolls form is the result of a change in sea level. Atolls begin as fringing reefs surrounding a volcanic island (Darwin 1842). Through the process of global warming, glacial melting and/or island subsidence, the level of the sea gradually rises relative to the seabed and water begins to overtake the island. Since most reef-building corals cannot grow easily at depths of more than 150 feet (45 m) below the ocean's surface, they will begin constructing their protective calcium carbonate encasements on top of one another at a rate fast enough to keep up with the sea level rise.

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<http://earthobservatory.nasa.gov/Study/Maldives/maldives2.html>

Calcium Carbonate Budget

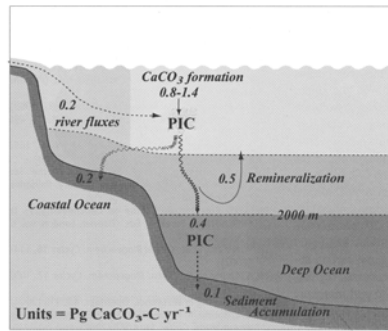


Fig. 5. Schematic diagram of the CaCO_3 budget for the global oceans. The values are in $\text{Pg of CaCO}_3\text{-C yr}^{-1}$.

Units = $\text{Pg CaCO}_3\text{-C yr}^{-1}$

Coral Atoll And Volcanic Island



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(Image by Robert Simmon, NASA GSFC)

Another factor influencing atoll growth is the flow of water around the reefs. For example, prevailing winds can agitate water on one side of an island, stimulating coral growth. (Red arrows in the image above indicate the prevailing wind direction.) On the lee side of the island the coral do not receive as many nutrients, resulting in slower growth and a thinner reef.

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Maldives



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Ecosystem Functions And Services Of The Coral Reef

1. *Sequesters calcium (Ca^{2+} is a second messenger for most cell surface transduction signals)*
2. *Sequesters carbon ($CaCO_3$)*
3. *Maintains biodiversity of ocean life:*
Reefs hold an estimated 4,000 species of fish and 800 species of reef-building corals; total number of species associated with reefs may be over one million!

Buffer Zones For The Coral Reef

1. *Hammocks: Clumps Of Trees In The Everglades*
2. *Seagrass Meadow*
3. *Mangroves*

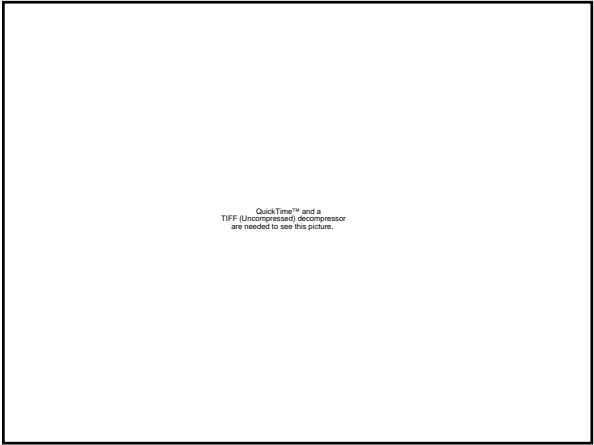
Mangroves

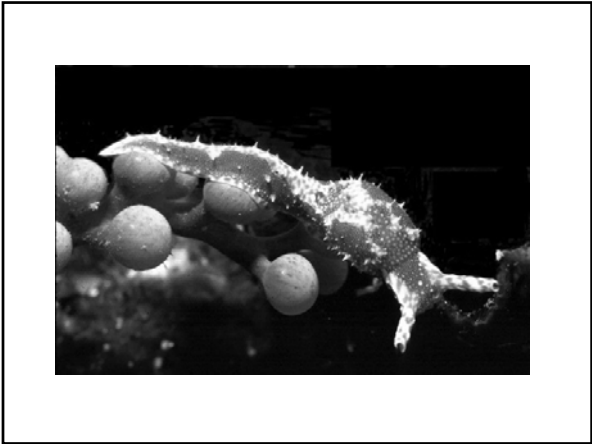


Diversity, Diversity, Diversity

Nudibranchs On Parade!

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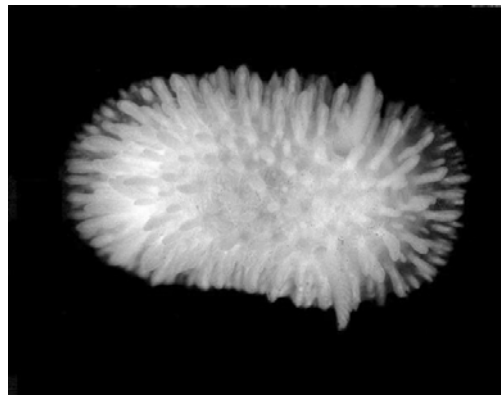
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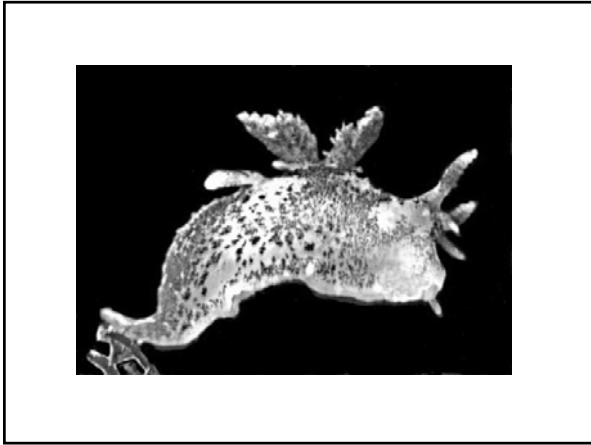
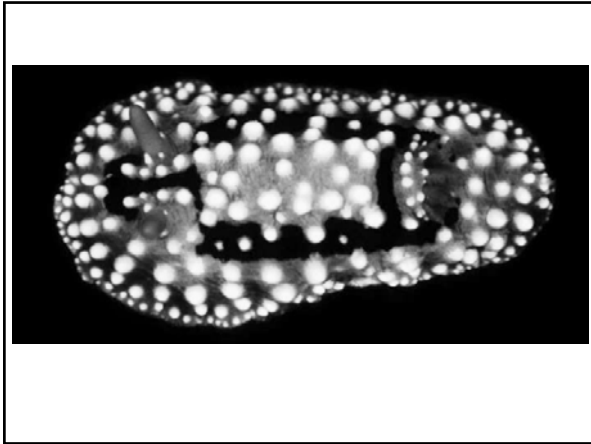
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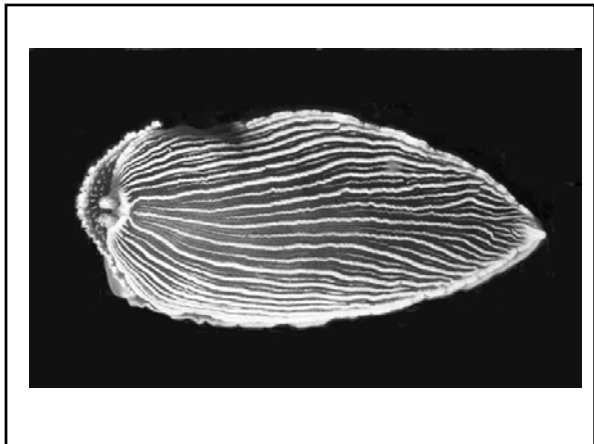
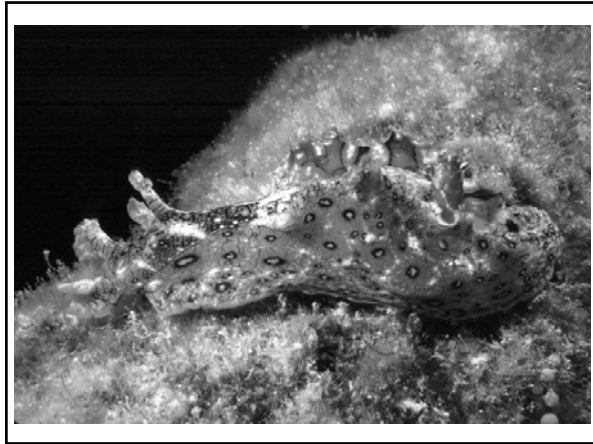
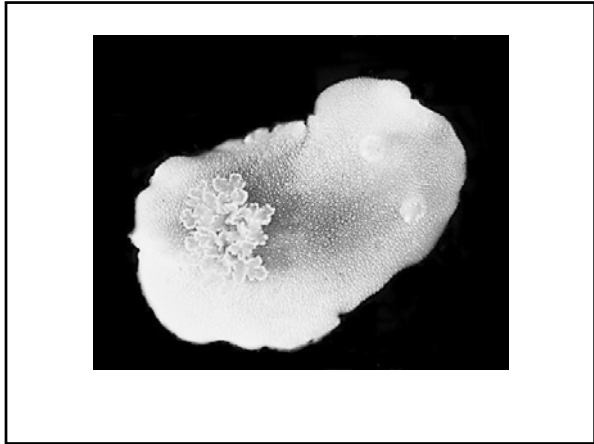
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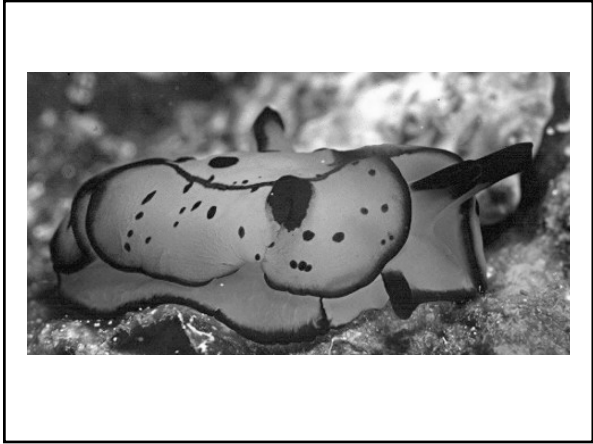
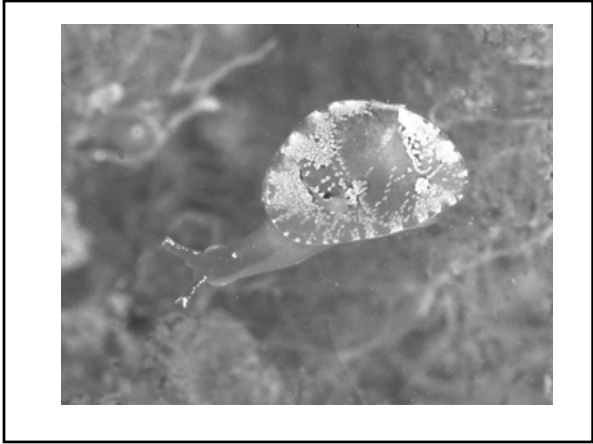
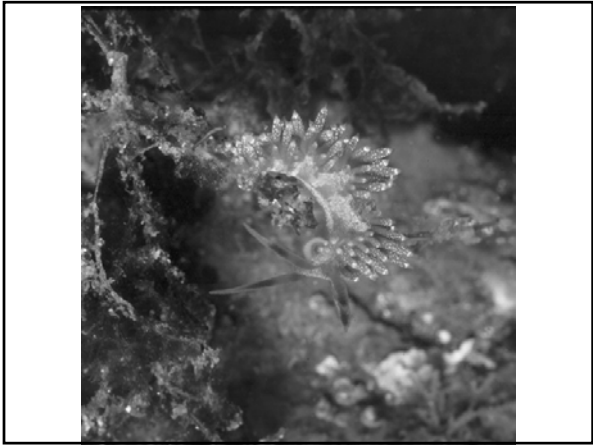
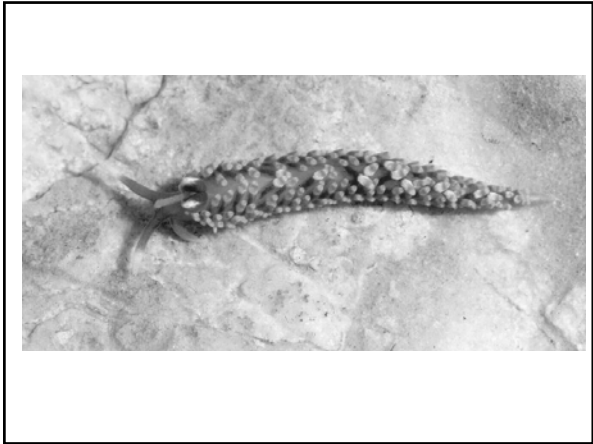
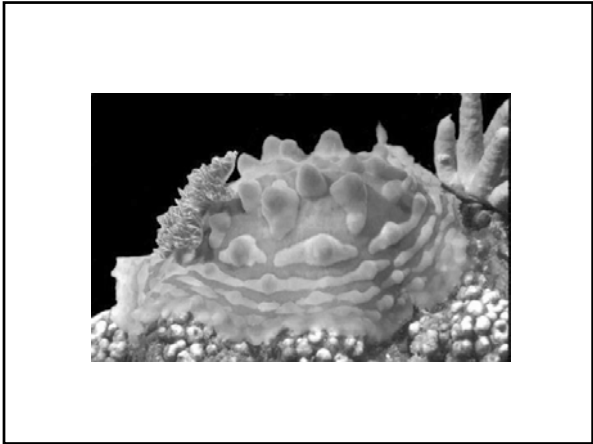
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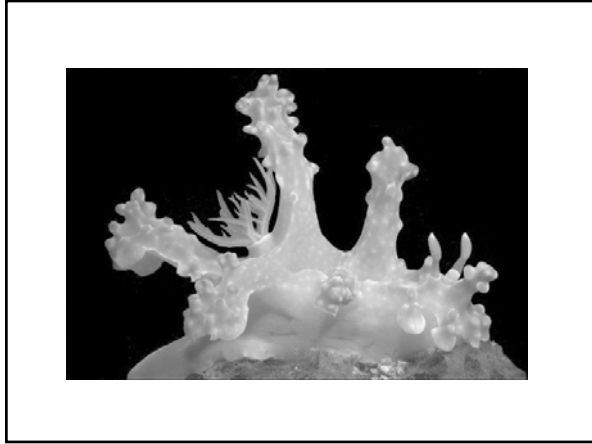
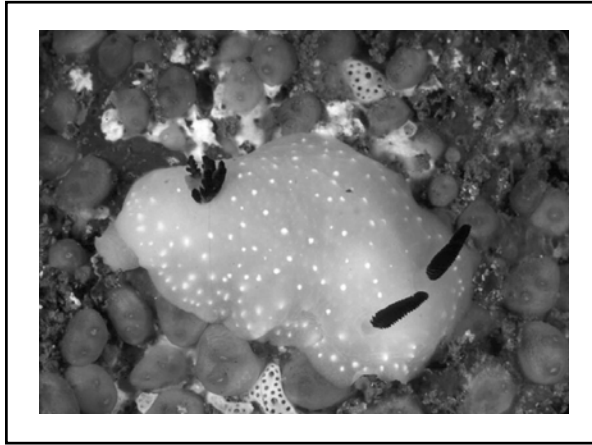
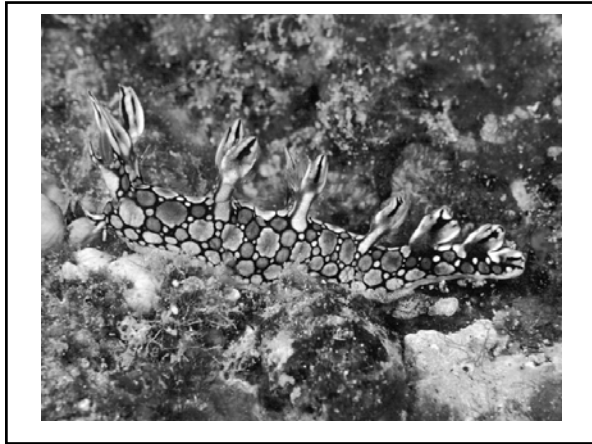
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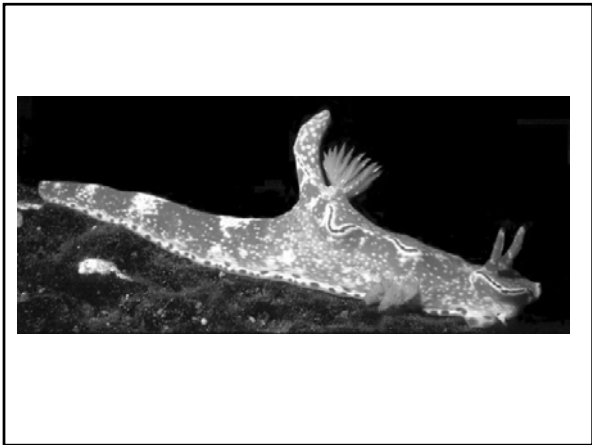


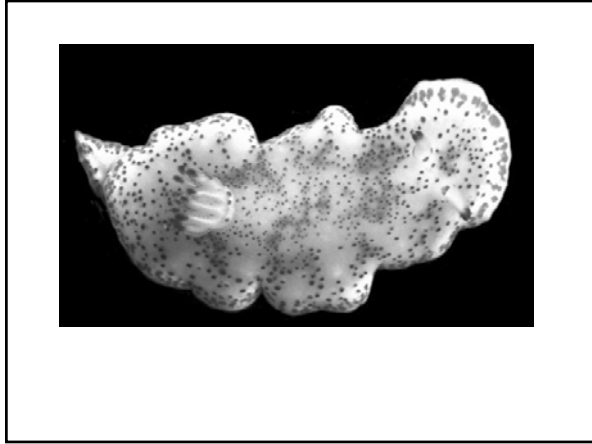


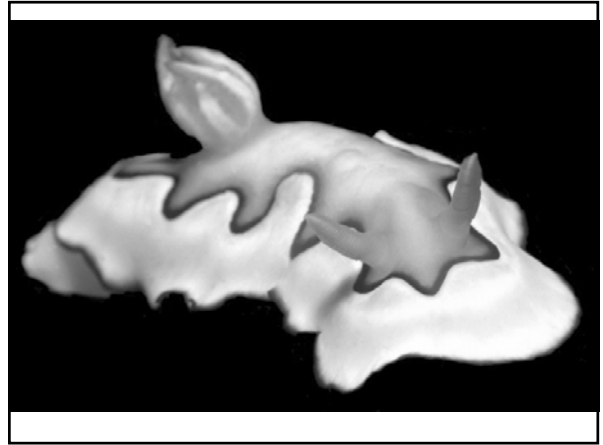
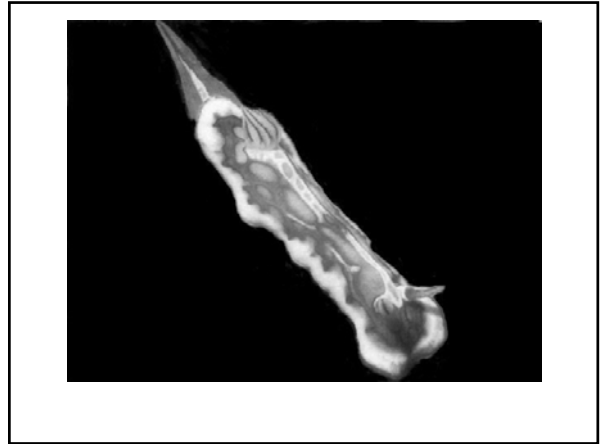
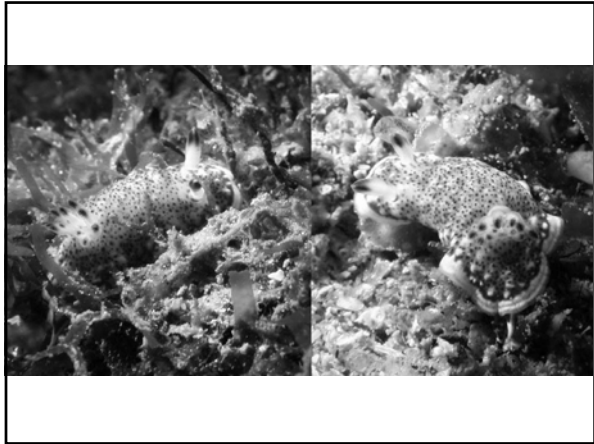


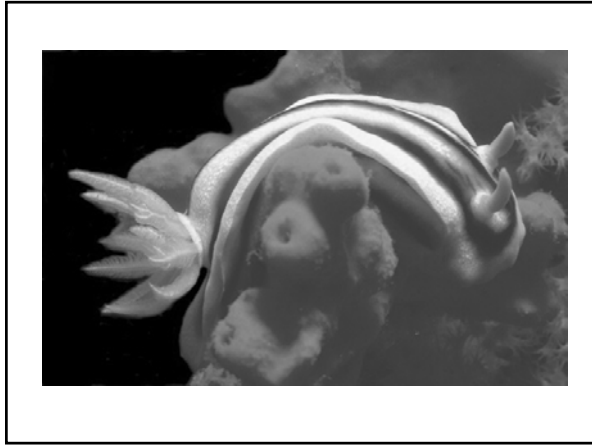
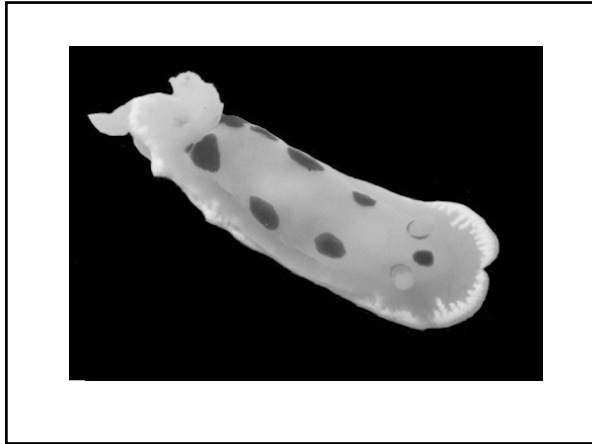
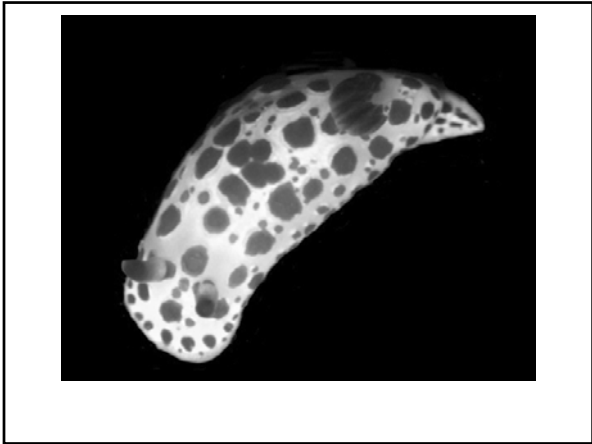


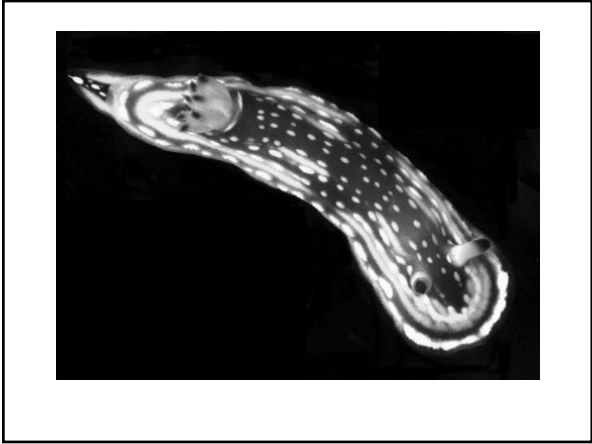
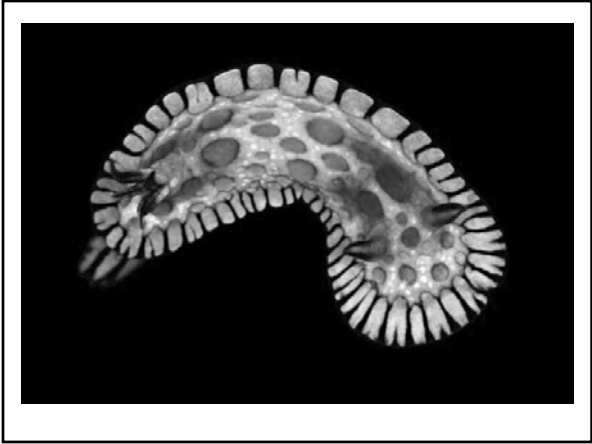
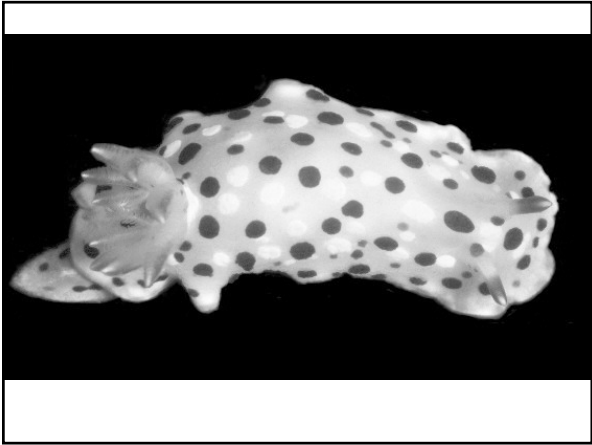
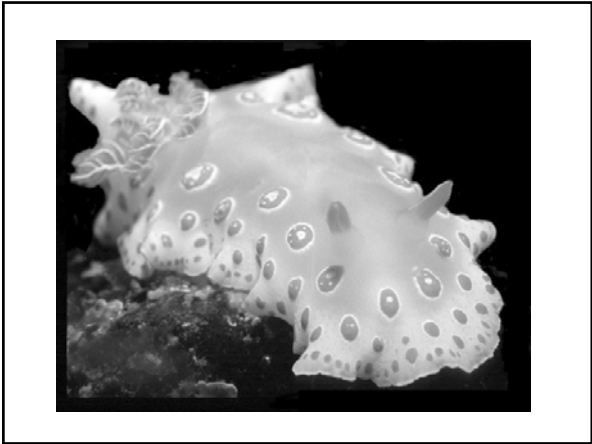


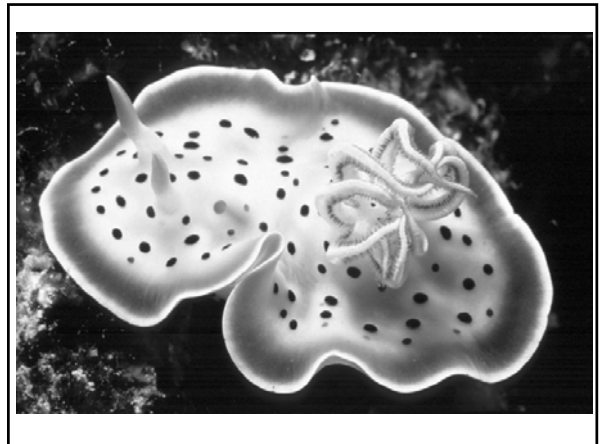
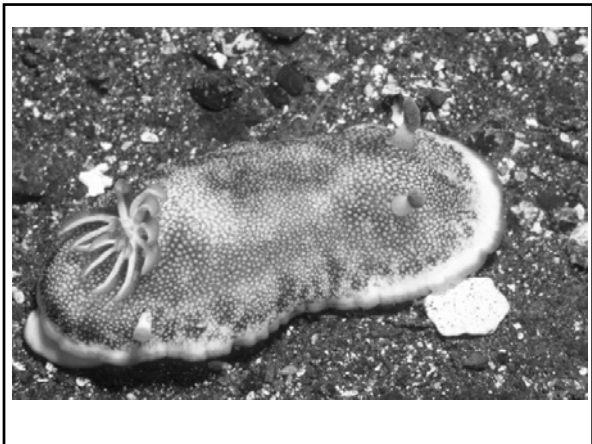


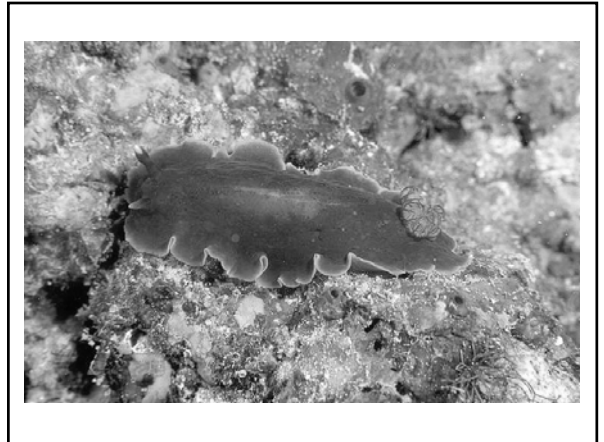
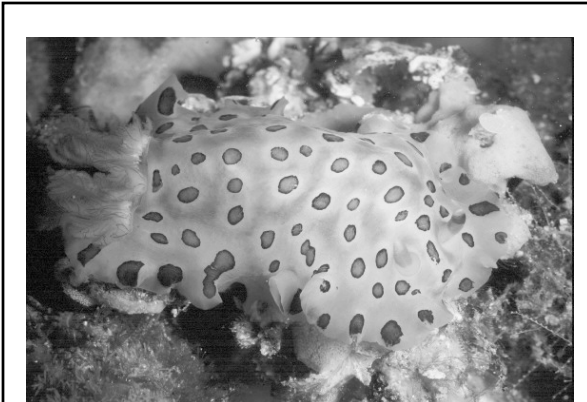
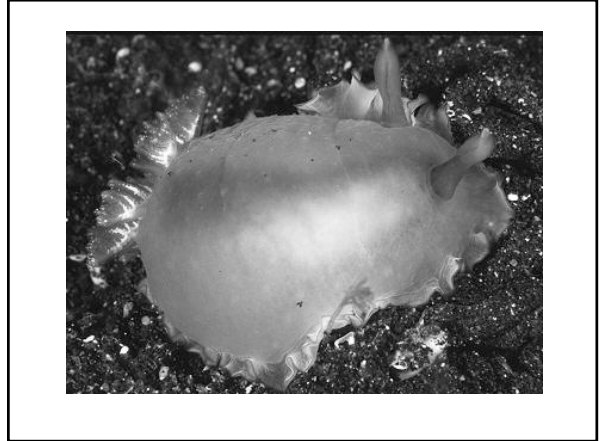


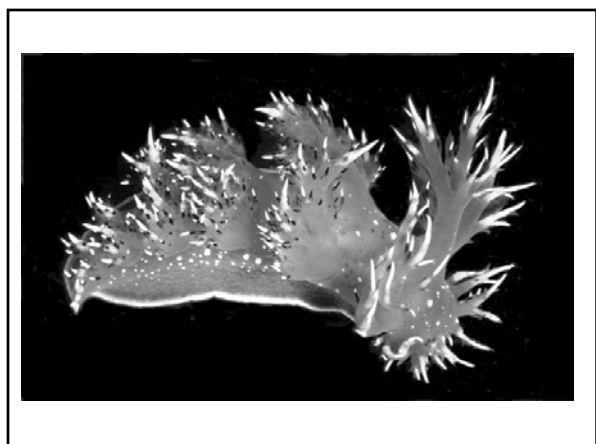
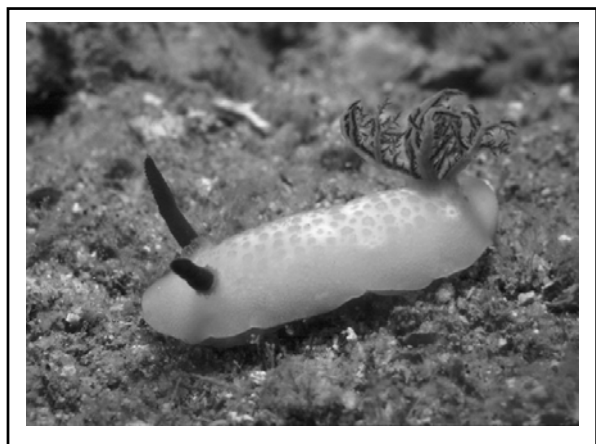


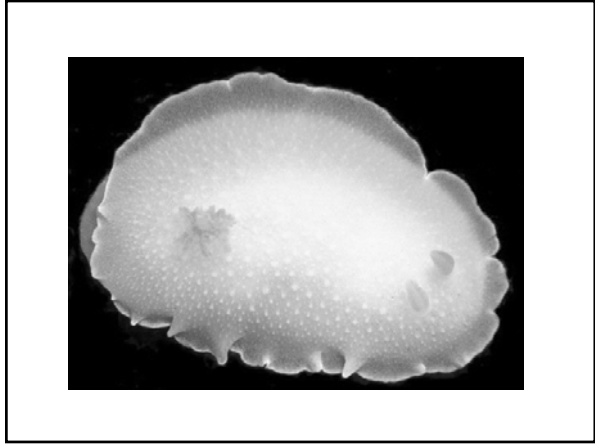
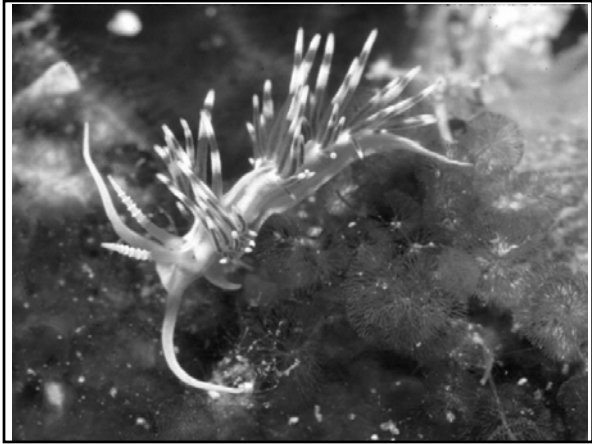


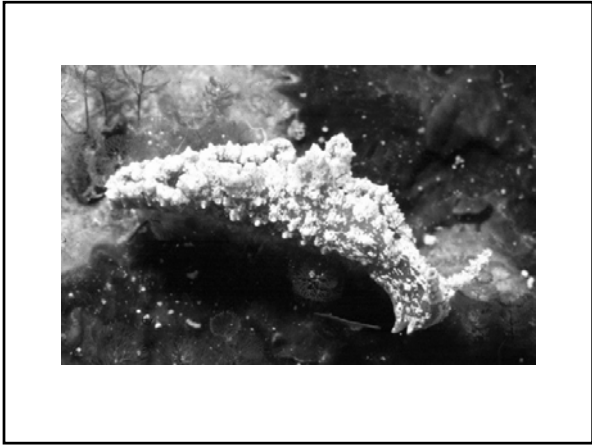
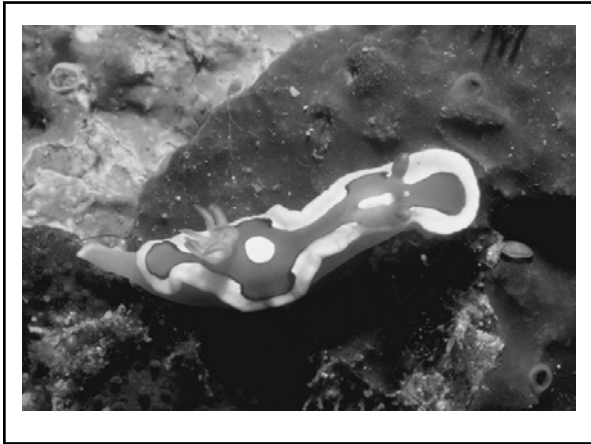












"Be A Clown, Be A Clown. Everyone Loves A Clown"

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Picasso Trigger Fish

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Long-nose Hawk Fish

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Cuttlefish

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Crinoid

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*Coral Reefs Are Found In Nutrient-poor Warm Waters,
So Why Are They So Productive?*

.... And Why Are Most Corals Green In Color?

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Green Is The Color Of My True Coral Reef's Hair

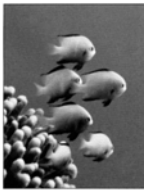


*Because They Have An Intracellular
Photosynthetic Symbiont*

Zooxanthellae are unicellular yellow-brown (dinoflagellate) algae which live symbiotically in the gastrodermis of reef-building corals. It is the nutrients supplied by the zooxanthellae that make it possible for the corals to grow and reproduce quickly enough to create reefs. Zooxanthellae provide the corals with food in the form of photosynthetic products. In turn, the coral provides protection and access to light for the zooxanthellae.

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Science Vol. 305, September 2004



Dascyllus marginatus swimming among *Stylophora ptilata*.

ECOLOGY/EVOLUTION

Rapid Fin Movement Sleep

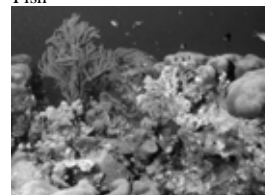
Coral and fish species often live in mutualistic associations, in which both partners benefit from the other's presence. For the fish, the association is usually obligatory, as they depend on the coral for both shelter and foraging (for zooplankton). The corals can survive on their own, but nevertheless show faster growth and greater reproductive output when fish are present; fish enhance nutrient input to corals via excretion and can protect them from predators and clear them of sediment.

Goldshmid *et al.* have documented another mechanism by which fish can benefit coral. In a reef of branching coral near the Red Sea port of Eilat, sleeping zooplanktivorous fish aerate their coral hosts at night. The fish, which were filmed by infrared video camera in their resting positions among the coral branches, spend the night sleep-swimming with their fins in vigorous motion. In the absence of fish, measurements showed that oxygen availability to the corals was severely reduced, to less than 30% of ambient levels. These observations may explain how dominant branching corals (whose morphologies hinder the free flow of water) can inhabit zones of relatively calm water. — AMS

Limnol. Oceanogr. 49, 1832 (2004).

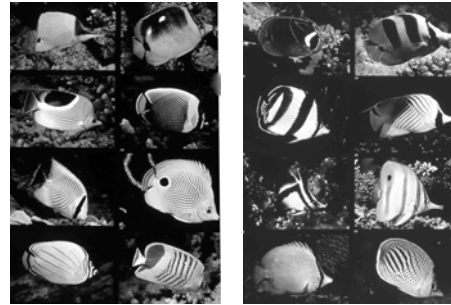
*Without Grazers, The Coral Reef
Would Soon Become
Overwhelmed
With Filamentous Algae*

Fish



So Who Are The Grazers?

Grazers Of The Coral Reef



Note the shapes of their mouths

The Coral Reef Is A Battle Ground In Which Mixed Species Of Coral Fight For Space



More Diversity

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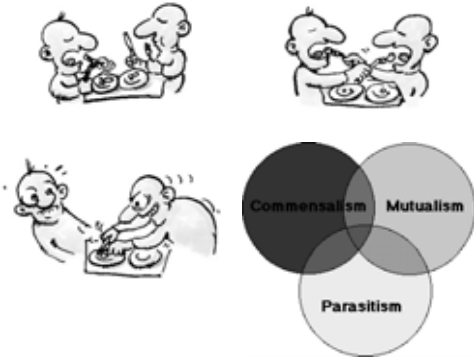
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Symbiotic Relationships



Nemo!

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Cleaner Wrasse At Work

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Wrasses comprise a large group of colorful cigar-shaped fishes. Some species are known as cleaners, and set up cleaning stations along the reef. When a larger fish aligns itself at one of these cleaning stations, a cleaner wrasse removes parasites from the fish.

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Cleaner Shrimp

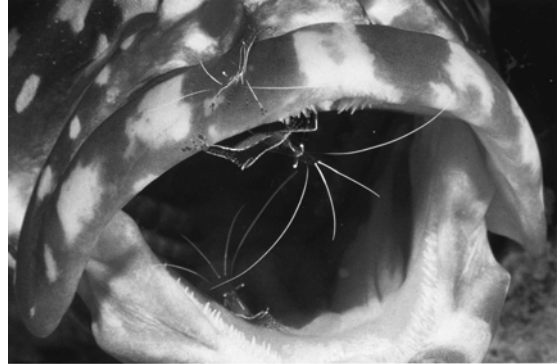
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Cleaner Shrimp With Grouper



Great Barrier Reef

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Movie!!!

<http://images.google.com/imgres?imgurl=svs.gsfc.nasa.gov/vis/a000000/a0006>

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Southern End, Great Barrier Reef

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Great Barrier Reef

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Barrier Reef Factsoids:

The Great Barrier Reef contains at least 1500 species of fish, 350 types of hard coral and 5000 varieties of molluscs.

Six of the world's seven species of marine turtle live there

Greater in area than the United Kingdom

Longer than the west coast of the USA

More than 2900 individual reefs

The largest green turtle breeding area in the world

More than 3,000 sq kms of seagrass meadow

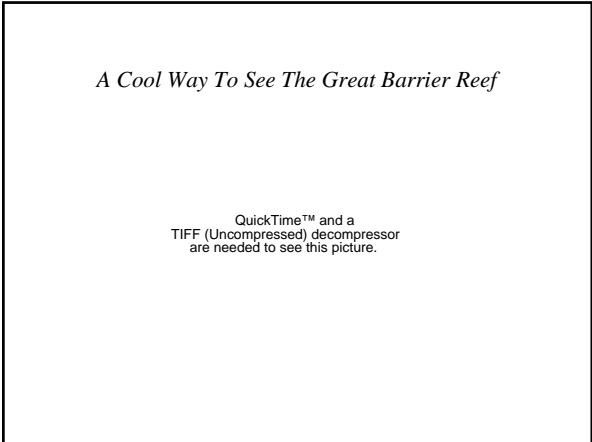
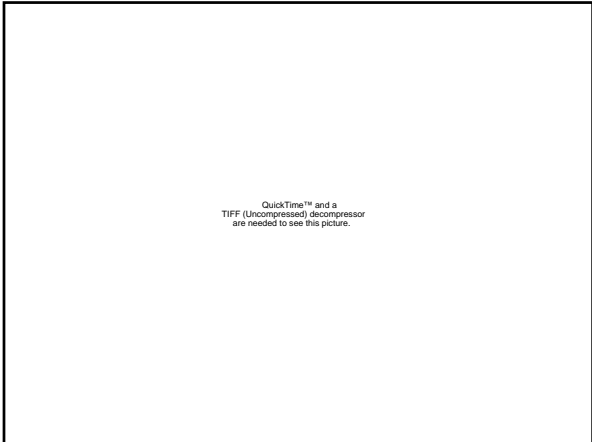
Heron Island, Great Barrier Reef

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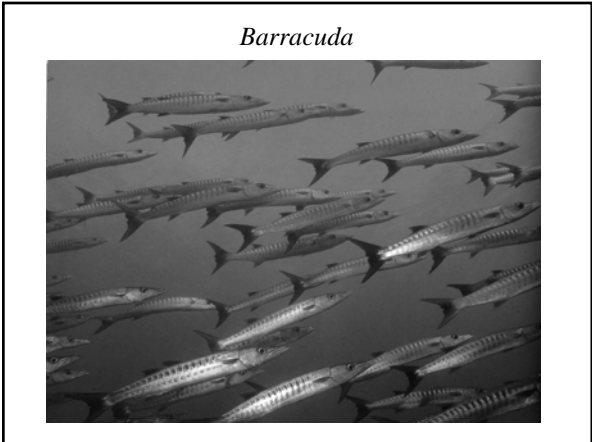
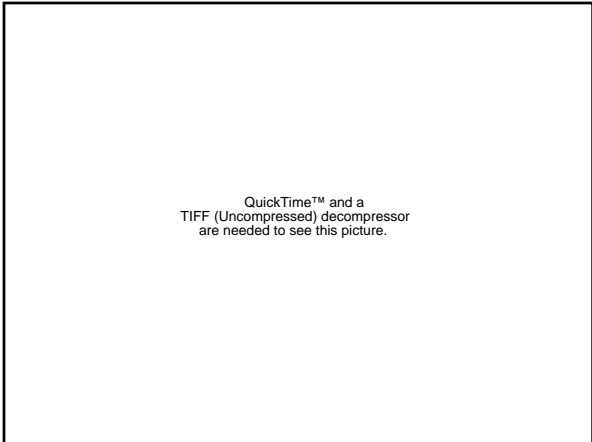
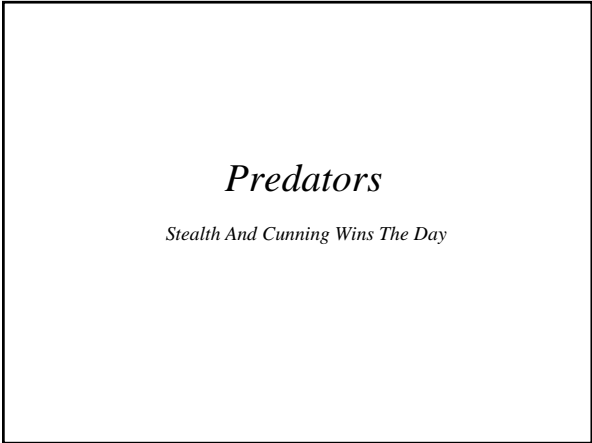
Research Laboratories

Clown Trigger Fish





- Problems Facing The Great Barrier Reef Today*
- 1. Declining regional catches*
 - 2. Decreased average size of fish*
 - 3. Increased fishing effort*
 - 4. Excess capacity in the fishery impacts of fishing activities on incidentally caught species, some of which are endangered*
 - 5. The impacts of fishing on the marine habitat*
 - 6. The increased significance of the recreational fishery*
 - 7. Indigenous use and rights to the resource*
 - 8. Issues associated with compliance of fisheries and marine park management regulations.*



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Moray Eel With Yellow Tang



Decorated Crab

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Ambush!





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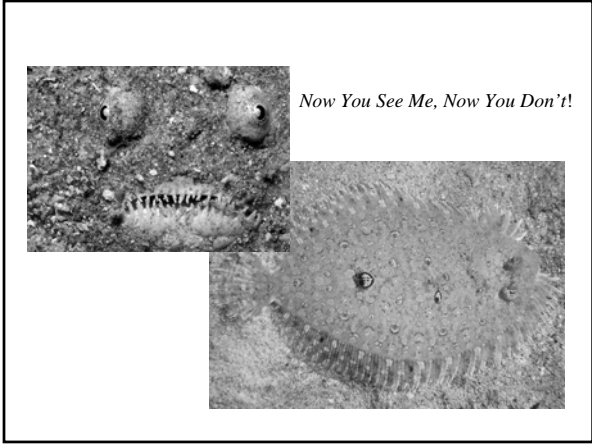
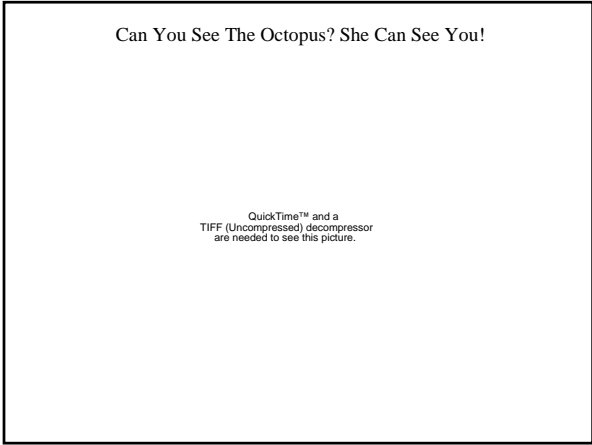
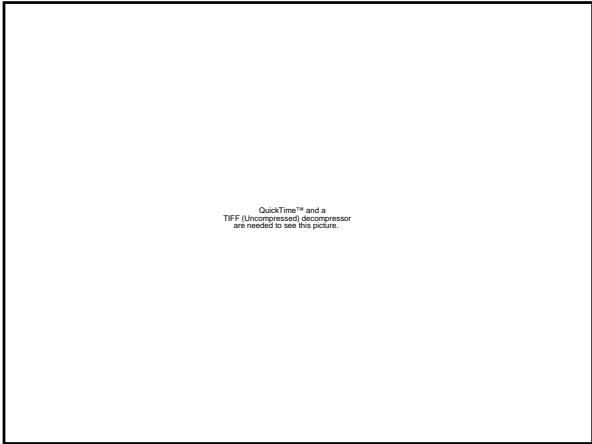
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Weedy Sea Dragon

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My, What Big Teeth You Have!



White-tipped Reef Shark

White-tipped Reef Shark
(Asleep!)

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*Eugenie Clark With Friend**

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*Bull Shark: Do Not Try This At Home!

Survival Tactics: Part I

Don't Touch!

Angler Fish

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Lion Fish

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Photo: David Doubilet

Sea Snake

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Blue Ringed Octopus

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*Tetrodotoxin Is Its Only Defense.
1 Milligram Kills An Adult Human.*

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*Survival Tactics: Part II
Camouflage And Protective Associations*

Razor Fish

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Safety In Numbers Strategy



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Finger Coral With Crab

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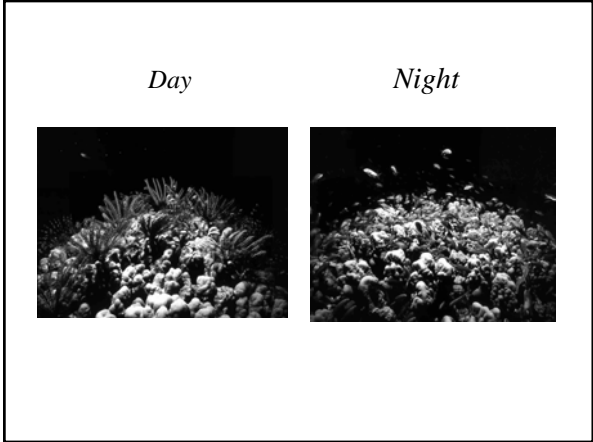
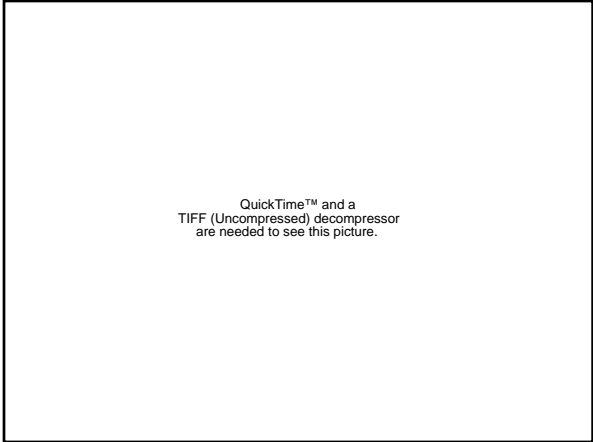
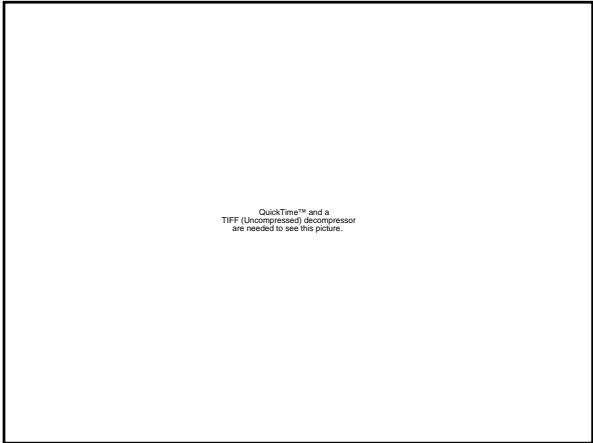
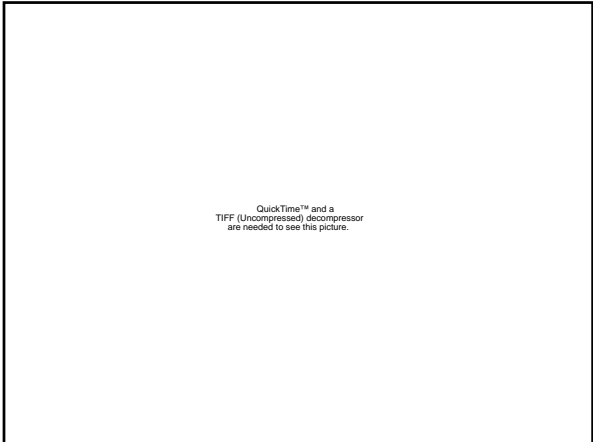
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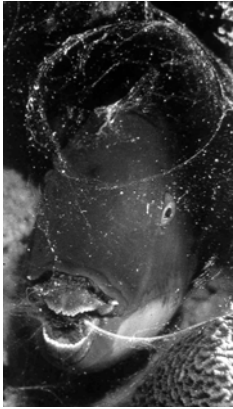
Big Fish, Little Fish



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Trigger Fish At Rest



Deep Water Coral

Causes Of Coral Reef Decline:

- 1. Sea Surface Temperature Rises*
- 2. Over-fishing*
- 3. Sedimentation From Agricultural Runoff*
- 4. De-forestation*
- 5. Urban Pollution Runoff*

*Bleached Coral Head Due To
Abnormally High Sea Temperatures*

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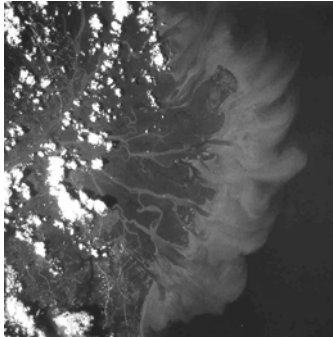
Bleaching Of Corals

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Encroachment

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Agricultural Runoff Due To De-forestation



Crown-Of-Thorns Star Fish

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Crown-Of-Thorns Sea Star Grazing On Barin Coral

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TIFF (Uncompressed) decompressor
are needed to see this picture.

Cyanide Fishing

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*Over-fishing and
Dismantling The
Predator-Prey
Relationships*

Diseases Of Coral

The recent emergence of diseases in corals may be interpreted as the consequence of (1) changing coastal ocean water quality favoring the proliferation, attachment and colonization of microbes, and (2) reduced efficiency of the coral's normal defenses."



Conspicuous white areas indicate presence of plague type II disease on a colony of *Montastraea annularis*

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Coral Diseases

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Hurricanes Often Topple Staghorn Coral Communities

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Its Getting Late

