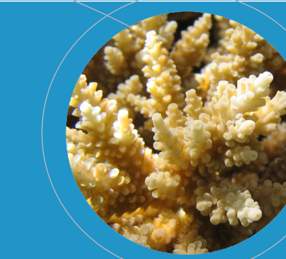
MOOREA CORAL REEF LTER RESEARCH

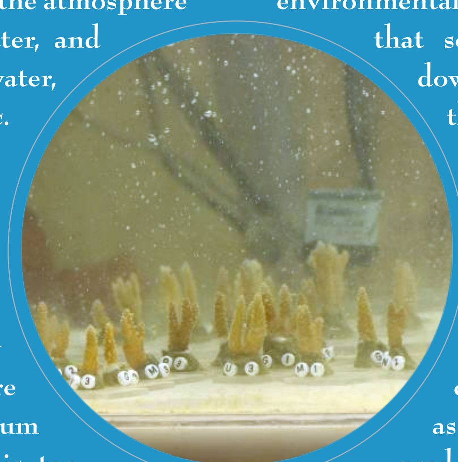


BURIED ALIVE

The crystal clear waters where coral reefs thrive are not just beautiful, they are also essential to the corals' health. Reef-building corals have microscopic algae, called zooxanthellae, living in their tissues. These zooxanthellae capture energy from the sun, just like plants, so corals do best with plenty of sunlight. Sediments like sand and mud make the water cloudy and block the sunlight, making it harder for corals to capture sunlight's energy to grow. These sediments also may settle on corals and smother them. Sedimentation is increasing due to a range of human activities.

Jackie Padilla-Gamino studies how sedimentation affects a common coral, Porites rus, in Moorea's lagoons. To do this, Jackie is measuring how much sediment the corals in different places encounter as well as how much the corals are growing, their strength, and how their bodies are working. She has found that although corals in different places may look the same to us, their bodies work differently, and their strength changes, when they are exposed to sediments. Jackie plans to share her research with resource managers so they can help make policies that protect the corals from the damaging effects of sedimentation.

GROWING PAINS

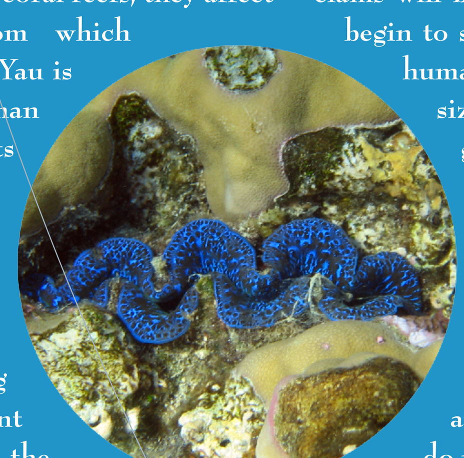


Changing climatic conditions such as warmer ocean waters or more frequent or intense storms can have a big impact on tropical coral reefs, primarily by affecting the stony corals that form the reef. Increasing temperatures damage and kill many corals, but increasing amounts of carbon dioxide in the atmosphere also affect corals across the globe. Carbon dioxide (CO_2) in the atmosphere is increasing due to human activities such as industry and transportation. More CO_2 in the atmosphere means more CO_2 in the water, and when CO_2 dissolves in ocean water, the water becomes more acidic.

Nancy Muehllehner wanted to know how this change, called ocean acidification, will affect coral growth rates. Corals are animals and the skeletons they build that make up the reef are made of a mineral called calcium carbonate. When the water is too acidic, it lowers the amount of carbonate in the water and corals can't build their calcium carbonate skeletons as easily.

Nancy is testing the fast-growing corals Acropora hyacinthus and Acropora pulchra in an aquarium where she can alter the acidity of the water to mimic what it will be like 100 years from now to find out if and how corals may change their growth rate under these different environmental conditions. Nancy found that some corals actually slow down their upward growth as they can weight, which could mean a denser skeleton. This could result in corals that are not able to grow tall quickly enough to compete with other organisms on the reef, or corals that cannot recover as well from damage due to predators and storms.

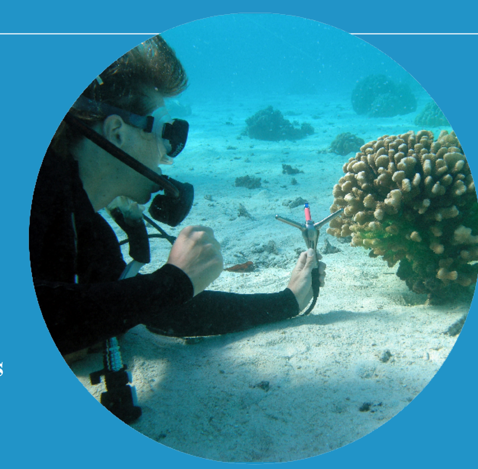
GONE FISHING



Coral reefs provide an important source of food to local people. When people harvest animals from coral reefs, they affect the communities from which they are taken. Annie Yau is interested in how human fishing activity affects nature, and hopes to understand which animals and how many we can continue fishing in the future. Annie is monitoring giant clams on different reef types throughout the northern lagoon of Moorea to estimate the size of the population and how giant clams grow in different habitats.

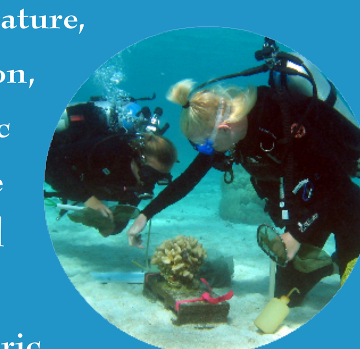
During her monitoring, Annie found very few large adult clams. By measuring "middens" (piles of shells fishermen leave behind after taking the clams from their shells), she found that people are mainly taking larger clams. This is worrisome because without adults, no baby clams will be made and the population may begin to shrink. Annie is calculating how human harvest is affecting population size, and how fast the population is growing. Once she understands this, she can calculate how many clams fishermen can take without hurting the entire population. Annie is working with local fisheries managers to determine how many clams can be harvested, and the best way to insure people do not harvest too many.

MCR LTER RESEARCH



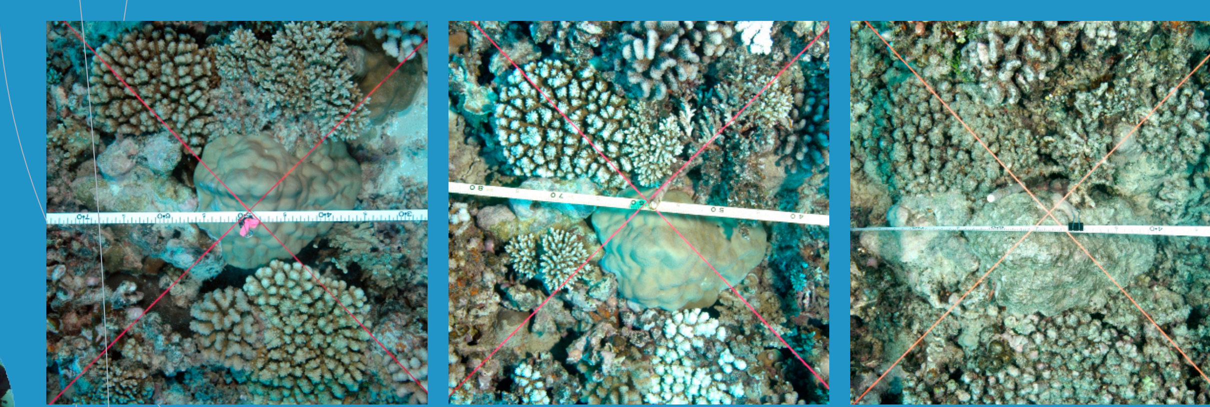
A central goal of the Long Term Ecological Research program is to advance our understanding of ecological processes within and among ecosystems that occur over long periods of time and across a range of spatial scales.

Data sets include:



- Physical oceanographic data on ocean temperature, conductivity, turbidity, wave height and direction, current speed and direction, concentrations of organic and inorganic nutrients and pH in order to explore linkages between hydrodynamic forces and biological communities;
- Climate data, including solar irradiance, atmospheric pressure, wind speed and direction, air temperature and rainfall;
- Settlement patterns of coral and reef fishes to investigate settlement cues and document survivorship and growth rates under different physical conditions;
- Rates of primary productivity;
- Abundance and community structure of major reef constituents including heterotrophic reef microbes, phytoplankton, algae, scleractinian corals, other major reef invertebrates and fishes in order to establish trophic linkages between these groups and examine the importance of diversity.

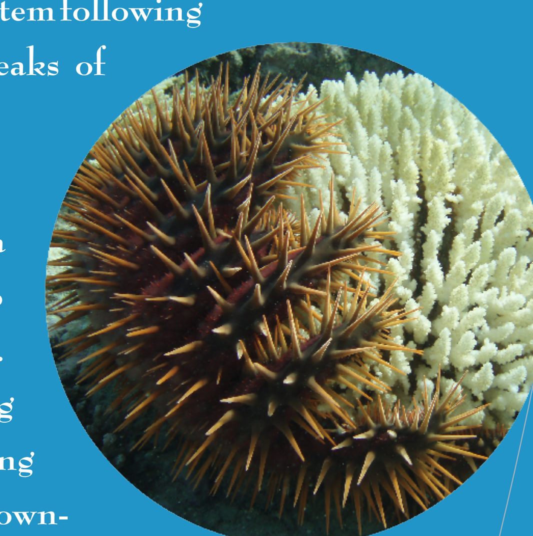
Moorea was recently struck with a thoroughly destructive crown-of-thorns seastar outbreak. MCR LTER experiments are in place to observe the recovery of the reef following this outbreak, and in particular whether the species that recover are the same as the species that made up the reef before the disturbance.



Photographs taken at set locations each year illustrate the effect of crown-ofthorns seastars during a recent outbreak off Moorea, French Polynesia. The picture on the left shows a healthy reef in 2005. The picture in the middle was taken in 2007, during the outbreak, and shows the bleached coral that results when live tissue is eaten. Finally, the picture on the right shows the same reef in 2009, following the outbreak. Note the turf algae growing on the dead coral.

TRACKING THE EFFECTS OF NATURAL DISTURBANCES

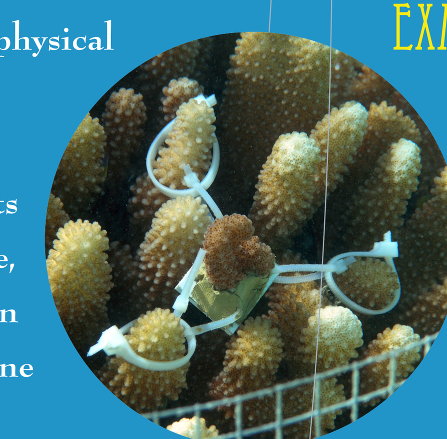
One of the benefits to having long term programs in place like the LTER is the opportunity to observe the resilience of an ecosystem following natural disturbances such as storms or outbreaks of predators.



The crown-of-thorns (Acanthaster planci) is a large, coral-eating seastar that can grow up to a meter in diameter and have up to 21 arms. Adult crown-of-thorns eat coral by exuding their stomachs from their mouths and digesting the living coral polyps. Small populations of crown-of-thorns occur naturally and are easily supported by healthy ecosystems. But if seastar larvae encounter favorable conditions and their populations increase, so does competition for food, and crown-of-thorns may eat greater portions of a colony or become less selective about the types of coral they consume.

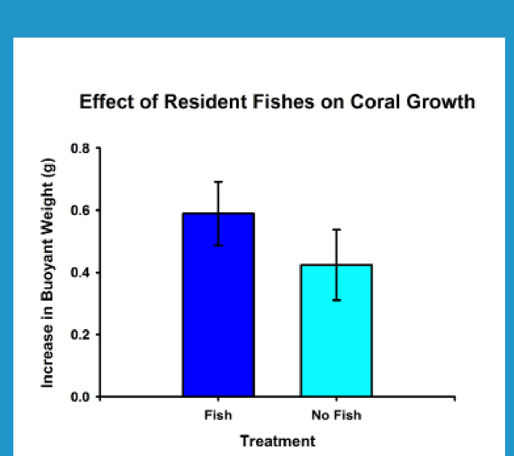
While fluctuations in the crown-of-thorns seastar population are a natural phenomenon, as larvae thrive in good conditions or adults run out of food, some scientists believe human influences may intensify the outbreaks or increase their occurrence. They hypothesize that fishing may remove natural predators and allow populations to expand, or that human use of coastal zones may increase nutrient flow to the sea and result in more food for seastar larvae.

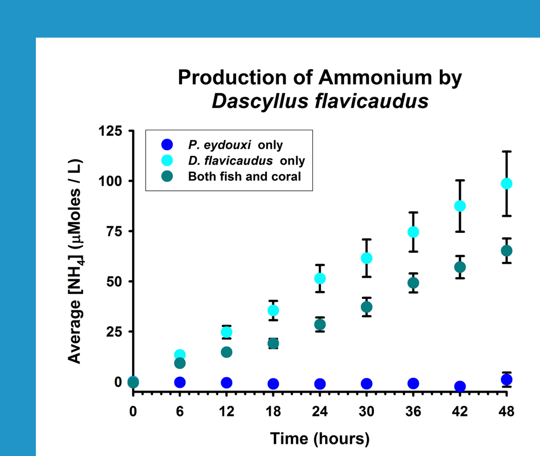
EXAMINING INTERACTIONS BETWEEN FISH AND CORAL



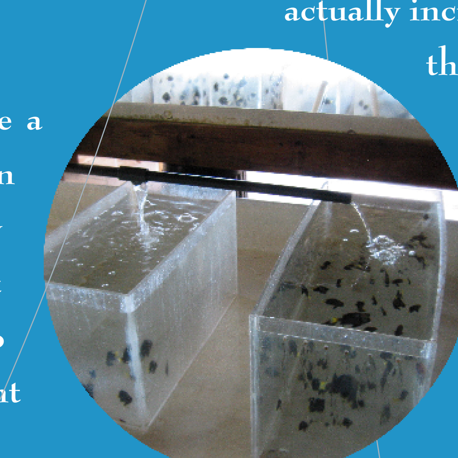
Corals rely on water flow to bring them nutrients and food. Because of this, water flow can affect the growth and survival of corals. Branching corals are common in the lagoons of Moorea and provide habitat within their branches for many reef fishes. Scientists hypothesize that these fishes may in turn benefit coral by excreting waste that provides nutrients.

Scientists with the MCR LTER conducted experiments to explore whether the relationship between water flow and coral growth was changed by the presence of resident fish. By transplanting "nubbins" (small, finger-shaped coral pieces) into colonies of a common branching coral, and caging half of the coral colonies to exclude fish, they were able to see whether coral with fish grew faster, slower, or at the same rate as coral that had no fish. They found that corals with resident fish grew faster than corals from which fish were excluded.

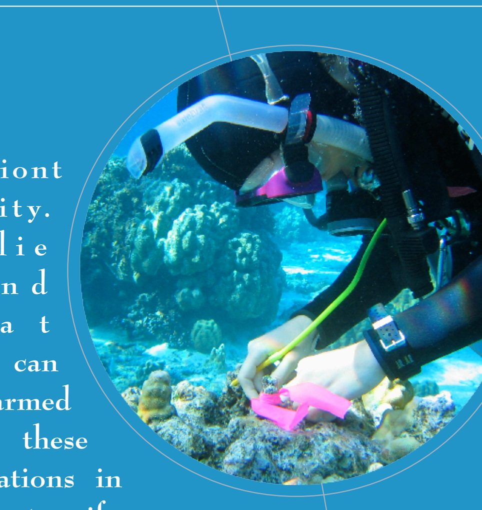




Once scientists were confident that fish living between coral branches did actually increase coral growth, they wanted to know why? To test the hypothesis that fish increase nutrients that stimulate coral growth, they measured ammonium (an important nutrient) concentrations in aquariums divided into four groups, tanks 1) with fish and coral, 2) with fish but without coral, 3) with coral but without fish, and 4) without fish or coral. Results showed that tanks with fish did have more ammonium, and that the ammonium was in fact taken up in tanks that also contained coral, suggesting that coral growth increases in the presence of fish due to the nutrients excreted by the fish.



SOME LIKE IT HOT, OR NOT?



It is well known that temperatures just 1-3°C above local average maxima can result in bleaching of tropical reef corals, or loss of the symbiotic zooxanthellae (algae that live within the tissue of coral and provide the coral with energy and oxygen), which can lead to mass coral mortality. However, despite the common occurrence of fluctuating temperature in the natural environment, little is known of coral response to these relatively rapid fluctuations in temperature.

To better understand how these fluctuating temperatures affect corals, Hollie Putnam is examining the response of both coral host and symbiotic zooxanthellae growing within the lagoon of Moorea, where daily fluctuations of up to ~4°C are common. Hollie simulates the fluctuating temperature conditions corals would experience in the lagoon, and measures several variables commonly associated with a bleaching or stress response, including growth, respiration, photosynthesis, and symbiont density. Hollie found that corals can be harmed by these fluctuations in temperature if the magnitude of the temperature change is too great (>4°C). Exposure to large, repeated fluctuations in temperature cause a decrease in the density and photosynthetic efficiency of symbiotic zooxanthellae within the coral, in turn harming the coral that relies on the symbiont for survival. Hollie's findings suggest that is it necessary to examine the response of corals to fluctuations in temperature to accurately predict the response of coral communities to the changes in seawater temperature that are forecast for the next century.

CLEANING UP THE NIEGHBORHOOD

One important, but often overlooked, interaction on coral reefs is parasitism. Parasites are so common on coral reefs that some fish, called cleaners, specialize in removing parasites from other species of fish. This relationship is an example of an ecological mutualism; the client fish get their parasites removed, while the cleaners get an easy meal. Cleaner fishes establish "cleaning stations," where they wait for potential clients to arrive for cleaning. Tom Adam is interested in finding out whether fish are attracted to these stations because of the presence of cleaners, and if so, how the higher fish densities at cleaning stations affects the other organisms on the reef.

Tom surveyed the fish communities around cleaning stations and found that fish with large home ranges, including some corallivorous (coral-eating) butterflyfish, are attracted by the presence of the blue-streaked cleaner wrasse, Labroides dimidiatus. The cleaners indirectly cause the coral to grow more slowly at cleaning stations, by attracting butterflyfish that eat the coral. Tom also found that although adults and young cleaners compete with each other for clients, the young do better where adults are found because adults tend to establish cleaning stations in places with many potential client fish, and because adults attract additional clients to these places. Together, these benefits are found to outweigh the negative effect of competition.

YOU ARE WHAT YOU EAT

Coral reefs are vibrant ecosystems buzzing with biological activity. These habitats are full of colorful fish, invertebrates, and algae. At the same time the waters surrounding coral reefs are famously crystal clear – which means they have far fewer nutrients and microscopic plants and animals (called plankton) than do waters in temperate (colder) and coastal regions. This contrast between the reefs and the oceans that bathe them has puzzled scientists for some time. How do all of the organisms living on a coral reef have enough food to grow, survive, and reproduce?

In her research, Kate Hanson asks this question from the point of view of the yellowtail dascyllus (Dascyllus flavicaudus). These fish are found across the island of Moorea, from the very nearshore fringing reefs, to the shallow back-reef flats, to the plunging forereef. Kate is interested in the diet of these fish, which feed primarily on tiny animals in the water column (zooplankton). Do these fish rely on zooplankton from the open ocean which are swept over the reef? Does diet differ between fish living close to shore and those at the seaward edge of the reef? Kate collects yellowtail dascyllus from around the island of Moorea and examines the composition of their fat, muscle and liver tissue. The biochemistry of the fish tissues reflects that of their diet and between these chemical analyses and examination of the stomach contents of collected damselfish, Kate gets a 'sneak-peek' into the long-term dietary patterns of these fish.