Simulated Pycnostads (Intra-Thermocline Eddies) in the Japan/East Sea

Patrick J. Hogan

Naval Research Laboratory, Oceanography Division, Stennis Space Center, MS, 39529-5004, USA

hogan@nrlssc.navy.mil

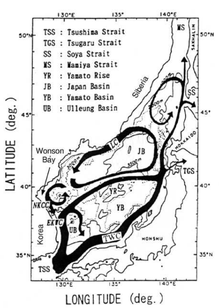
Background: HYCOM is a generalized (hybrid isopycnal/sigma/z) vertical coordinate ocean circulation model. It is isopycnal in the open stratified ocean, but reverts to a terrain-following coordinate in shallow coastal regions, and to z-level coordinates near the surface in the mixed layer. This generalized vertical coordinate approach is dynamic in space and time via the layered continuity equation, and permits the existence of zero thickness layers. Hence HYCOM allows for an accurate transition between deep and shallow water, historically a difficult problem for ocean models. It also allows high vertical resolution where it is most needed, over the shelf and in the mixed layer. The isopycnal coordinate reduces the need for high vertical resolution in deep water.

JES-HYCOM is funded by the Office of Naval Research. HYCOM development is also funded by the National Ocean Partnership Program (NOPP) in a collaborative effort with the University of Miami (E. Chassignet and G. Halliwell), Los Alamos National Laboratory (R. Bleck), and the University of Minnesota (M. Okeefe). The long term goals of the project are to make HYCOM a state of the art community ocean model with data assimilation capability which can (1) be used in a wide range of ocean-related research, (2) be used in a next generation eddy-resolving global ocean prediction system, and (3) be coupled to a variety of other models, including atmospheric, ice, and biological.

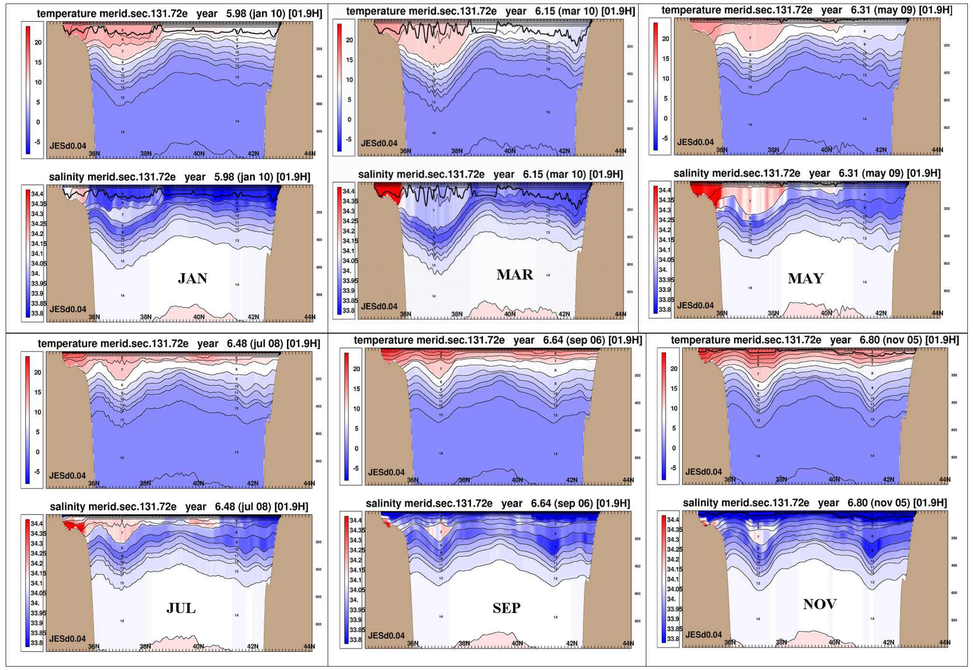
JES-HYCOM characteristics:

- Generalized vertical coordinate ocean model
- 3.5 km horizontal grid resolution
- Includes realistic coastline geometry and bottom topography, including the shelf
- Forced by ECMWF 10 m reanalysis monthly with 6 hourly variability superimposed
- Also forced with ECMWF 10m reanalysis atmospheric flux forcing
- K-Profile Parameterization (KPP) mixed layer
- Vertical resolution: 15 layers
- 2 Sv barotropic throughflow
- Bimonthly relaxation to temperature and interface depth at the straits
- Bimonthly relaxation to MODAS SSS (instead of E-P)
- Currently no assimilation of oceanic data

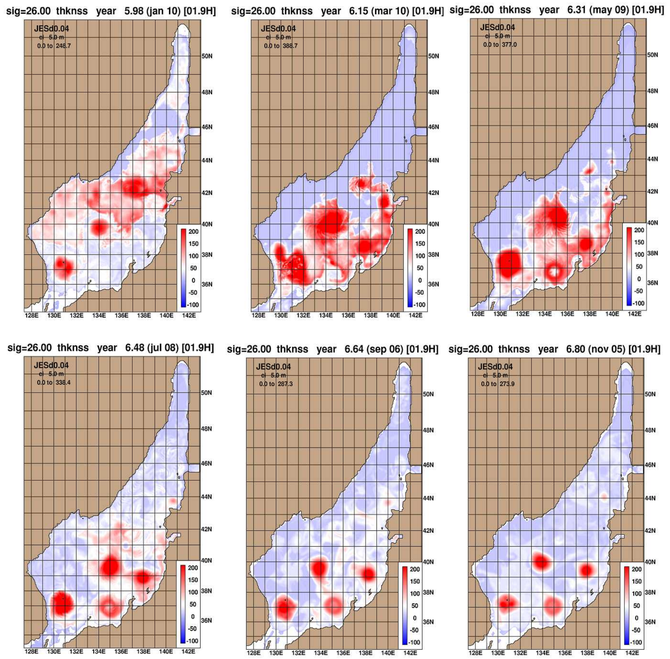
Conclusions: A Hybrid Coordinate Ocean Model (HYCOM) has been configured for the Japan/East Sea and used to investigate the formation of pycnostads (also called intra-thermocline eddies). These features, which are lens-shaped and characterized by relatively warm and saline water are simulated at approximately the same depth and location as those observed (Gordon et al., DSR, in press). The simulations elucidate two formation mechanisms for theses features which are not mutually exclusive. One is simple restratification of the mixed layer accompanied by changing water properties flowing into the JES through the Tsushima Strait on seasonal time scales. Here, warm saline water gets overridden by colder less saline water, but the water that gets overridden maintains positive vorticity and hence forms pycnostads within the thermocline. The other mechanism is frontal subduction of more saline water along the subpolar front. With this mechanism, localized pockets of warm saline water on the southern side of the subpolar front are overridden by cooler less saline water on the northern side of the front, and the location of the pycnostads is determined by meandering of the subpolar front.



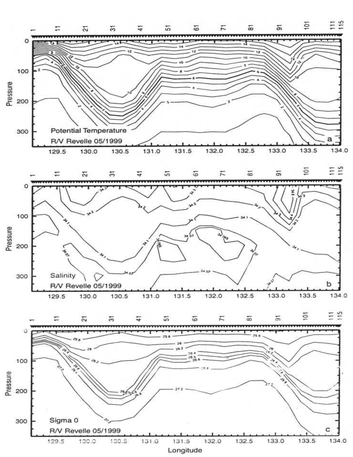
Schematic diagram of the General circulation features In the Japan/East Sea.



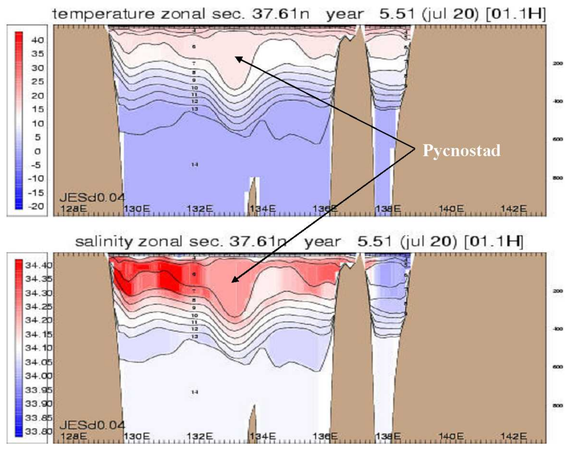
Bi-monthly cross-sections of temperature and salinity along 131.7°E (section A-B). The sections depict pycnostad formation that results from the combined effects of seasonal restratification of the mixed layer and seasonal inflow through the Tsushima Strait.



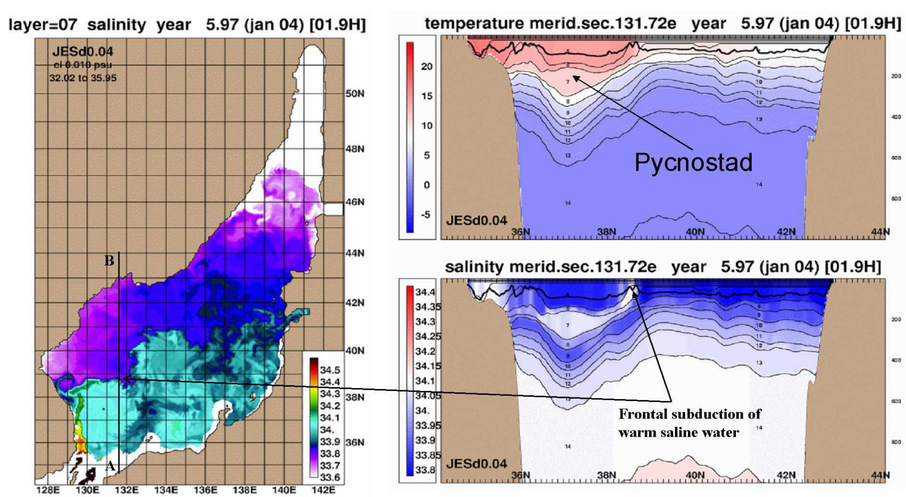
Layer thickness anomalies on the 26.0 isopycnal surface, which carries the pycnostad signature. The red areas (thicker) indicate regions of preferred pycnostad formation in this simulation.



Cross-sections of temperature, salinity, an d Density across 37.7°N in May, 1999 from Gordon et al., (in press).



Cross-section of temperature and salinity from JES-HYCOM across 37.7°N on July 20, a climatological date. The pycnostads are the lens shaped features characterized by anomalously warm, saline water.



Snapshot of salinity on the 26.0 isopycnal surface and cross-section of temperature and salinity along A-B. Here, a pycnostad forms as a result of frontal subduction along the subpolar front. The pycnostads have no surface expression due to compensating baroclinicity.