Name:____

- Each week you will receive a study guide on Thursdays. You will complete the tasks in the study guide and turn it in on Tuesday (or the next class meeting if no meeting on Tuesday) for a grade.

A. Scientific Measurement Terms

1. Study the Worksheet #3 you worked on in class Thursday.
2. Prepare for a quiz on that material Tuesday. There will also be items on the quiz from this weekend work.

B. Chemistry - Last weekend you discovered that the periodic table represents the most common isotopes of the elements, which are usually also the most stable. In this class we are mainly concerned with the elements C, H, O, N, P, & S. This weekend we will look at some of the less common versions (isotopes) of these same elements. They have almost the same chemical properties (reactivity is the same), but the differences are important and useful.

Look at your chemistry textbook and other sources on the web to fill in the following table:

Symbol	Element	Atomic Number	Number of Electrons	Number of Protons	Number of Neutrons	Atomic Weight
^{2}H	*deuterium*					
^{14}C	*carbon-14*					
^{18}O						
^{15}N						
^{32}P						
^{35}S						

C. Biology - Read the "Tiny Larvae" handout. Answer the following question using the reading and the class discussion. *How are isotopes important in answering the question of where Marine Protected Areas should be placed?*

Tiny Larvae Go with the Flow – but Where?

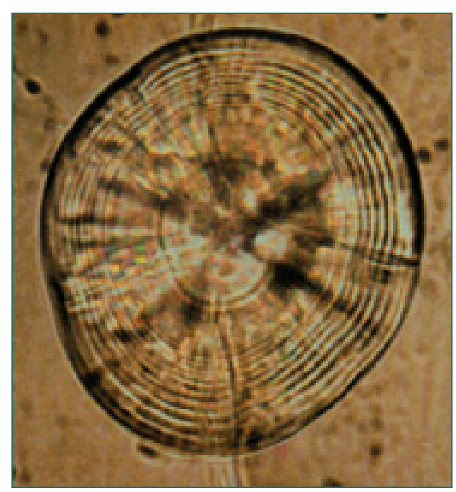
Most marine animals, including many commercially important species, begin life as microscopic larvae that drift on the ocean currents for weeks or months, potentially traveling hundreds of miles. Mussels, barnacles, sea stars, urchins, rockfishes, and numerous other invertebrates and fish display this early life stage of dispersal. Eventually, the larvae settle onto a rocky shore, reef, or other appropriate habitat, metamorphose into the adult form, and may spend the rest of their lives at that site.

This facet of marine biology means that the number of adults at a particular site may depend more on the arrival of young transported from elsewhere than on local reproduction. The process of population replenishment, called recruitment by marine ecologists, can be a major factor governing the fluctuations of local populations. Knowledge about patterns of larval dispersal and the processes that cause variability in population replenishment over time and distance is critical for successful fisheries management and marine conservation. For example, if one reef serves as the primary source of fish larvae for many "downstream" reefs along a coast, that site might be essential to protect as a marine reserve, so it can continue to sustain the other populations.

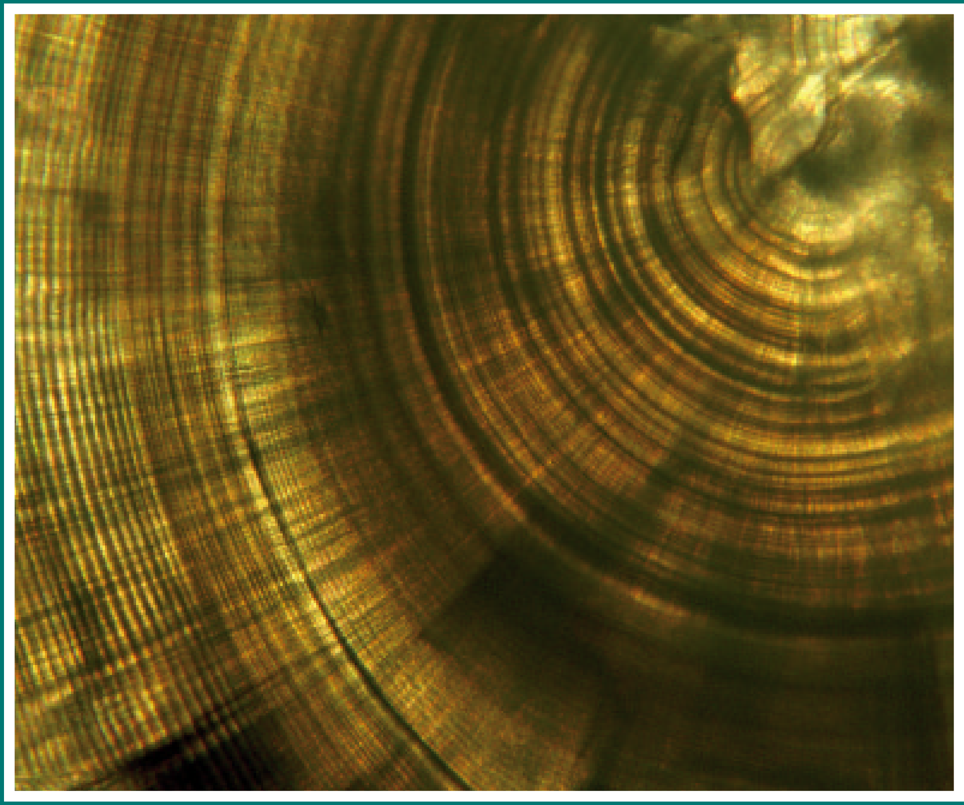
Ecological "Black Box"

Scientists know little about where and how far larvae disperse, and it is a mystery how ocean currents link different populations of adults. Individual larvae are extremely small, and most are impossible to follow as they are carried — possibly over long distances – through the ocean. The flow of ocean water near coastlines is extraordinarily complex and variable, and larval swimming behaviors mean that scientists cannot assume that these tiny animals travel as passive particles. Today, the "black box" of larval dispersal represents one of the central challenges in marine ecology. Ultimately, resolving this challenge will improve resource management by revealing the ecological ties among sites.

PISCO scientists are at the forefront of addressing this challenge. One technique the consortium is developing involves analyzing natural chemical markers from ocean waters that certain hard body parts of larvae incorporate as they grow. These chemical signatures can serve as a "flight recorder" of where a larva originated and the route it traveled. Other methods include mathematical modeling and genetics for investigating the ecological consequences and spatial patterns of larval dispersal. Coupling all these approaches with a comprehensive program of oceanographic monitoring, PISCO is generating key insights into larval dispersal. Examples of this research are on the following pages.



Above: Fish incorporate trace elements from seawater into the daily growth layers of the otolith (right, magnified). Left: Like this sea urchin larva (magnified), many young invertebrates and fish drift on ocean currents.



Using Natural "Flight Recorders" to Track Larvae

PISCO scientists have developed a technique of analyzing the chemical "signatures" in hard, calcareous body parts of fish and invertebrates to identify the birthplace and dispersal path of individuals. For fish, they use the otolith, a balance structure in the inner ear, and for invertebrates they use the statolith or protoconch. These structures form at birth and grow daily as new layers deposit around the core, like rings in a tree trunk. The layers incorporate trace chemicals from the surrounding seawater, which vary from place to place. Consequently, the layers act as a "flight recorder" of the chemical environment. Analysis of the layers' chemical signatures can yield detailed information about the larva's birthplace and dispersal route. PISCO research significantly advances these microchemistry techniques and proves the viability of this approach for invertebrates and fish.

ecological linkages