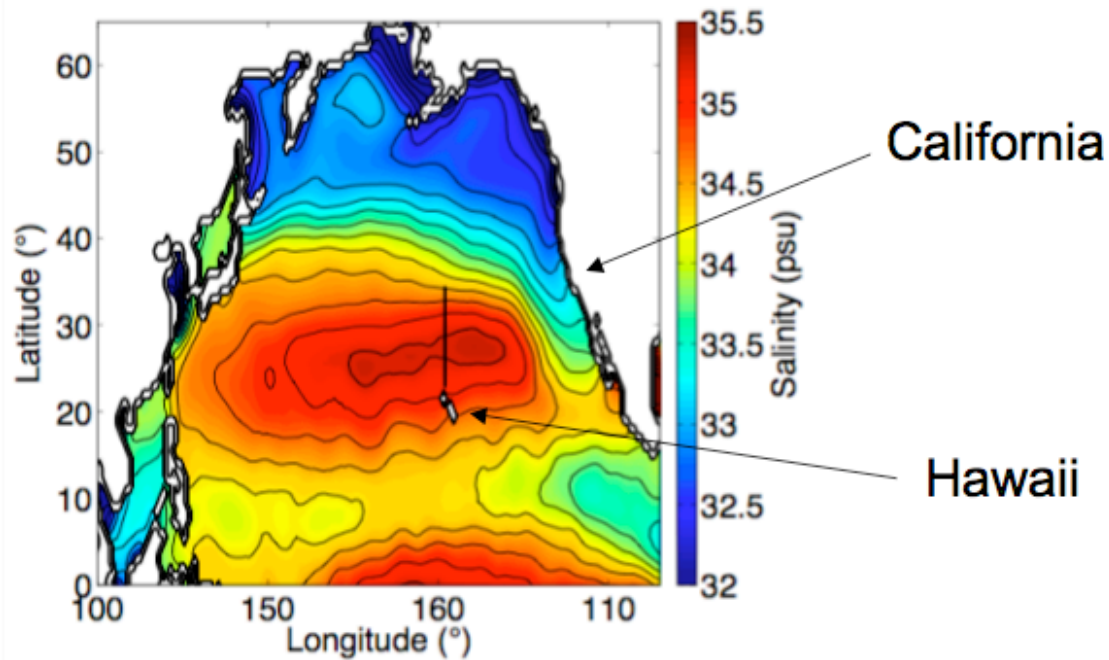


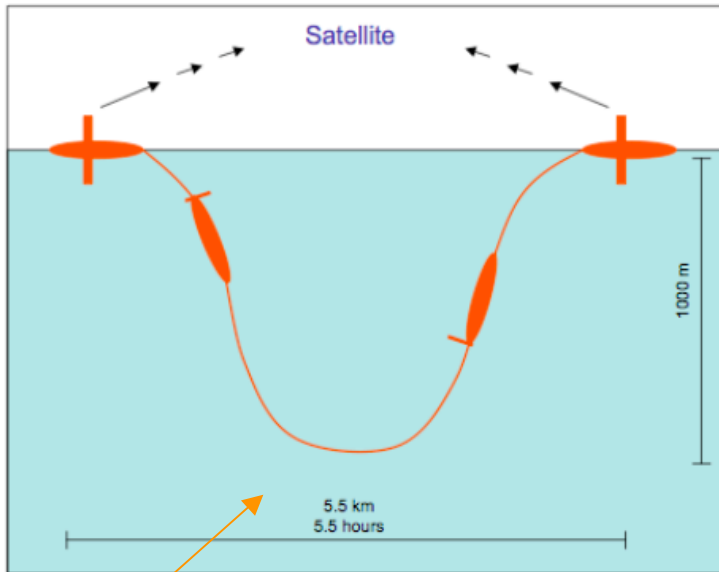
# North Pacific Observations



The picture shows mean salinity at the surface from the World Ocean Atlas, a compilation of many ocean measurements from the last few decades. Source: [http://www.nodc.noaa.gov/OC5/WOA05/pr\\_woa05.html](http://www.nodc.noaa.gov/OC5/WOA05/pr_woa05.html). Students will be looking at a set of observations along the black line. The track runs from 22.75-34.5°N, a distance of 1300 km. This track slices through the high salinity region in the middle of the gyre. It is also close to land (Hawaii) making deployment and recovery of the instruments used easier.

# Underwater Gliders

No propulsion  
Communicate with satellites



Picture of a spray glider (by Robert Todd). See [spray.ucsd.edu](http://spray.ucsd.edu) for more information.

Surface every  
3-6 hours

Travel 3-5 km  
between  
surfacing

1) The glider is ~6ft long, with a 3ft wing span and weighs about 100 lbs. There is a satellite antenna in each wing.

Time to complete a dive:  
~ 5.5 hours for 1000 m dives  
~ 3 hours for 500 m dives

Distance traveled in one dive:  
~ 5.5 km for 1000 m dives  
~ 3 km for 500 m dives

Time on the surface between dives to talk to the satellite: 10 min.

2) Schematic of one dive. At the surface, oil is transferred from an external bladder into the glider so that the glider's density increases (the mass is packed into a smaller space), and it sinks. Battery packs shift forward so that the nose points down. Because of the wings, the glider moves forward as it sinks. At the bottom of the dive, oil is pumped into the external bladder so that the glider's density decreases and it rises. Battery packs shift backwards so that the nose points up. At the surface, the glider rolls 90° by shifting battery packs side to side so that a wing with a satellite antenna is in the air. The glider sends back data it just took, and checks for new instructions. It then starts the next dive.

# Glider Deployments

Each glider deployment lasts 4 months

Deployed and recovered from a small boat close to shore

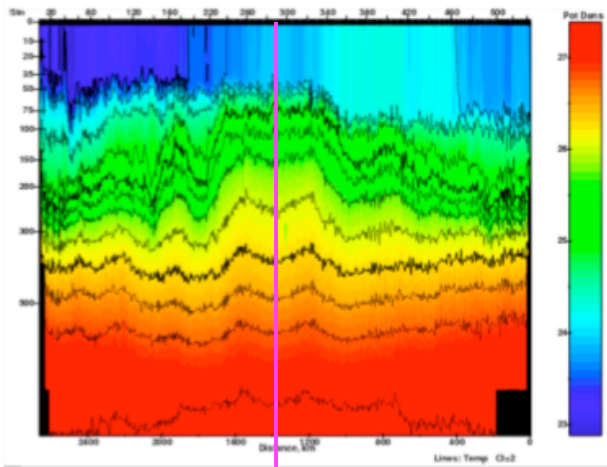
Use a website to check the glider



1) A glider's batteries will last up to four months, so this determines how long the deployments are.

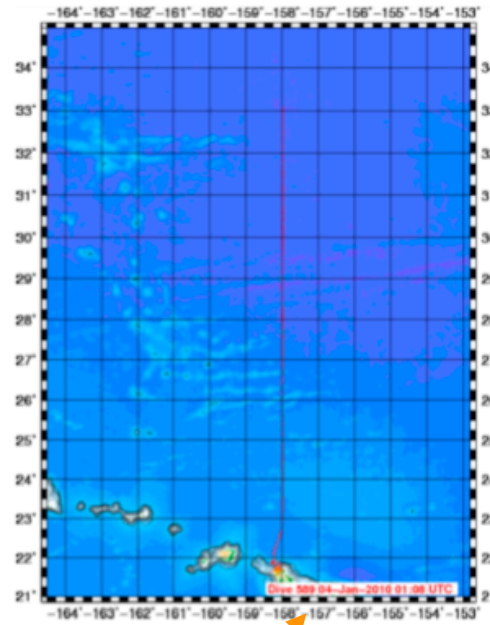
2) The figure (far left) shows temperature from one of the deployments. The x-axis is total distance. The y-axis is depth, but with a stretched uneven scale. The first half of the deployment is the glider traveling north, and the second half is the glider traveling south.

3) The temperature section and map are obtained from the spray website: <http://spray.ucsd.edu>. Similar maps can be obtained for deployments in other areas



The glider turned around to head south here.

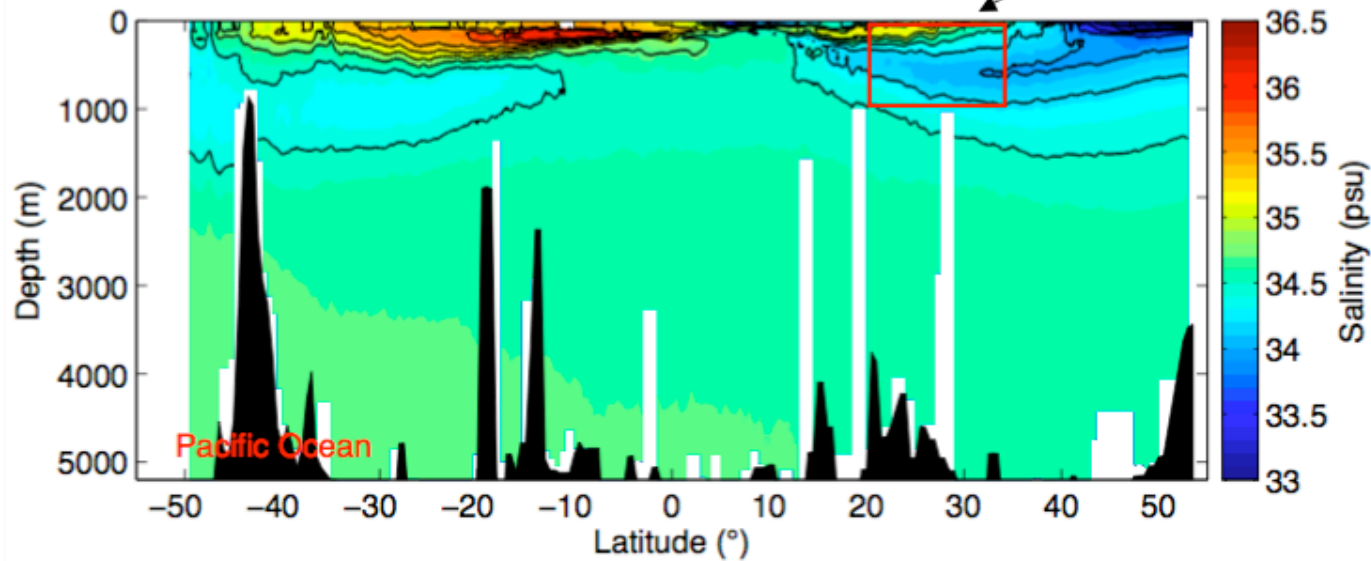
4) When the glider is in the ocean, we can check that it has surfaced and reported back data recently, that the data are good, and the instruments are happy.



Glider is deployed just off the coast of Oahu and travel to 22.75°N, 158°W to start the section.

# Glider Sections

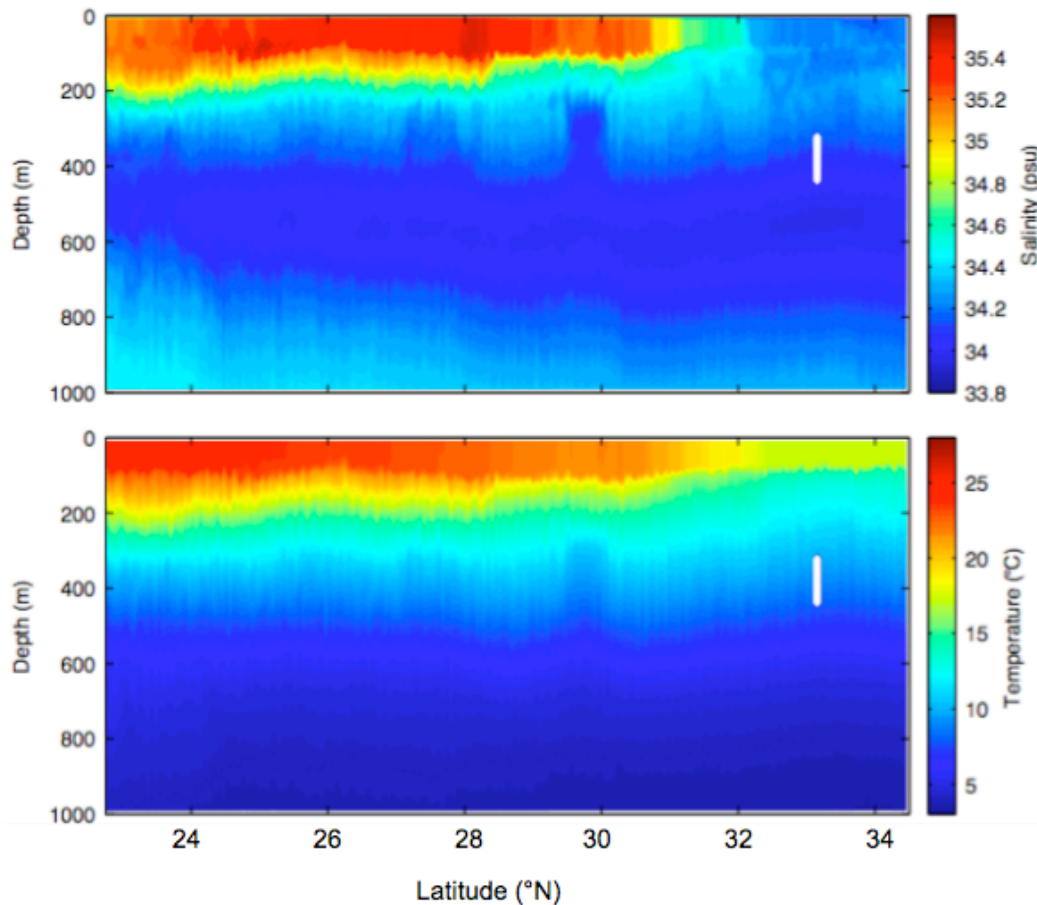
16 sections in the red box



The figure shows a section of salinity in the North Pacific along 160-170 °W. The red box is the part of the ocean that the glider samples. The glider only observes a small fraction of the ocean, but it is the important fraction near the surface where a lot of things happen. Gliders sampled this box 16 times in 2.5 years.

The glider takes 10 times as many profiles in the red box as the ship did to make the salinity section shown. Glider = 5 km horizontal spacing; Ship + CTD = 50 km horizontal spacing.

# Temperature and Salinity



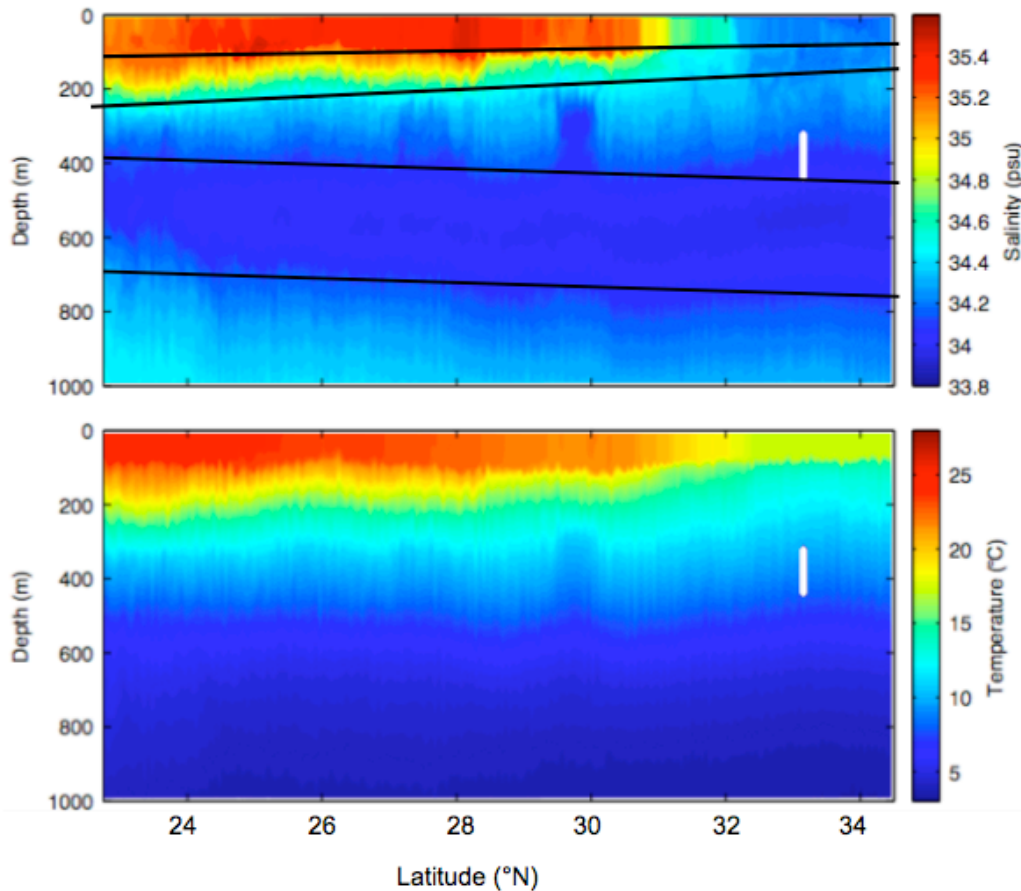
2) Bottom line: There is a lot of structure in the ocean.

The rest of the slides are to be used with the activity '03t.activity.nplayers' (<http://earthref.org/cgi-bin/erda.cgi?n=1019>).

1) This is what a section looks like. This is a different section from any that the students will have in the activity 03t.activity.nplayers (<http://earthref.org/cgi-bin/erda.cgi?n=1019>). It was taken between 9 Dec 2008 and 31 January 2009. The white areas are gaps in the data, the instrument essentially had a hiccup.

Ask the students what they notice. Point out that temperature and salinity at the surface change from the south to the north, and they change abruptly. This is called a front, and is similar to fronts in the atmosphere. Point out the little wiggles, these are just waves moving the water up and down. Point out some of the bigger features, like the fresh salinity near 30°N and 300 m depth. This is just variability, the ocean is not smooth or boring.

# Temperature and Salinity



## 5 Vertical Layers

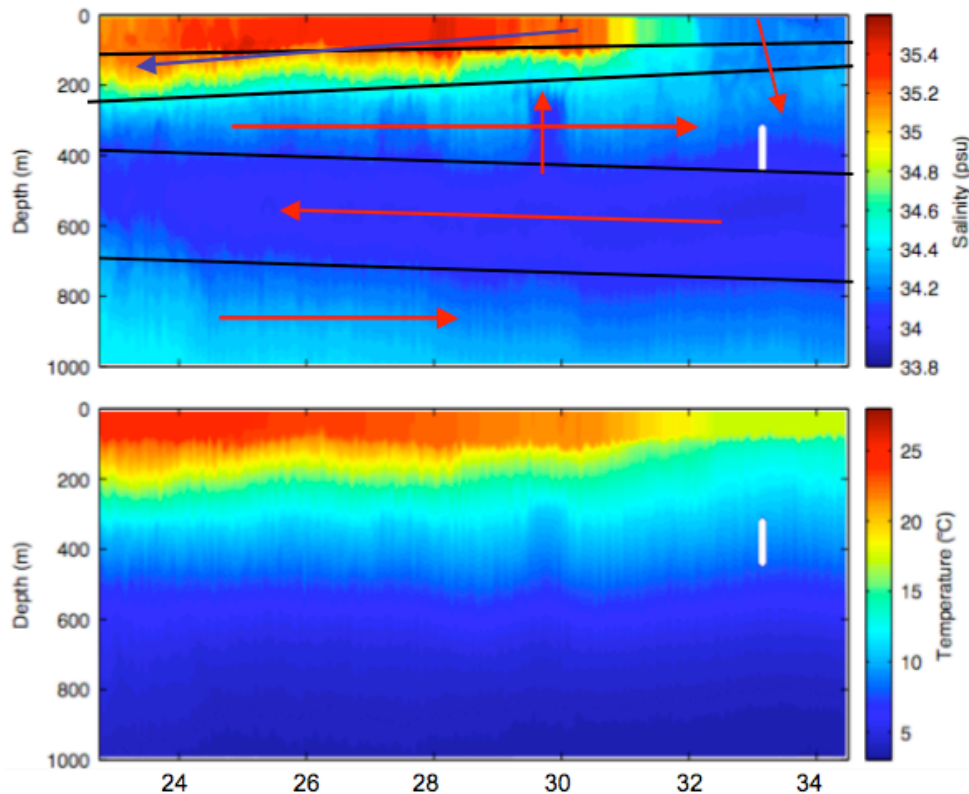
1) This is one example of how you might divide the section into vertical layers. There is no right or wrong way to do this. The layers do not have to be perfectly horizontal either. The goal is to get the students to decide how they might want to tackle the data if they were a scientist. How can it be divided up?

This shows five layers.

- 1) A surface layer where the salinity does not change with depth
- 2) A second layer where salinity changes fast with depth in the south and slowly with depth in the north
- 3) A third layer where salinity changes slowly with depth, and there is a lot of variability in the horizontal
- 4) A salinity minimum layer.
- 5) The layer below the salinity minimum.

2) Another possibility is to divide into regions where salinity is decreasing with depth and where salinity is increasing with depth.

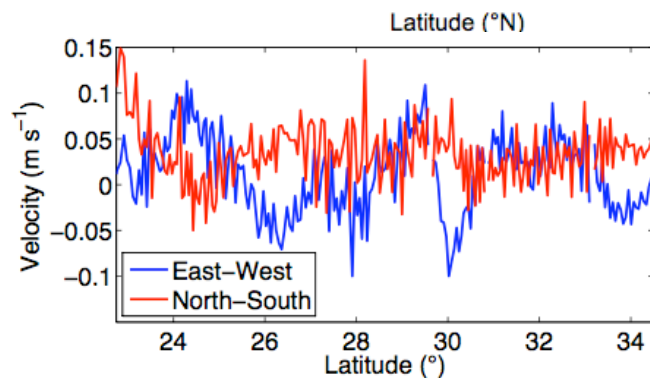
# Temperature and Salinity

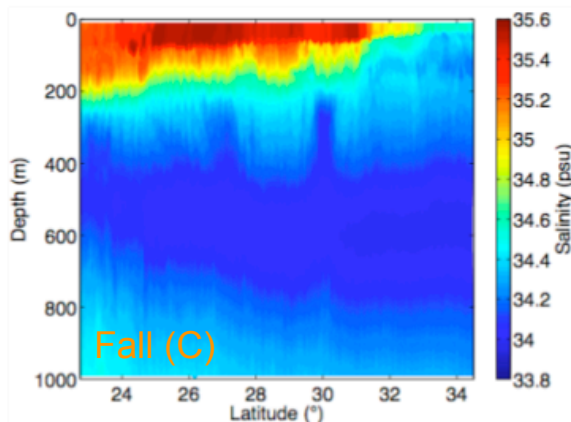
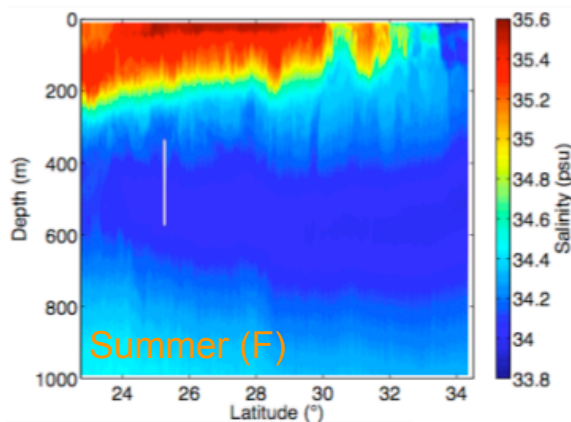
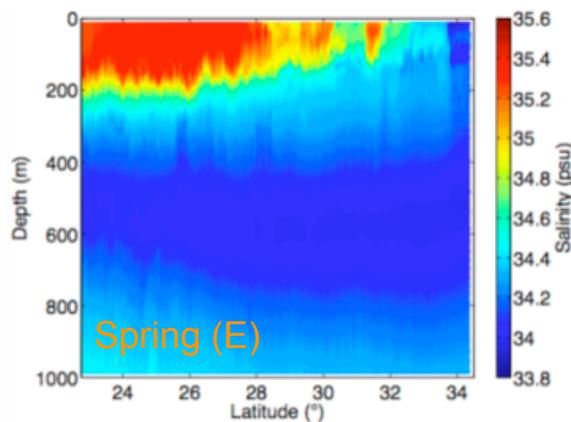
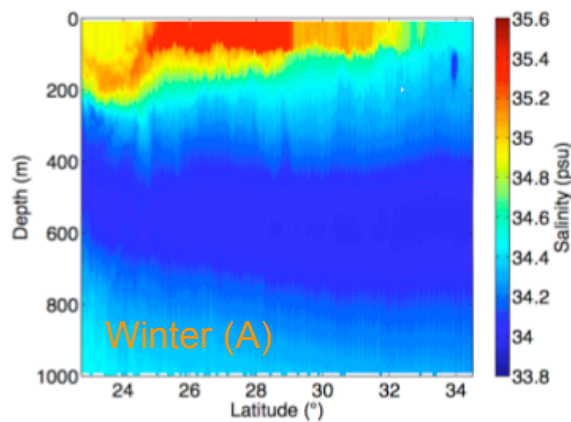


## 5 Vertical Layers

1) This shows one possibility of where you might guess the water is moving based on salinity. The strong fresh patch at 300 m depth suggests water has moved upwards from below. The salinity minimum water is probably all moving in the same direction as well. And based on salinity, water could be moving up or down north of 32°N. The salty water at the surface is probably all moving in the same direction.

What is the actual circulation? At any time, the water is moving east-west, north-south, and up and down. The picture below shows the average currents in the upper 1000 m that the glider observed for this section. The currents change direction and size frequently. Salinity shows the effects of longer term currents, like the slow spreading south of the salinity minimum layer, or past currents, like the fresh patch at 300 m depth.

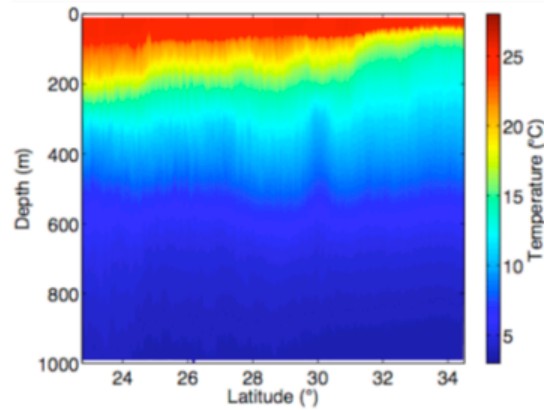
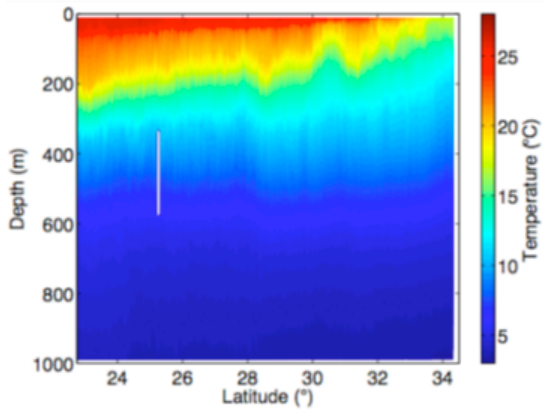
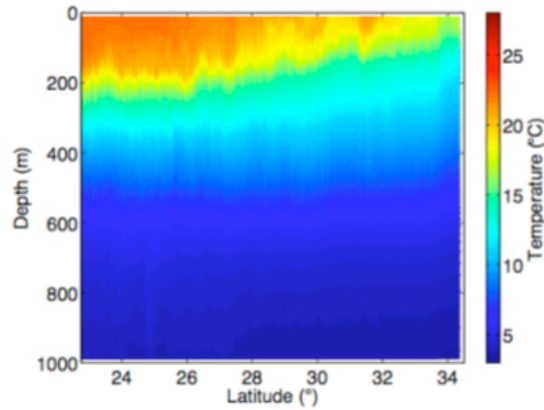
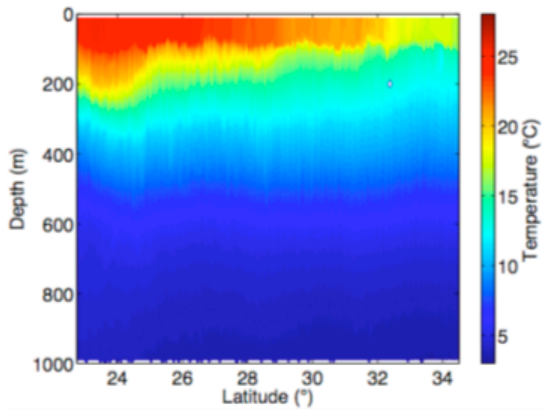




2) Example sections of salinity in each season. Some of the similarities and differences between the sections are evident. In all sections, salinity gets fresher to the north, but sometimes it is fresher than at other times. The maximum salinity is in the middle of the section, and again sometimes it is saltier than at other times.

From salinity, you can pick out how deep the mixed layer is. The mixed layer is the region at the surface that has been vertically mixed because of winds or cooling. It is more than 100 m deep in winter, and looks to be more than 100 m deep in spring, but is about 10 m deep in summer, and about 75 m deep in fall.

1) Use this slide and the next one to conclude the discussion. What are some the similarities and differences between the different observations? How does the ocean change with the seasons?



1) Example sections of temperature in each season. Temperature also decreases to the north at the surface. The mixed layer is also evident in temperature.

The seasonal changes are more apparent in temperature than in salinity. Temperature changes of more than  $5^{\circ}\text{C}$  are clear in the northern portion of the section. Use this slide with the last one to conclude the discussion.