Educational Product	
Educators	Grades 5–8

Investigating the Climate System

WINDS

Winds at Work

PROBLEM-BASED CLASSROOM MODULES

Responding to National Education Standards in:

English Language Arts ◆ Geography ◆ Mathematics
Science ◆ Social Studies

Investigating the Climate System

WINDS

Winds at Work

Authored by:
Phil Astwood, University of South Carolina, Columbia, SC

Prepared by:
Stacey Rudolph, Senior Science Education Specialist, Institute for Global Environmental Strategies (IGES), Arlington, Virginia

John Theon, Former Program Scientist for NASA TRMM

Editorial Assistance, Dan Stillman, Science Communications Specialist, Institute for Global Environmental Strategies (IGES), Arlington, Virginia

Graphic Design by:
Susie Duckworth Graphic Design & Illustration, Falls Church, Virginia

Funded by:
NASA TRMM Grant #NAG5-9641

Give us your feedback:
To provide feedback on the modules online, go to:
https://ehb2.gsfc.nasa.gov/edcats/educational_product
and click on "Investigating the Climate System."

NOTE: This module was developed as part of the series "Investigating the Climate System." The series includes five modules: **Clouds, Energy, Precipitation, Weather,** and **Winds.** While these materials were developed under one series title, they were designed so that each module could be used independently. They can be freely downloaded at:
http://www.strategies.org/CLASS.html

June 2003

CONTENTS

SCENARIO *You work for a fishing company that is seeking investors. You believe that one of your company's strengths is that you use TRMM data to locate fishing areas. You must convince the investors that this gives your company a significant advantage.*

PART 1

What determines where fish are found in the ocean?

BACKGROUND

The location of fish in the open ocean is determined primarily by the temperature of the water and the availability of food. In a broad sense, the temperature of the water at the surface depends on the latitude—with warmer waters near the equator and colder waters at higher latitudes. Even at lower latitudes, however, cooler water and **nutrients** from deeper layers can be brought to the surface by an overturning process called **upwelling**. Cold water will hold more dissolved oxygen than warm water; as a result, many large and active fish seek the oxygen-rich cooler water. At the same time, however, because most chemical reactions proceed more slowly at low temperatures, the growth of plants and animals may be slower.

Because plants are at the base of the **food chain**, the rate at which they grow determines the rate at which all other living things can grow. To survive, plants require sunlight for energy and nutrients to build their structures. Nutrients are elements such as sulfur, potassium, and nitrogen that are essential for the growth of plants, but are not readily available in water. On land, plants can receive direct sunlight from above and derive most nutrients from the soil, where they have accumulated following the decay of prior generations of plants. In the ocean, dying organisms sink to the bottom and their decay products accumulate there, whereas sunlight can only penetrate the upper 200 meters of the ocean water. Thus, nutrients and sunlight may be separated vertically by thousands of meters.

As a result, ocean plants, such as microscopic **phytoplankton** (algae), near the ocean surface must depend on upwelling for the nutrients they need. The phytoplankton provide food for **zooplankton** (very small animals). The zooplankton are food for larger animals, that are food for even larger animals, and so on up the food chain. Each level in a food chain is referred to as a **trophic level**. The first trophic level is made up of **producers**, plants that can obtain energy directly from the sun via **photosynthesis**. The producers on the first level provide food for **consumers** on the next level that must obtain their energy by eating plants. Consumers on the third level obtain their energy by eating animals on the second level, and so on up the chain.

In this way, energy originally obtained from the Sun is passed from one trophic level to the next. However, the transfer is very inefficient, with only about 10% of the energy at one level making it to the next. As one might expect, this process is most efficient in upwelling areas where nutrients are abundant and an organism does not have to travel far to find food. Areas of upwelling have traditionally been highly productive fishing grounds.

Activity One: Exploration

Brainstorm:

- "What do animals need to survive?"
- "Fish are animals. What do they need to survive in the open ocean?"
- "How do fish get food?"

Have your students research current world ocean fishing patterns and develop a complete world map. Using this map, ask the students to determine where most fish are caught and what is unique about these areas.

Activity Two: Concept Development

Trophic Levels: Math Problem

One way to show trophic levels is in the form of a pyramid. This shape is not correct for all ocean areas, but it shows how the system works. Draw a pyramid with a human at the top and phytoplankton at the base. The pyramid should represent the sea life needed to support one human who is eating 1 kg. of fish each day from the fourth trophic level. Remembering that only 10% is passed from one level to the next, calculate the weight of small fish at the third trophic level, weight of zooplankton at the second trophic level, and weight of phytoplankton at the first trophic level that are needed to support this "pyramid."

Activity Three: Application & Assessment

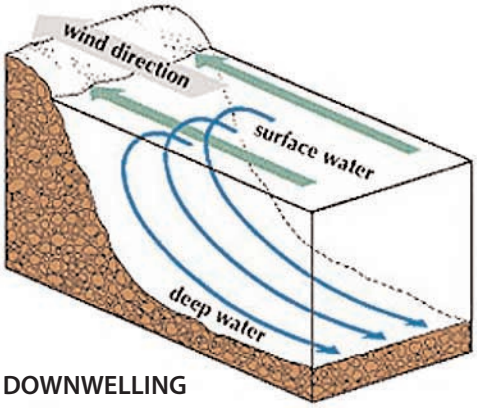
Some people believe that large-scale fishing should be limited to areas where the target fish are eating no higher than the third trophic level. Do you agree with this? Why or why not?

The majority of the food people eat comes from land (vegetables and meat). When we eat seafood, we often select large animals such as tuna and swordfish. Which type of food is more "efficient" in terms of the trophic level at which we are operating?

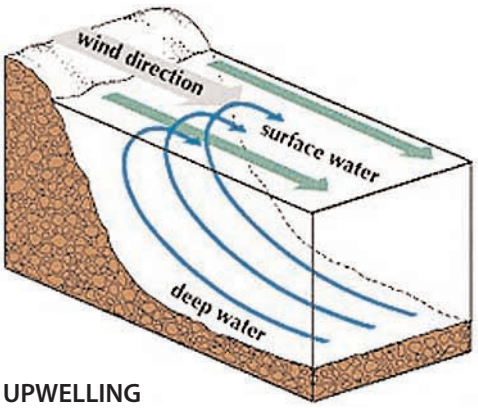
PART 2
How do upwelling zones form in the equatorial area?

BACKGROUND

Wind creates horizontal currents along the ocean surface (See Part 3). Under certain circumstances, these horizontal currents can cause vertical currents. For example, in the diagram below, wind is pushing ocean water at the surface toward a landmass. Some of the moving water will be turned to the left or right, but some will be forced downward. This process of water from the surface being pushed toward the bottom is known as **downwelling.** Since water at the surface is generally warmer and contains more oxygen, the effect of downwelling is to warm the deeper water and increase its oxygen content.



DOWNWELLING



UPWELLING

The reverse of this process occurs when a surface current is forced to flow away from a landmass. Under these conditions water is drawn up from below in a process known as **upwelling.** Upwelling has a major biological significance because it brings nutrients from deep in the sea up to the surface waters. Upwelling can also affect the temperature of the water at the ocean's surface. The water at the bottom is generally colder than the water above. When this cold water comes to the surface, it can impact local weather and climate.