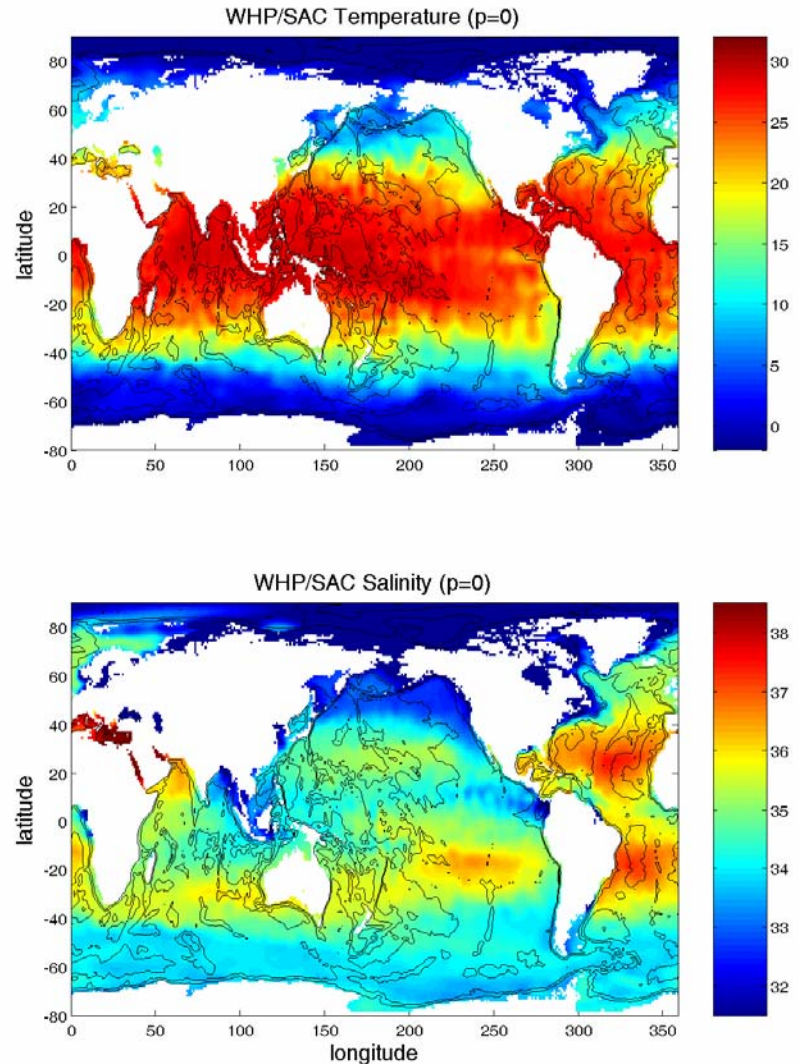# WOCE hydrographic Atlas, 1

As a result of the World Ocean Circulation Experiment (**WOCE**), a hydrographic survey of the world oceans occurred from 1990-1998. These data were unprecedented in terms of the global coverage and quality. They were subsequently used by a group in Hamburg (Goruretski & Koltermann, BSH Tech. Ret. 35/2005) to regionally 'correct' previous cruise data, and produce a Global Hydrographic Climatology [GHC] of gridded hydrographic data [half degree of lat/lon] at 45 standard depth levels for the world oceans. Spatial averaging ranged from 50 to 700 km scales, with smaller scales near boundaries and where available data density allowed. While nutrients and oxygen we included in the gridded Atlas, we will be using just temperature, salinity, and neutral density (Jackett & MacDougall, JPO 1996). And since we want a tool for global calculations, we will subsample the half degree climatology to every whole degree of lat/lon [reduction of file sizes by a factor of 4].

WOCE hydrographic Atlas, 2

Because we want a tool for calculations, the original depth levels were resampled or interpolated onto pressure levels (in decibars) so that standard calculations for potenetial temperature, potential density, geopotential anomaly [dynamic height] could be easily made with our MATLAB routines. Each of the gridded data arrays are padded with NaNs where no data are available [over land or below the local ocean water depth/pressure]. Each array is three dimensional with latitude, longitude and pressure the three independent variables. Thus salinity, (dataS_pr(171x360x45) has 171 latitudes [-80:90], 360 longitudes [0:359] and pressures [variable 1:45]. Local bathymetry is provided by the MATLAB "topo" one degree file. The MATLAB script "**atlas_test.m**" was used to create all of the following figures. It, as well as the data file [GHC_pr] can be found in the course notes under "**GHC** Files".
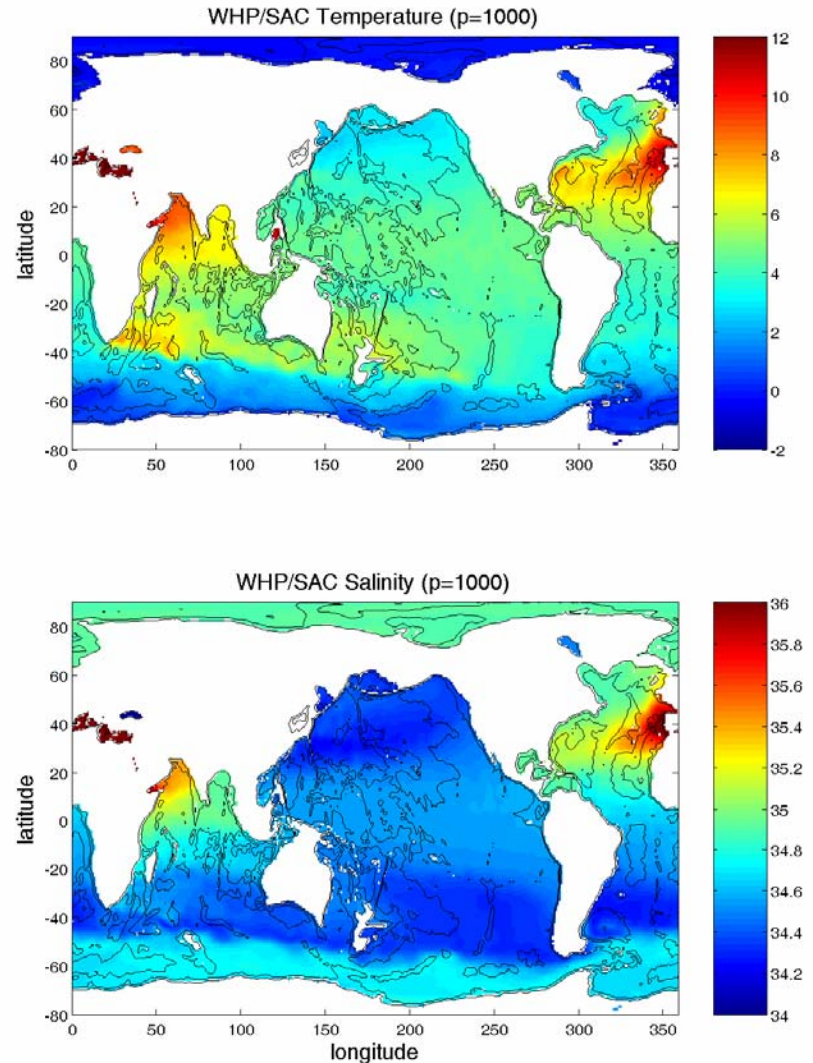
WOCE hydrographic Atlas, fig. 1

To begin with, we select the temperature (upper) and salinity (lower) values at the ocean surface and plot their global distribution. White values are generally over 'land' but in other figures at greater pressures, they will be where the pressure level does not exist in the data file. Bathymetry contours (black lines) are plotted at 1, 3, and 5 km depth.
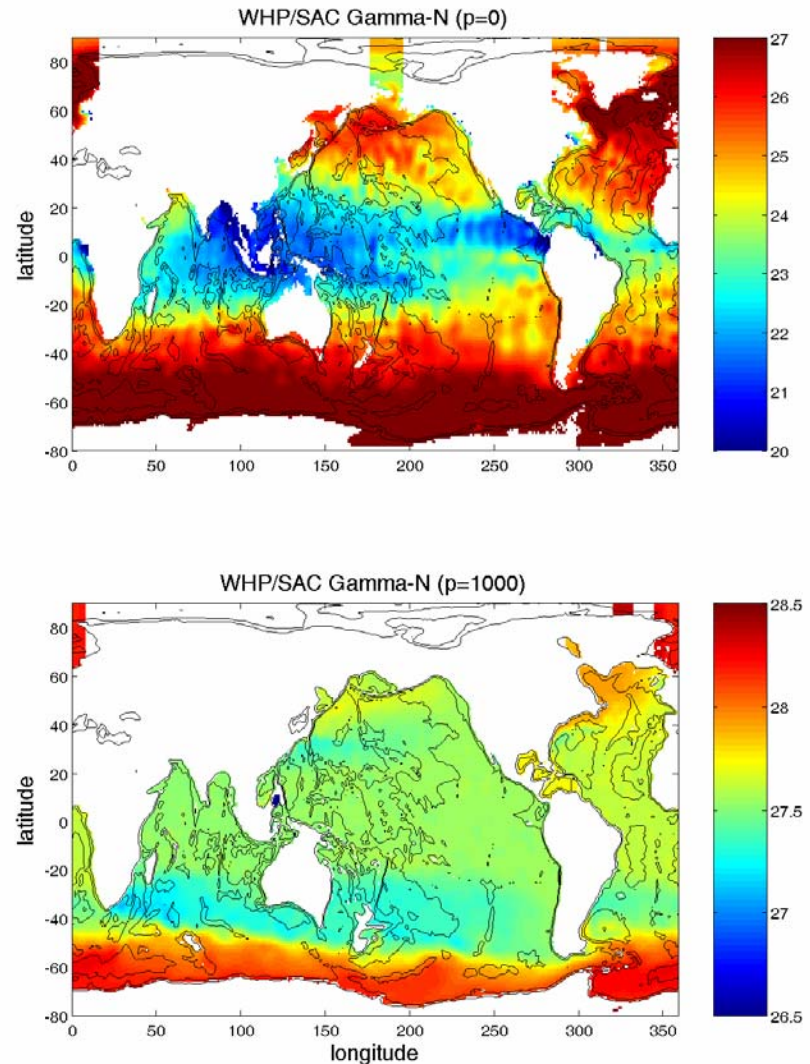
WOCE hydrographic Atlas, fig. 2

At the right, I have plotted the temperature and salinity at a pressure of 1000 dbar. Note the large salinities in the North Atlantic and NW Indian Oceans: these are due to outflows from the Mediterranean and Red Seas, respectively. The Arctic Ocean appears to be cut off from the rest of the ocean because 1000 dbar is below the sill depths for the Bering Straight and the Iceland/Faroe Ridges.
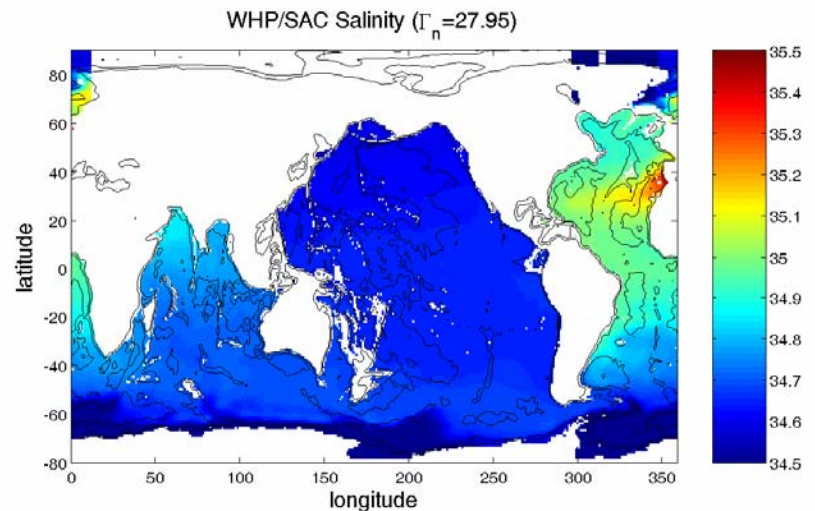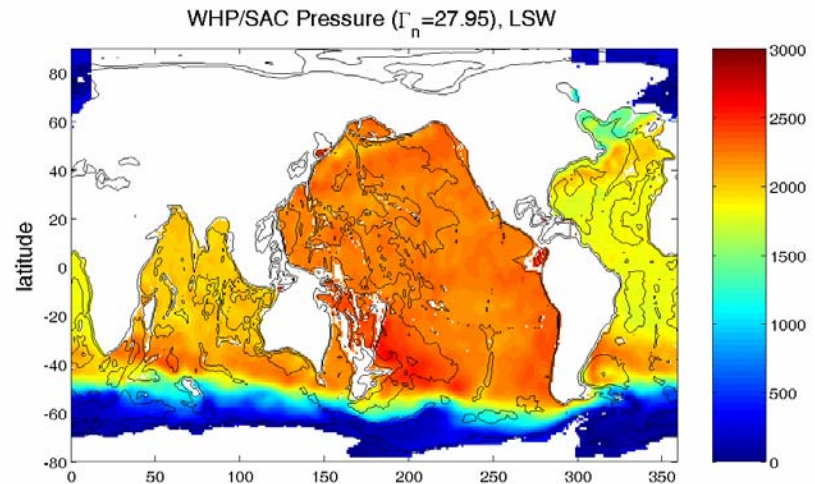
WOCE hydrographic Atlas, fig. 3

It is often common to plot properties on density surfaces, in order to see water mass structure. We have used neutral density surfaces for this exercise. Neutral surfaces will vary for a fixed pressure because of geostrophic flow in the ocean. At the right are plotted neutral density at the surface and at 1000 dbar.

WHP/SAC Gamma-N (p=0)


WHP/SAC Gamma-N (p=1000)

WOCE hydrographic Atlas, fig. 4

At the right salinity has been plotted following the neutral density surface 27.95. This surface is one which can characterize the 'classical' **Labrador Sea Water**. One can see this level to be shallow in the Lab Sea and to have its lowest salinities locally there. The layer obviously comes near or to the surface in the Southern Ocean, where low salinities are also imprinted.

WHP/SAC Pressure (Γ_n=27.95), LSW



WHP/SAC Salinity (Γ_n=27.95)

WOCE hydrographic Atlas, fig. 5

At the right, we have plotted pressure (top) and salinity (bottom) on the neutral density of 27.3. This density is one which rises to the surface (outcrops) in the Southern Ocean and is a good level for tracing properties of **Antarctic Intermediate Water** (AAIW). We can also see effects of the Red Sea and Med Outflows. Note how this display shows a much broader salty Med 'tongue' than on the 1000 dbar pressure level.

WHP/SAC Pressure (Γ_n=27.3, AAIW/MW)

WHP/SAC Salinity (Γ_n=27.3)
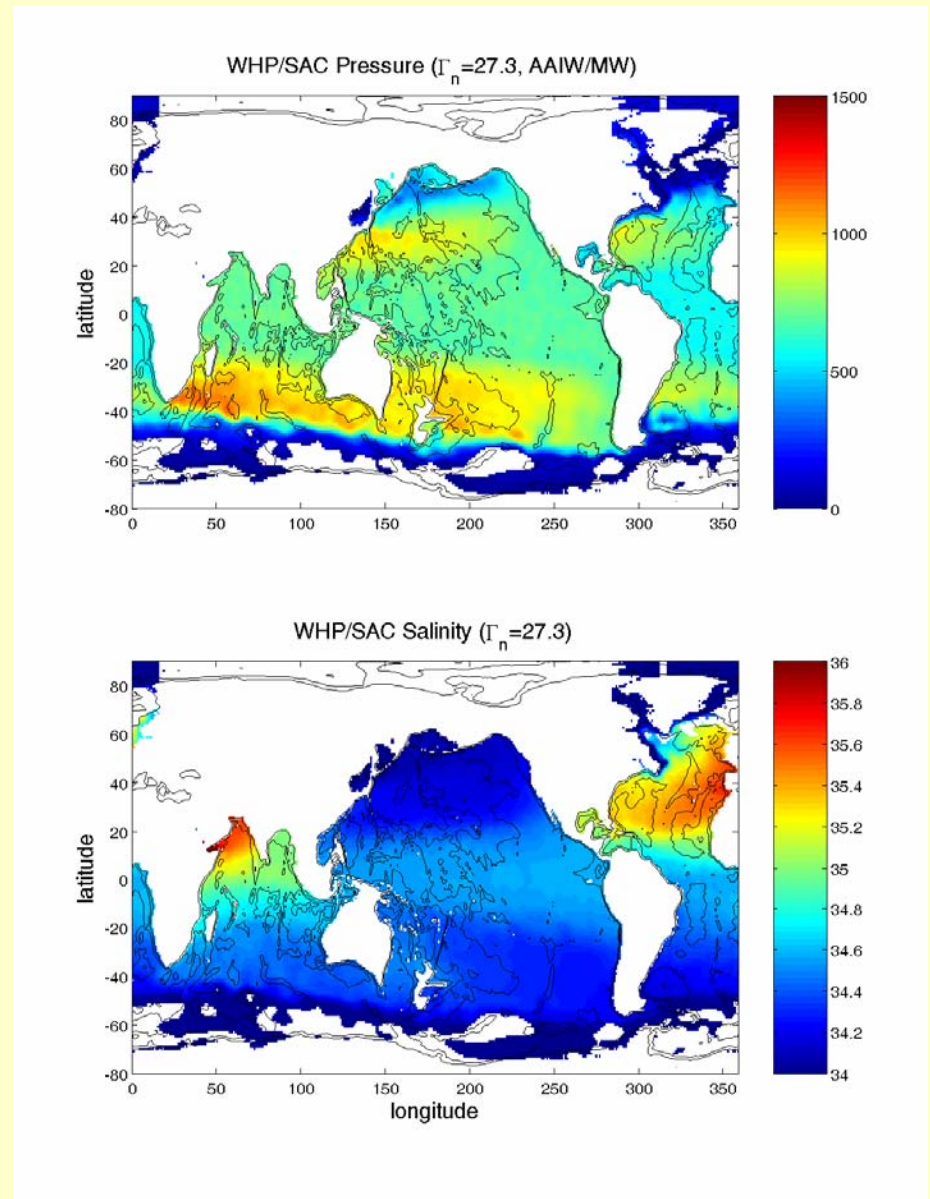
WOCE hydrographic Atlas, fig. 7

Other neutral layers are plotted with the atlas_test program. For now, we move on to a different display. Here we select a particular longitude (190 or 170W) and plot a vertical 'section' from south to north across the central Pacific Ocean. We have calculated potential temperature and plotted it (bottom) and salinity (upper). Note the outcropping of cold water in the Southern Ocean and the appearance of intermediate waters of low salinity in both the Southern Ocean (**AAIW**) and North Pacific (**North Pacific Intermediate Water**: **NPIW**).
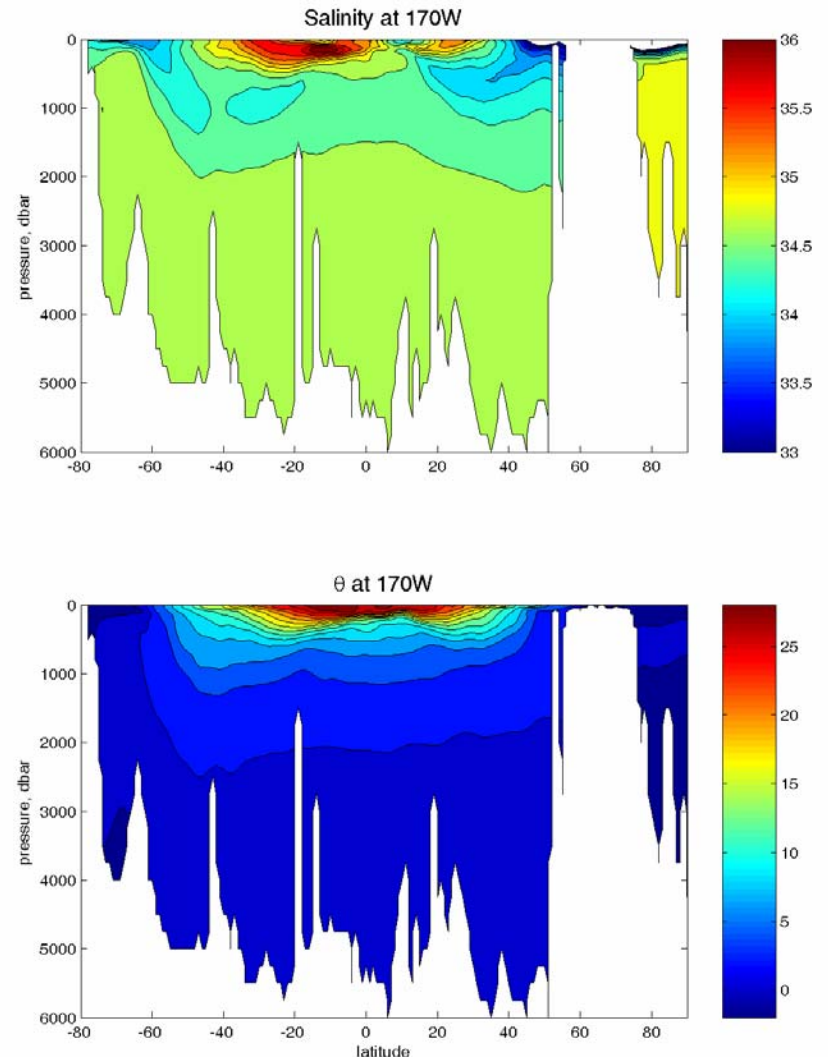
WOCE hydrographic Atlas, fig. 8

Finally, we plot a θ/S diagram for data along the 170W section from the previous figure. We have coded the points to contrast those in the polar regions from the 'central' Pacific. In the former, one can see near surface waters at or very close to the freezing point.

θ/S diagram for 170W