

# How Do Upwelling and El Niño Impact Coral Reef Growth?

## NOTES FOR THE INSTRUCTOR

### ADVANCE PREPARATION

#### Activity 1

The instructor should print the photographs of the corals from each gulf ([Handouts S1 and S2](#)). All images used in this lesson should be printed in color and at 100% size on single 8.5 × 11 inch sheets of paper to maintain the appropriate scale needed for analyses.

#### Activity 2

The instructor should print one benthic-cover identification key ([Handout S3](#)) per student group. In addition, the instructor should print the quadrat reef images ([Handout S4](#)) and practice quadrat ([Table S3](#)) so students can identify the appropriate benthic components. The quadrat reef images should be laminated so that the students can use dry erase markers to randomly select which cells in the grids they will identify. The instructor should be familiar with the benthic categories that will be identified. Please note that it is normal for living *Pocillopora* to sometimes have white tips.

### LESSON DELIVERY

#### 1. Pre-Lab Activity and Discussion

The instructor should provide students with an opportunity to conduct a comparison of the environmental conditions between two gulfs in Pacific Panamá ([Table S1](#)) to help guide them toward formulating explanations for the differences they may observe in coral growth and percent cover between the gulfs. This pre-lab activity can be completed as a homework assignment or as an introduction to the lesson at the beginning of class. During the discussion the instructor should highlight the different environmental conditions that occur naturally in the two gulfs (upwelling versus no upwelling, which is the primary reason for the difference in coral growth between gulfs, as observed in Activity 1; [Table S1A](#)). The instructor can also introduce the topic of ENSO and explain how El Niño (the primary reason for the difference in coral cover between the gulfs, as observed in Activity 2) affects each gulf differently because of the influence of upwelling. At the end of the discussion, the instructor should guide the students toward creating a hypothesis to explain how the different environmental conditions might impact coral reefs in each gulf.

#### 2. Activities

The questions provided for each activity will prompt the instructor to discuss the scientific method with the students. For instance, random selection of grid cells is a common scientific practice and is used to eliminate sampling bias. Randomization should result in some variability among student pairs; however, the overall trends should be similar to the key provided ([Table S5sA](#)). The instructor can initiate a discussion about the variability in each pair's results, the scientific method, and possible suggestions that students might have for minimizing the variability in data collection. We provide a “practice quadrat” that the instructor can use to prepare the students for Activity 2 (see [page 6 in the Student Activity Sheet](#)).

The instructor should notify the students that Activity 3 is meant to serve as a model for how scientists use ecological data to estimate or predict changes in the reef under certain conditions or events. The instructor should make students aware that corals can also grow horizontally as well as vertically, which is not reflected in this lesson. Horizontal growth of a coral reef is also

important for reef accretion.

### **3. Extensions and Modifications**

To reduce variability in the data collected in Activity 2, the teacher can opt to have students estimate each selected grid cell in increments of 25% (i.e., subdivide each selected grid cell into four sub-cells, count the number of sub-cells covered more than 50% by coral, and estimate percent cover as the number of cells with more than 50% coral divided by 4).

Both the pre-lab activity and Activity 3 can be designated as homework assignments if the teacher is concerned about time. The teacher can also challenge the students to perform simple statistical tests (i.e., independent t-tests) to compare the data between gulfs as extensions of Activities 1 and 2; the differences for both activities are statistically significant.