

Improved Student Research with the Use of Drifting Buoy Data

Workshop to Define Student Collaborative
Climate Research
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Ruth Krumhansl

Programs

Development Center, Newton, MA

AND

Diane Stanitski

Adopt a Drifter Program Coordinator

NOAA, Silver Spring, MD

Science and Math
Education

photo courtesy of MeteoFrance

Students become involved in scientific research at the data analysis stage, looking for patterns in real-time and archived scientific data available online

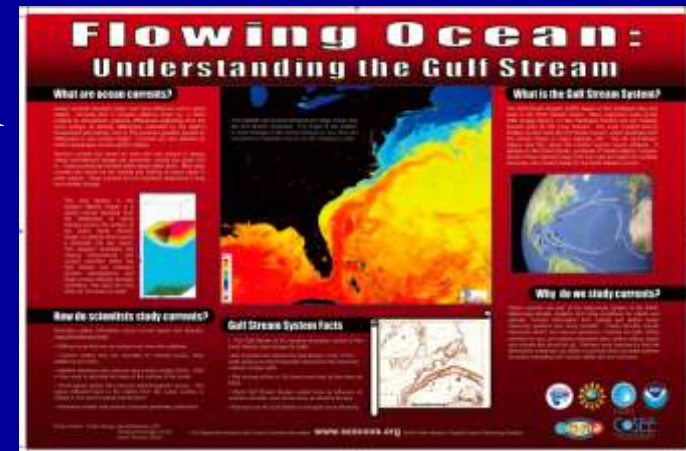


Image courtesy of the Center for Environmental Visualization, UW



Context for Project

Changes in the direction and velocity of ocean currents due to global warming may affect the migratory patterns of marine species. Long-term monitoring of the position of ocean currents and sea surface temperatures (SST), particularly along the northern and southern boundaries of migratory species' ranges, are necessary to identify long-term trends in environmental conditions and distinguish them from normal seasonal variability. These data, correlated with larvae retention or transport, reports of marine species strandings, and/or unusual sightings of marine species as documented by marine laboratories, will provide important insight into the potential impact of shifting ocean currents on marine organisms.



Research Objective

Students will search for links between ocean currents and marine species to determine if changing climate has impacted or is affecting their migration patterns.

CATCHING THE CURRENT

Who Goes With the Flow?

Understanding the migration of the North Atlantic Right and Gulf Stream helps a lot of researchers. Using their marine free coastal ocean observing systems, satellites, floats, gliders, autonomous and underwater vehicles and other tools that support the observation of marine resources.

Shifting the Gulf Stream

Imagine what happens when a huge volume of water flowing at high speed collides with an immovable obstacle. This is the situation off the coasts of Georgia and South Carolina when the northward flowing Gulf Stream encounters a rise on the seafloor called the Charleston Bump (Fig. 1). When the two meet, the pattern of flow has to change.

The Charleston Bump, rising nearly 375 m (1231 ft) and covering an area that may encompass more than 3900 sq km (1506 sq nautical miles), deflects the Gulf Stream eastward. The meandering Gulf Stream spins off smaller currents—rising eddies and gyres. One distinct spin-off, the Charleston Gyre, circulates counter-clockwise and moves shoreward across the continental shelf. In the process, nutrient-rich bottom water rises up towards the surface, which is called upwelling (Fig. 2). Upwelling areas have increased production of phytoplankton, the base of the food web that supports a variety of important fishery species such as menhaden, grouper and swordfish. The combination of food and favorable habitat near the Charleston Gyre supports abundant marine life.

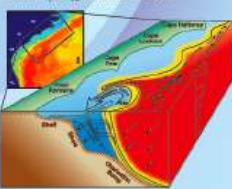


Fig. 1. Where Gulf Stream water (red) is deflected offshore by the Charleston Bump creating upwelling of deep, cold water (blue). The Charleston Bump is located off the Charleston Gyre east of the Gulf Stream. Image: John Ryan and Phil Walbran.

Spawning And Dispersal

The Gulf Stream, in spin-off eddies and gyres, upwelling, and coastal currents play important roles in the dispersal of the eggs, spawning fishes and invertebrates. Here's one example. Weakfish, large groupers like fish living more than 90 years, release eggs near the Charleston Bump—their only known spawning grounds in the western North Atlantic Ocean (Fig. 3). Because invertebrates are rarely caught on the Bump, scientists propose that young weakfish are transported in the Gulf Stream, using floating seaweed and debris for shelter until they mature. Sleeper, grouper and swordfish also rely on the Gulf Stream system to disperse their eggs and young to new locations (Fig. 4). Coastal and tidal currents carry eggs and larvae of fishes, shrimps and crabs into and out of estuarine nursery areas.




Fig. 3. Weakfish, a pelagic species, spawning along the Bump. Adult weakfish are the Charleston Bump in the western North Atlantic Ocean. Image: George S. Helfferich and David P. Swan.




Fig. 4. The presence of fish larvae like the weakfish, sleeper, grouper, and swordfish also rely on the Gulf Stream system to disperse their eggs and young to new locations. Image: George S. Helfferich and David P. Swan.

Migration and Life Cycle Journeys

Many marine animals use the Gulf Stream and coastal currents in some part of their life cycle. Coastal ocean observing capabilities scientists to build models that predict the locations of animals during different life stages.

Swordfish and whitefish are highly migratory. Studies tracking tagged fishes show that they feed along the western edge of the Gulf Stream in summer, then cross the Atlantic Ocean by following the North Atlantic Gyre in autumn (Fig. 5). Swordfish return to warmer Gulf Stream and Caribbean waters in winter. Other large pelagic fishes such as tunas and dolphins (mahi) also concentrate along the edge of the Gulf Stream, where cooler coastal waters meet warmer Gulf Stream waters, and prey is plentiful.

Loggerhead sea turtles use currents in their life cycle journeys. Hatchlings leave southeastern beaches and head for the Gulf Stream and its protection provided by floating seaweeds. Once in the Gulf Stream, loggerheads are carried northward around the North Atlantic Gyre. It takes about five to eight years before the juvenile loggerheads return to shallower coastal waters of the South Atlantic (Fig. 6). Many spend this time feeding on seagrasses in Pamlico Sound and Chesapeake Bay.

Humpback whales and some endangered right whales swim close to the coast as they migrate south to waters off Puerto Rico and Georgia in the winter. During spring, whales use the Gulf Stream current to support their northward travel to New England and summer feeding grounds.



The Charleston Bump

Fig. 7. The Charleston Bump with 375 m high ridge elevates the surface. Red colored areas show areas that were bathymetric. Image: George S. Helfferich and Paul T. Olson.



Fig. 5. Loggerhead sea turtles, Canada sparrows, and seabirds in coastal feeding grounds where they eat seaweeds, maki, shrimp, jellyfishes and sponges. Image: Mike Perry.



Fig. 6. Juveniles take the Gyre to spend 5 years feeding. From there, at that season, depending, they may migrate back to the Gulf and back to the coast to spend the summer. Image: George S. Helfferich and Paul T. Olson.



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For classroom lessons and more information visit www.SEACOOS.org South East Atlantic Coastal Ocean Observing System

Project Credits: Charles E. Deserchers, 178 0143, George Helfferich, 822088, John Ryan, UNC-CH and Louise Spence, 210332, 501 - Point Diego, Jason Piner - Point Diego OOI; Large Loggerhead, Small Canada Sparrows, Feeding Loggerheads, Mike Perry

How do we measure ocean currents?

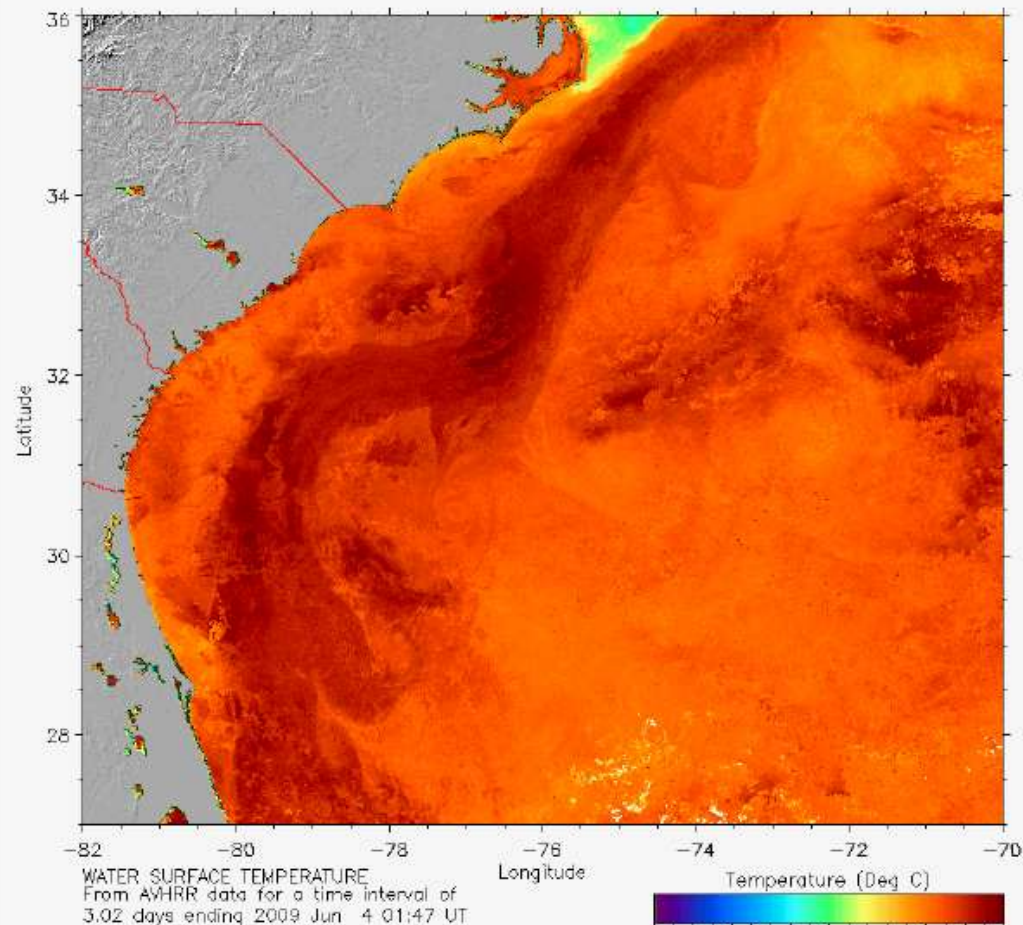
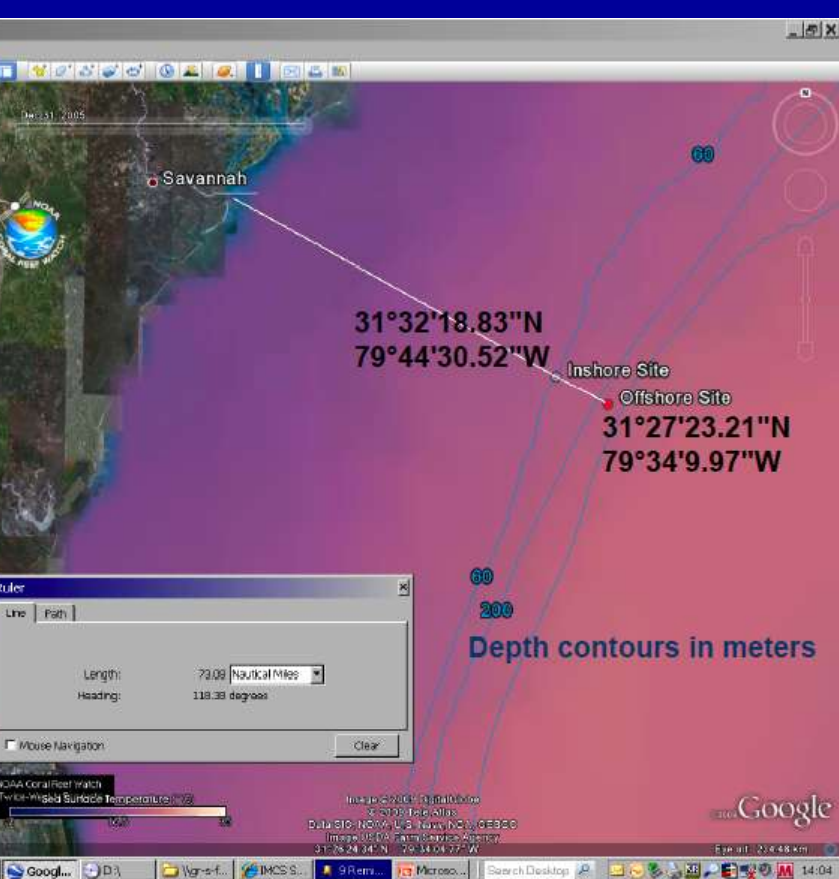


What is a Drifting Buoy?

Drifting buoys are satellite-transmitted ocean instruments that measure sea surface temperature and sea surface pressure.

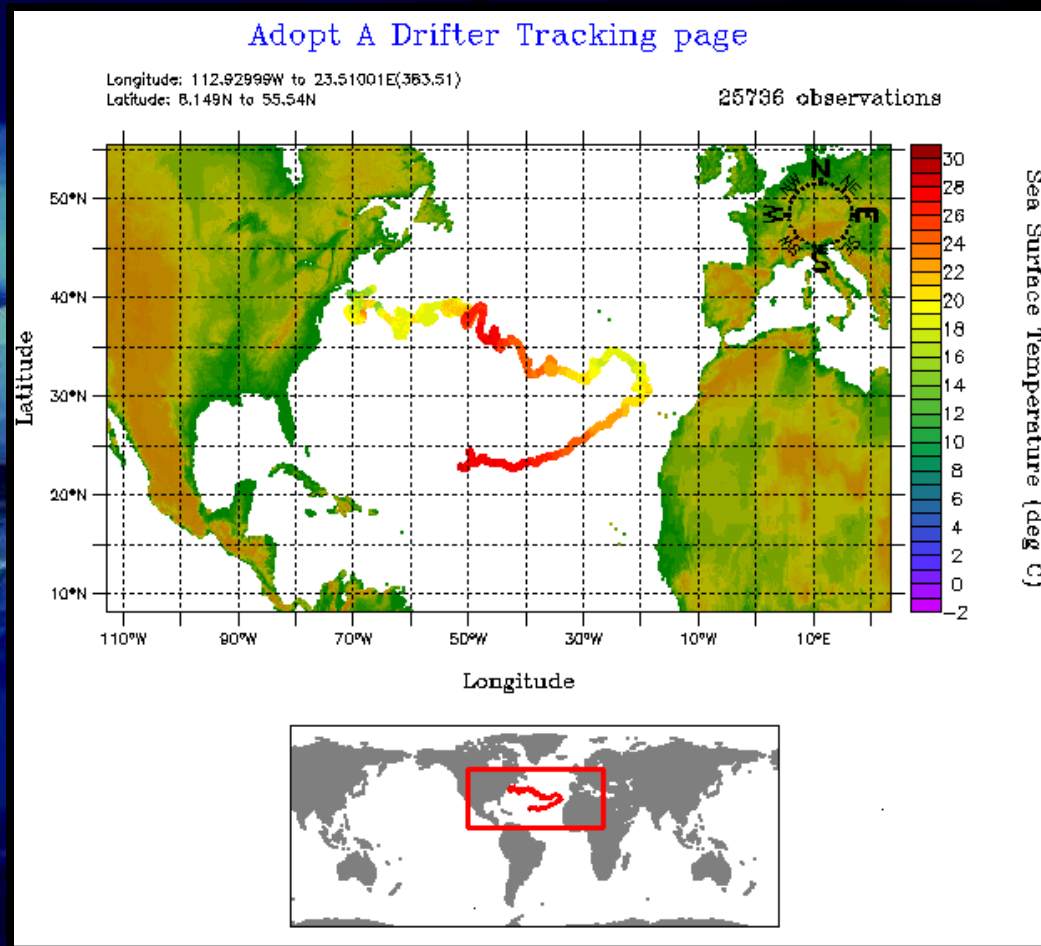


Drifting buoys are deployed in ocean currents and currently schools co-adopt drifters and analyze the data as part of the NOAA Adopt a Drifter Program.



The Global Drifting Buoy Array

The Adopt a Drifter web site allows you to
Select a Buoy to Track Ocean Currents and
Sea Surface Temperature in Real Time

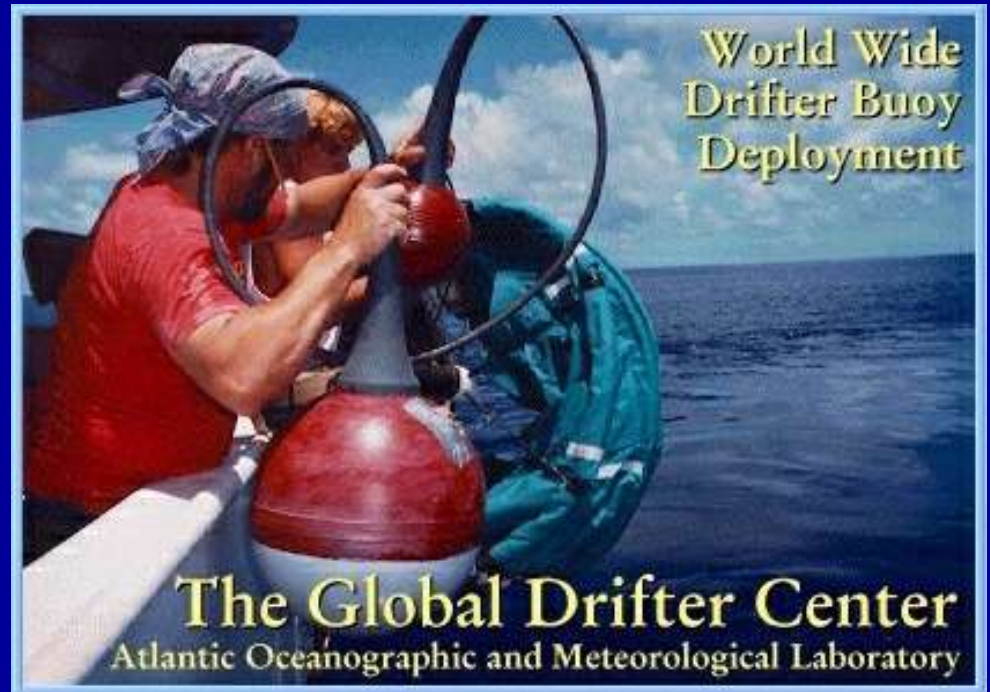


Adopt a Drifter Tracking Page

<http://www.adp.noaa.gov/>

Drifter Data Are Important

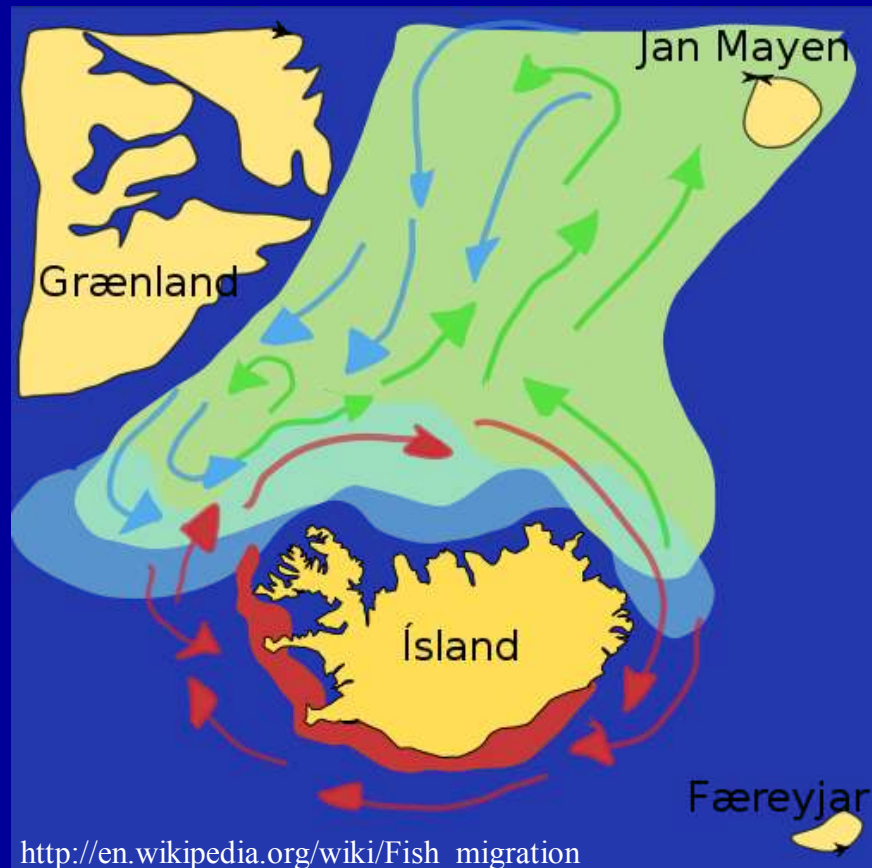
- Help to Predict Path of Hurricanes
- Reveal Ocean Temperature Patterns
- Monitor Ocean Currents, Winds
- Ground truth Satellite Data
- Predict the Path of Ocean Pollutants
- **Help Determine the Path of Migratory Species**



<http://www.aoml.noaa.gov/phod/dac/gdc.html>



Important Migrations



Migration of Icelandic capelin

Example Species

Altering Migrations

Many species depend upon ocean currents to aid movement, with a number of turtle species using ocean currents to migrate. During their juvenile phase, hawksbill turtles and loggerhead turtles float on ocean currents until they mature. Turtle hatchlings instinctively swim towards local surface currents to help transport them across ocean basins. Changes in ocean circulation are likely to change the distributions and migration patterns of such species.

Climate change impacts on migrating ocean species

Global Change Biology (2009), doi: 10.1111/j.1365-2486.2009.01875.x

Climate-driven changes in abundance and distribution of larvae of oceanic fishes in the southern California region

CHIH-HAO HSIEH*†‡, HEY JIN KIM†§, WILLIAM WATSON¶, EMANUELE DI LORENZO|| and GEORGE SUGIHARA‡

**Institute of Oceanography, National Taiwan University, No. 1, Sec. 4, Roosevelt Road, Taipei 10617, Taiwan, †Institute of Marine Environmental Chemistry and Ecology, National Taiwan Ocean University, 2, Pei-Ning Road, Keelung 20224, Taiwan, ‡Scripps Institution of Oceanography, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0208, USA, §Monterey Bay Aquarium Research Institute, 7700 Sandholdt Road, Moss Landing, CA 95039, USA, ¶Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037-1508, USA, ||School of Earth and Atmospheric Sciences, Georgia Institute of Technology 311 Ferst Drive, Atlanta, GA 30332-0340, USA*

Abstract

We examined climatic effects on the geographic distribution and abundance of 34 dominant oceanic fishes in the southern California region using larval fish data collected from the 50-year long California Cooperative Oceanic Fisheries Investigations (CalCOFI) surveys. The oceanic species responses to environmental changes in their geographic distributions were not very pronounced, perhaps because they lived in the deep layer where temperature change was relatively small or because the environmental variation of the CalCOFI region is not strong enough (with an average temperature gradient of the upper 100 m around $91 \text{ km } ^\circ\text{C}^{-1}$). Among the 34 taxa, 16 showed a significant distributional shift (median latitude or boundaries) in relation to environmental variables, and eight species significantly shifted their geographic distribution from the 1951–1976 cold period to the 1977–1998 warm period. Interestingly, the vertically migrating taxa more often showed a significant response to environmental variables than the nonmigrating mesopelagic taxa, reflecting the more significant increase in heat content of the upper ocean (<200 m), compared with the deeper zone (300–500 m) where the mesopelagic fishes typically remain. Climate change has significant effects on the abundances of oceanic fishes. Twenty-four taxa exhibited a significant change in

Student Data

Students will conduct this research by using:

- 1) drifting buoy data to track the flow patterns of ocean currents (both location and velocity), and
- 2) marine species data collected by marine labs to determine spawning grounds, larval retention, and migratory patterns or displacements from typical paths.

Potential Research Sites / Collaborations

1. Northeast shelf in the North Atlantic (data possibly available through the Office of Marine Ecosystem Studies, NE Fisheries Science Center)
2. Gulf of Mexico near the loop current (data possibly available through the National Marine Fisheries Center/SE Fisheries Science Center)
3. Coastal California region as part of the CalCOFI investigations (data collected by Southwest Fisheries Science Center and NOAA CalCOFI survey teams)

Data Access

1. Global Drifter Program Data Assembly Center, NOAA/AOML:
<http://www.aoml.noaa.gov/phod/dac/dacdata.php>
2. NOAA Adopt a Drifter Program, NOAA CPO:
<http://www.adp.noaa.gov>
3. Observing System Monitoring Center:
www.osmc.noaa.gov
4. CalCOFI larval fish data:
<https://oceaninformatics.ucsd.edu/ichthyoplankton/secure/login.php>
5. Sea surface temperature and chlorophyll satellite data can be accessed at: http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=ocean_month
6. Ocean Tracking Network: <http://oceantrackingnetwork.org/>

Metrics for Success

A special **on-line student science fair** would highlight results of projects. The number of students participating could serve as one metric of success.

Fisheries science center **scientists who specialize in marine species and climate could serve as judges** to determine those projects satisfying criteria proposed at the start of the project and highlighted on line. Judges would rank projects based on use of appropriate methods and most accurate results.

Scientists could then follow up with additional research in those areas where climate impacts have been identified.

Results could be posted on the Adopt a Drifter Program and Global Drifter Program website, along with other sites.

Important Questions

Who?

High school students in Earth Science, Environmental Science and Biology Classes

How much?

Start up costs associated with curriculum development, website and software development and piloting of prototype.

Schools would need computers and software to implement.

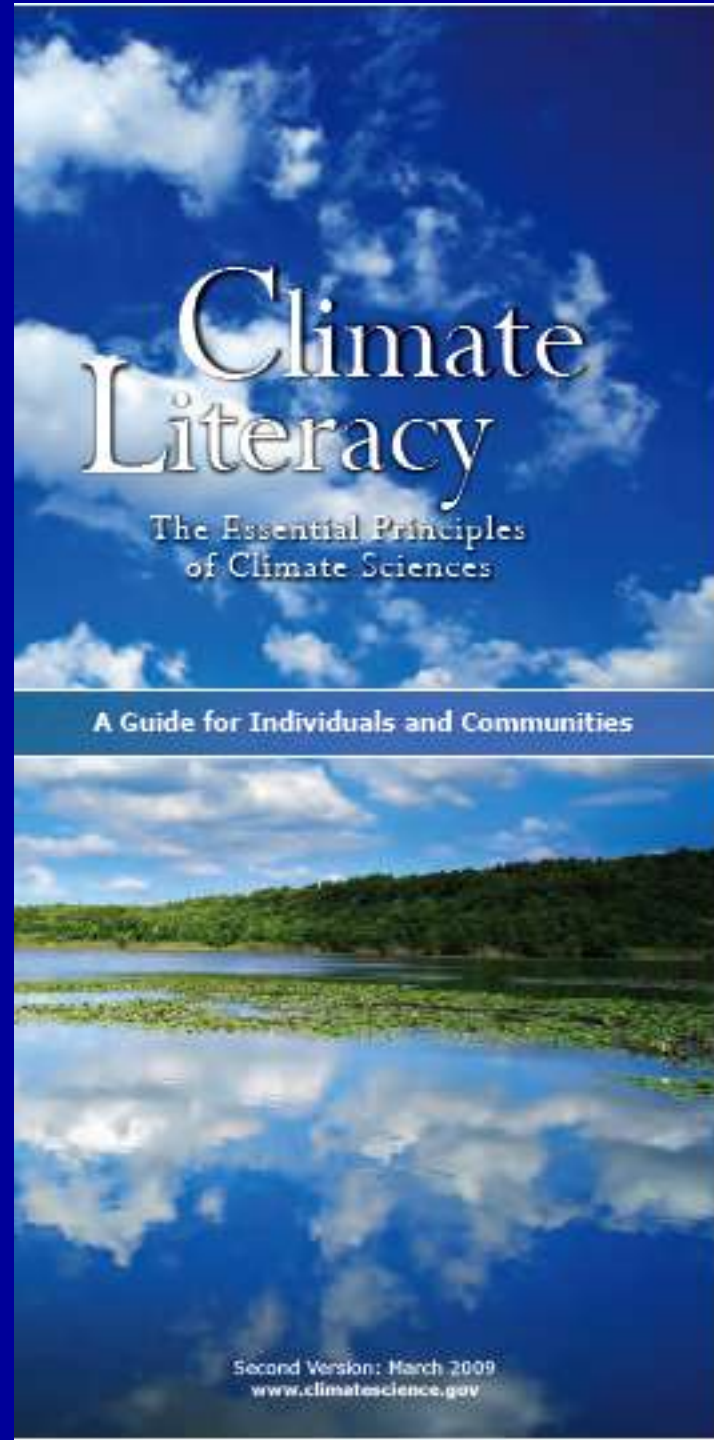
When?

Work with data collected over entire year, paying particular attention to seasonal patterns

Climate Literacy

Principles Addressed

- Life on Earth depends on, is shaped by, and affects climate;
- Our understanding of the climate system is improved through observations, theoretical studies, and modeling; and
- Climate change will have consequences for the Earth system and human lives.



Thank You



Photo courtesy of Sweeney