NOAA Teacher at Sea
Dave Grant
Onboard NOAA Ship *Ronald H. Brown*
November 6 – December 3, 2008

NOAA Teacher at Sea: Dave Grant
NOAA Ship *Ronald H. Brown*
Mission: VOCALS, an international field experiment designed to better understand the physical and chemical processes of the Southeast Pacific climate system.
Date: November 12

Weather Data from the Bridge
Sunrise: 07:12
Sunset: 20:11
Wind: S-SW 8-10 Kts
Seas: S-SW 8-10’
Precipitation: 0.0
Temperature: 18º-C
Pressure: 1015 Mb

Science and Technology Log

“Send them our latitude and longitude.”
Admiral William Halsey, 1944
(Response to an intercepted Japanese radio message: “Where is the American fleet?)

Now that we are out of sight of land and the ocean is featureless except for the waves, so pinpoint navigation becomes crucial. Using the most modern navigation tool – GPS (Global Positioning Satellite system) our navigation officer has put us precisely where we need be to await over-flights from aircraft sampling the atmosphere above us.

A Twin Otter plane flying over

We are not just near our sampling station - not a *mile*, a *minute*, a *knot*, or a *league* – we are within a *hairsbreadth** of it. We will be here for the day taking water and air measurements, while waiting for the only things we’ll see flying over the Pacific besides birds and balloons; our last connection to the land for several weeks.

“Thanks for the memories.”

The ocean water we test has a memory for the weather and climate conditions today and over the last several months and years. The “code” we need to understand these secrets is hidden in the temperature and salinity of the water, and the keys to unlock them are a number of devices that sink, float and drift. Over the next few weeks we will use all these techniques to see what stories the water has to share.

My first introduction to this remote sampling and sensing was a long-necked beverage bottle with a weight, retrieval line, and a cork that could be popped with a string. (And of course, duct tape to hold it all together.) Using it in the local pond and discovering that there were indeed differences between the surface and bottom temperatures was enough to pique my curiosity to move on to bigger things in college.

This involved more sophisticated devices, typically named after the oceanographers that perfected them: Secchi, Nansen, Eckmann, Peterson and Niskin. All students of science and oceanography should study these pioneers and their struggles and achievements, but perhaps the foremost is Fridtjof Nansen (1861-1930)…arctic explorer, distinguished scientist and Nobel Laureate.

The Nansen bottle has been a standard water collection device since 1910 and when lowered by a strong line, can be signaled to close with a weighted “messenger” sent down the line to “fire” off a release mechanism that closes off a tube of water from any depth. The only limitation is the length of your line. Then that water can be brought to the surface for analysis of its physical features, nutrients and even contaminants washed into the sea or wafted from land.

The CTD Rosette

In 1966 Shale Niskin perfected a version of the bottle that today we will lower with eleven others on a circular frame called a *rosette*. These Niskin bottles can be signaled automatically to capture water at preprogrammed depths as the CTD device on the bottom of the frame records data.

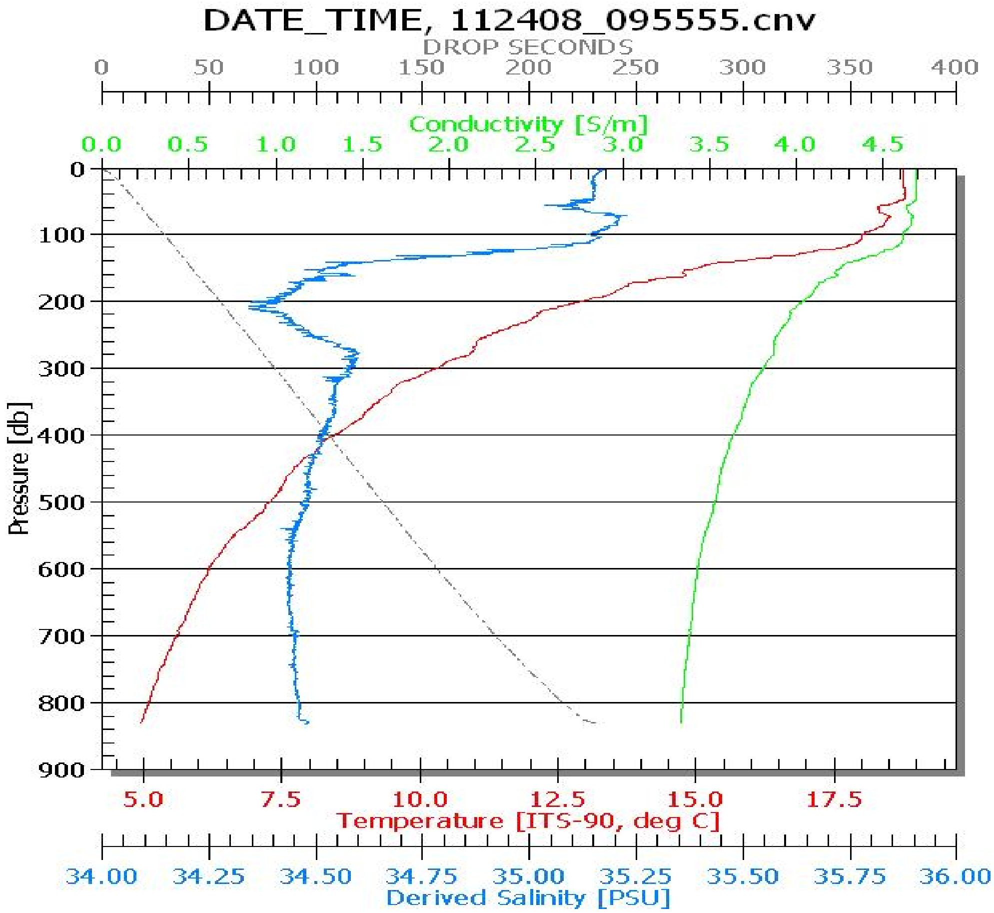
The CTD (Conductivity, Temperature, Depth) is one of today’s most important oceanographic tools. It is mounted on the rosette with the Niskin bottles and records the temperature and salinity of the layers of water, which allows oceanographers to trace the origins of the currents. The Brown has enough cable to lower it to 6,000 meters, but here in the Peru Basin, we are limited to less than 4,000 (Still deep enough to swallow any mountain east of the Mississippi, and most of the ones in the west.)

The crew does an amazing job holding the Brown on station, and can literally turn on a dime since the ship has fore and aft thrusters. When the seas are high and it is choppy, they maneuver into position by making a slow (right) turn to starboard (Where the rosette is deployed) so it is in the lee of the wind and much calmer. The turning creates a “pond” of flat water that also attracts seabirds, so I try to have my camera ready at all times.

A storm petrel

The whole process takes several hours and has to be done with great care and constant adjustments from the bridge since anything lowered over the side might become tangled with the rudder or propellers, its own cable, or otherwise be damaged or lost.

The water brought up from depth in the Niskin bottle is collected for chemical analysis, salinity, dissolved oxygen and plankton samples. Nutrient bottles are quickly frozen for later analysis in the lab, plankton is preserved for identification under the microscope, and dissolved oxygen must be chemically tested immediately; so there is always a flurry of activity when the CTD finally is retrieved and in deck.



Data from the CTD cast

Water on the surface is 18º and drops to 5º near the bottom. Salinity ranges between about 35.25 ppt on the surface and as low as 34.5 ppt at depth.

An NSF C-130 sampling information

***A Mariner’s Measurements**

Fathom	6-feet; the spread of a sailor’s arms
Knot	A nautical mile; also speed – one nautical mile/hour
Nautical mile (Statute mile is 5280 feet)	1/60 of a degree. Or 1 minute of Latitude at the Equator (6,076.1 feet)
League	3 Knots; or 3 nautical miles
Hairsbreadth (Width of the indicator hair on the armature of a sextant)	1/48 of a degree; or about 126 feet
Dimensions of the Ronald Brown	Length: 83.5 meters (274 feet) Breadth: 16 meters (52.5 feet)

Personal Log

There has been a good roll to the ship about every 10 seconds since we left port and after a few days your body anticipates it and I only notice the movement when I see water in a basin or the shower floor sloshing with it, or when something that is not secured bangs around. This movement approximates the wave period of the largest swells and they are generated by the constant winds drawn towards the Equator - the Trade Winds which merchant sailing vessels could always rely upon. In 1520, these same winds pushed Magellan northwest after crossing into the waters to our south that he called *El Pacifico*.

When on deck, I have noticed a low and longer period swell from the west, which is a clue that there is some far off storm brewing. Or perhaps, since the Pacific is so wide, that like the light from distant stars, it has gone through its entire existence, dissipated, and its energy is just reaching us now…only a faint remembrance in the sea.

I’ll take note of things over the next few days and look for changes like the Polynesians did when watching for storms. Higher, shorter period swells indicate that the storm is approaching. This gives you time to prepare for the large, short period, wind-driven *seas* that challenge ships and sailors.

“Look not to leeward for fine weather.”
J. Heywood, 1546

This sailor’s expression helps illustrate the fact that because winds are generated by the pressure gradient between high and low air masses, tacking into the wind moves you closer to fairer weather than running with it. (In actuality, the high pressure, and hopefully fair weather, is about 90º to the pressure gradient.) That doesn’t always explain waves however. Wave size is determined by wind speed, duration and fetch (the distance over which the wind blows), and over the broad expanse of the Pacific, there can be many storms and wind patterns creating waves simultaneously.

Before physicists and meteorologists fined-tuned the mathematics, sailors had their own theories about waves. One observation was that the size of seas (waves in a storm) could be estimated by the wind speed…*a storm with 60-knot winds might produce 60-foot waves*. People tend to overestimate wave size, especially when at sea, and the theoretical height is probably *only* about 80% of that figure (Still a very sizable and terrifying mass of water if you are in the midst of it!).

“Now would I give a thousand furlongs of sea for an acre of barren ground.”
Shakespeare – The Tempest.

Another difficult aspect of wave behavior is estimating the velocity and distance between waves (wave period); and here we turn to the oceanographers and their experimental wave tanks. To try to understand waves at sea, it is much simpler to generate perfect swells in a controlled environment. Although wave behavior in a storm is chaotic and almost impossible to monitor accurately, there is good data on the swells that spread out from the fetch, and for that we turn to the ship’s “Bowditch.” (Nathanial Bowditch’s - *American Practical Navigator*)

Wave observation	Equation
Wave Velocity in knots	V = 3.03 (Period in seconds)
Wave Length in feet	L = 5.12 (Period)·(Period)

So the 10 second swells rocking the ship are traveling at a speed of about 30-knots, and have a wavelength of over 500-feet; which means, among other things, smooth sailing for the Brown (and *most* of her passengers).

I’ll continue to watch for signs of change and hopefully our fine weather will continue.

A breathtaking sunset