

Physical Processes and Meromixis in Pit Lakes

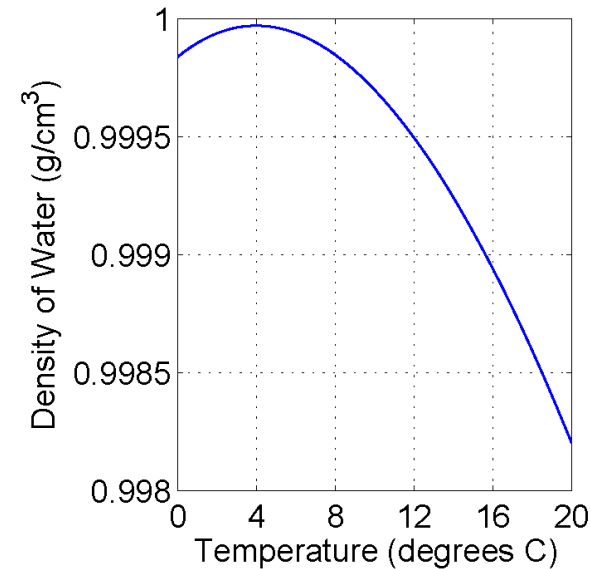
Greg Lawrence and Roger Pieters

UBC

29 November 2006

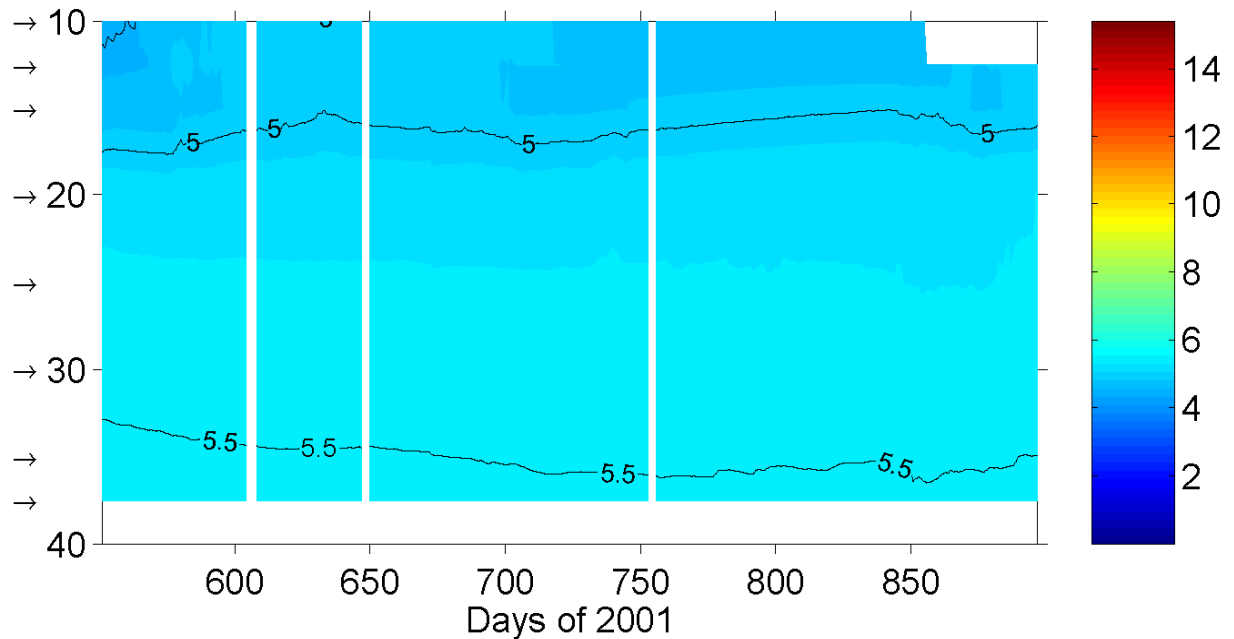
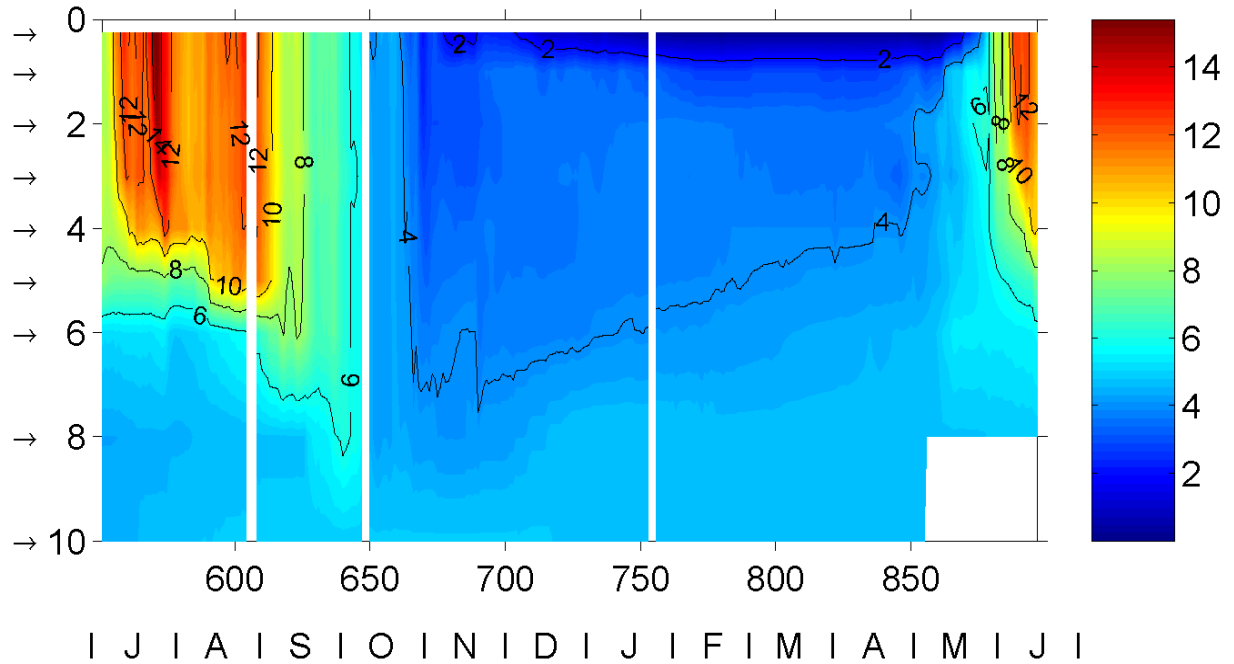
LAKE STRATIFICATION

- Typically lakes are temperature stratified
- Maximum density at 4 C
- Lakes commonly mix completely at Spring and Fall turnover when temperature passes through 4 C
- Wind contributes to mixing and turnover
- Turnover may be inhibited when lakes are deep and/or salinity stratified
- Lakes that don't turnover are said to be MEROMICTIC

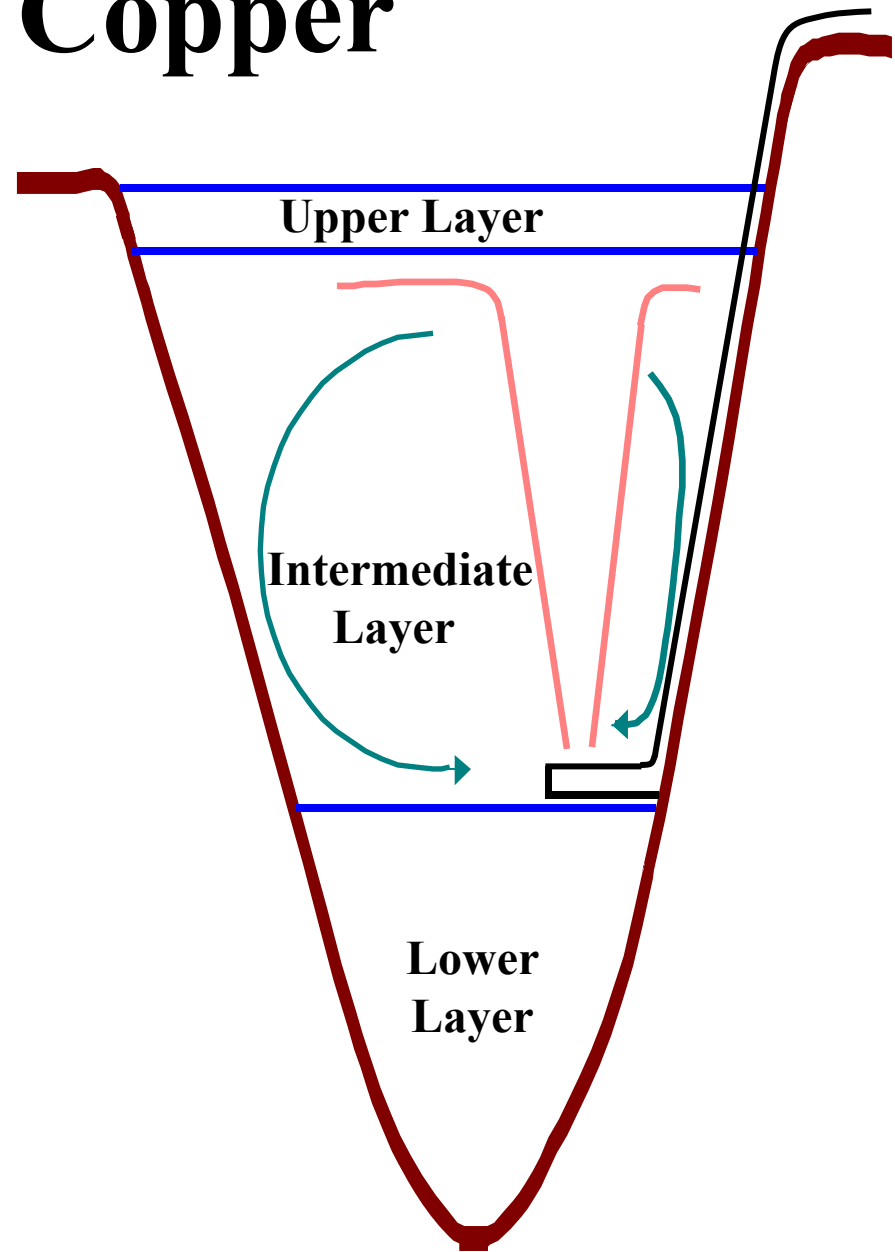
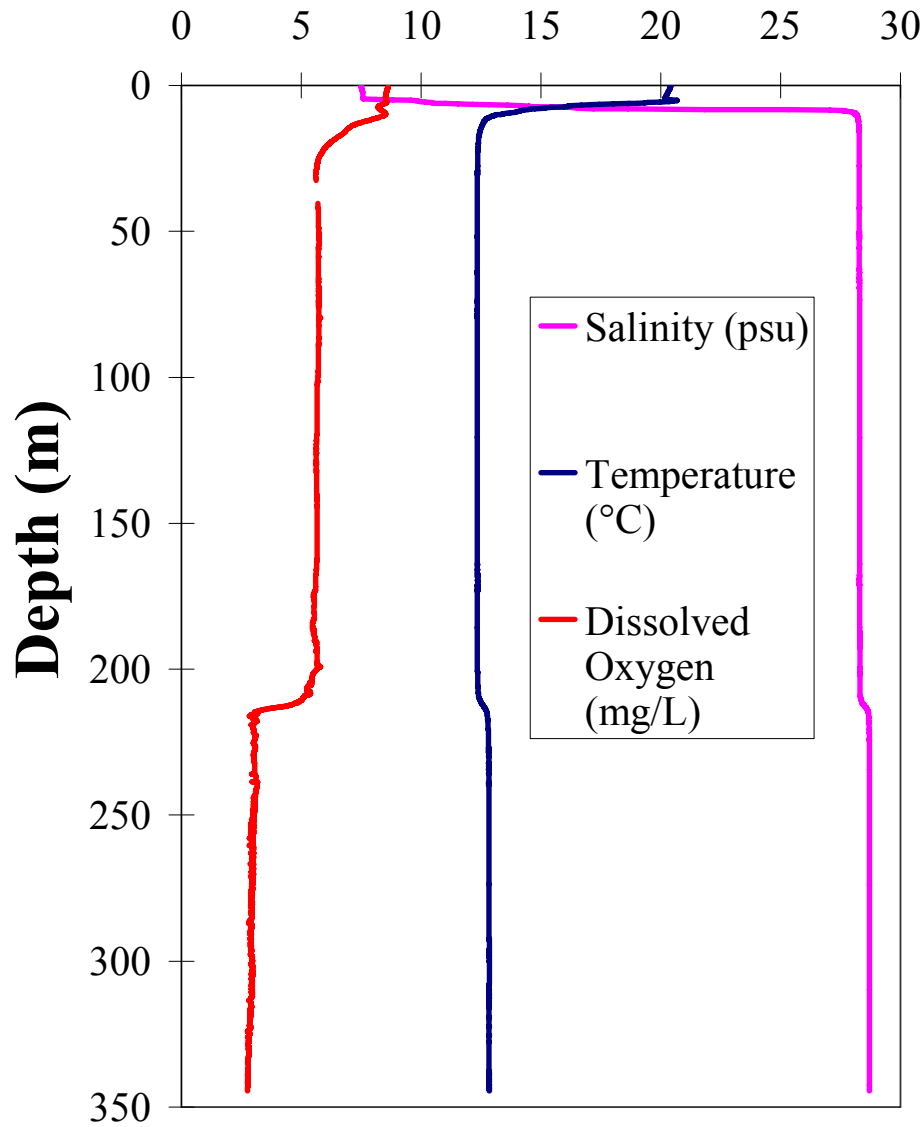


EQUITY WATERLINE Jul 04, 2002 – Jun 16, 2003

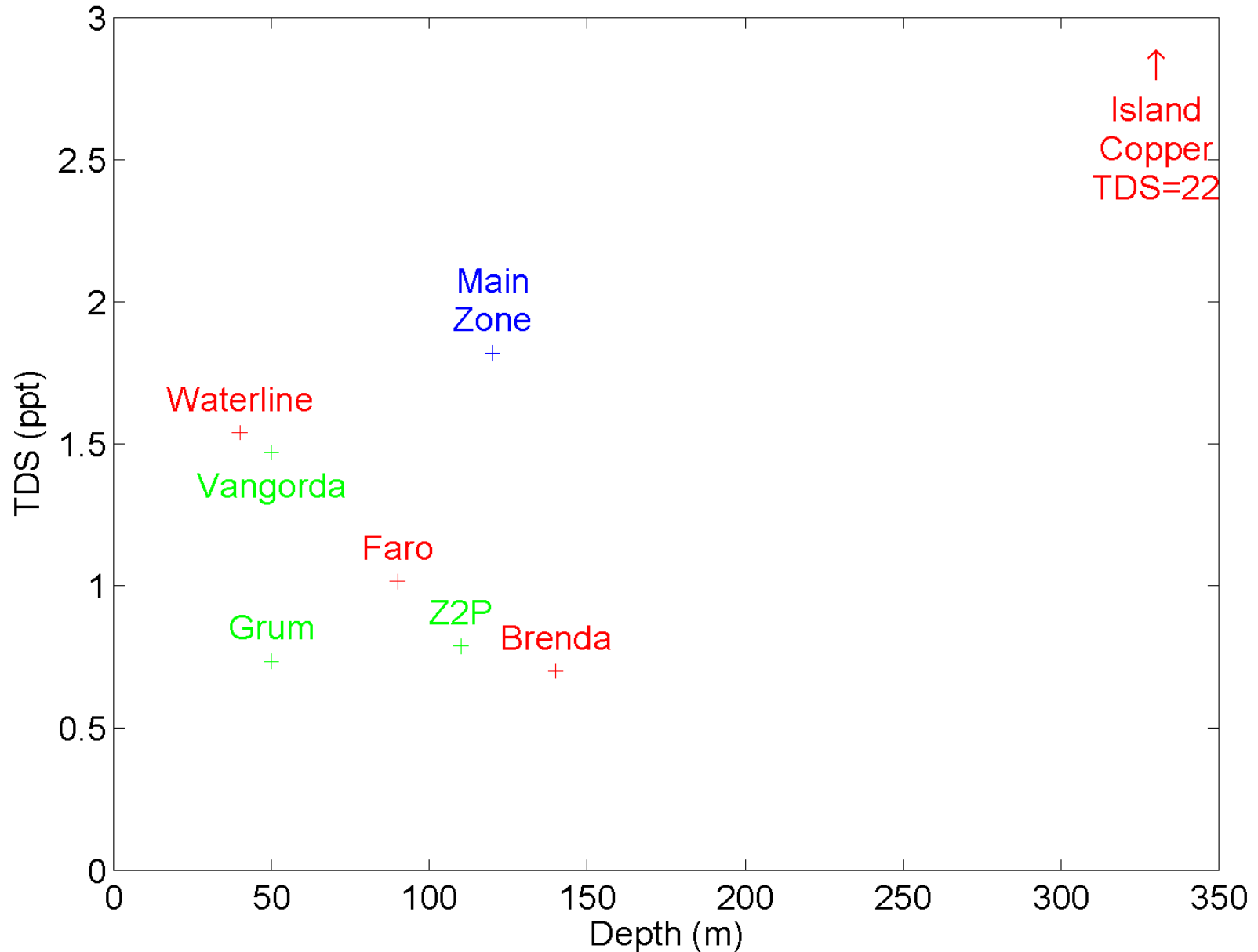
**Annual
Cycle**



Island Copper



Pit Lakes are often deep and saline but not meromictic



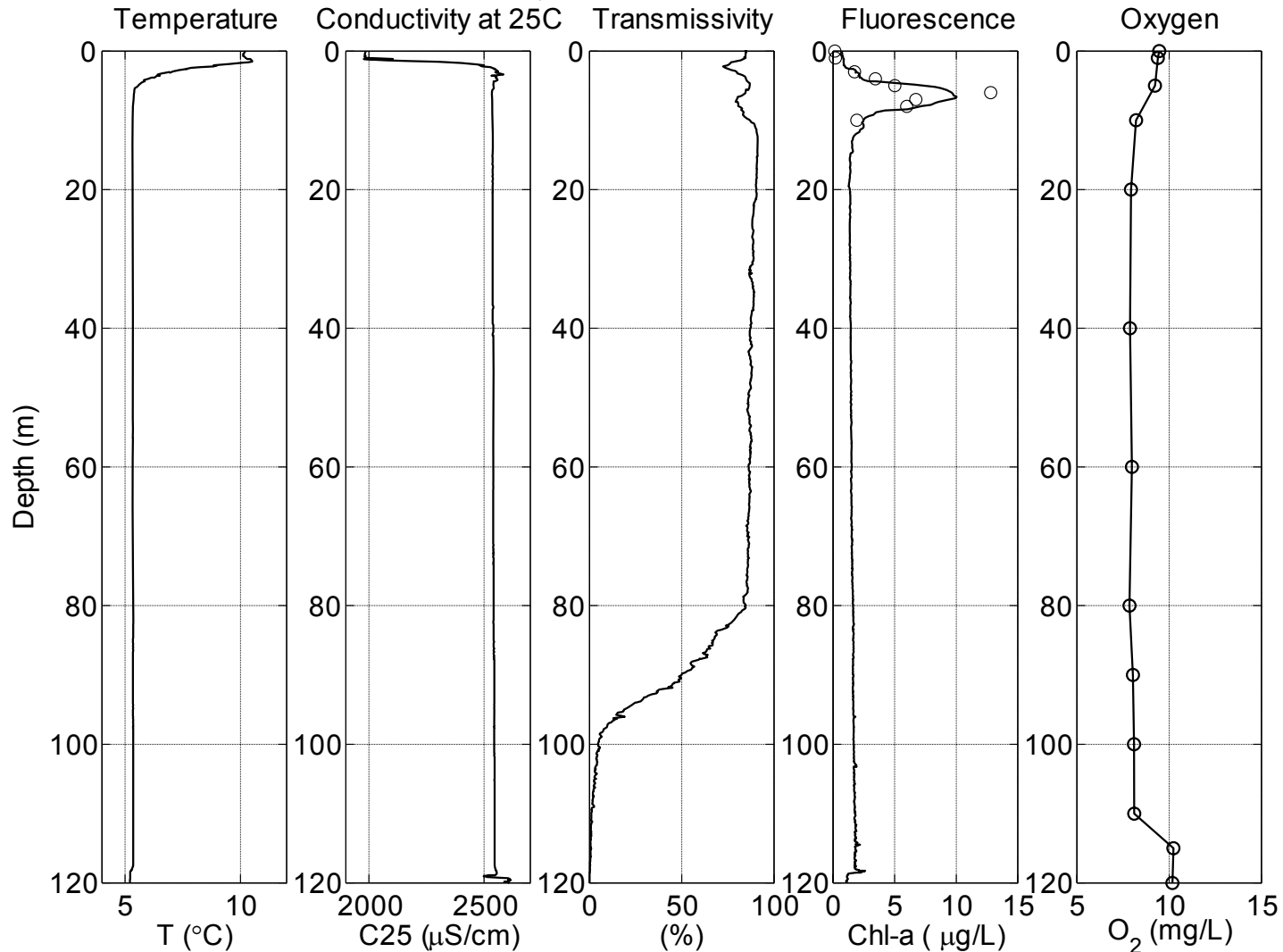
Meromictic Lakes

- Depth and salinity are not always accurate predictors of meromixis
- Other factors include:
- Climate (wind, temperature)
- Salt water exclusion
- Inflows (groundwater, sludge, runoff)
- Wall failure
- Double-diffusion
- Instructive to consider real cases



Equity Main Zone

MAIN ZONE June 25, 2001



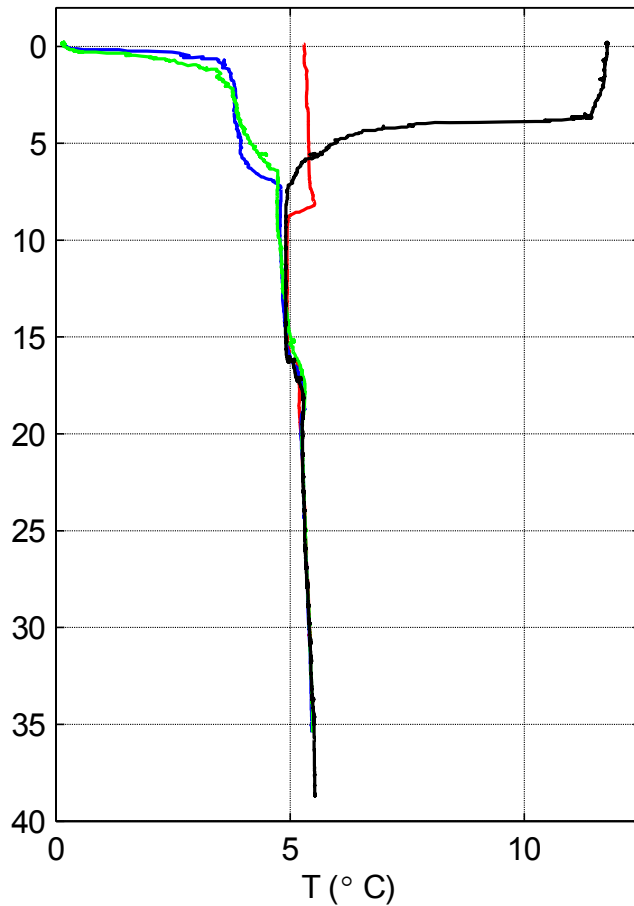
Equity Main Zone Sludge inflow



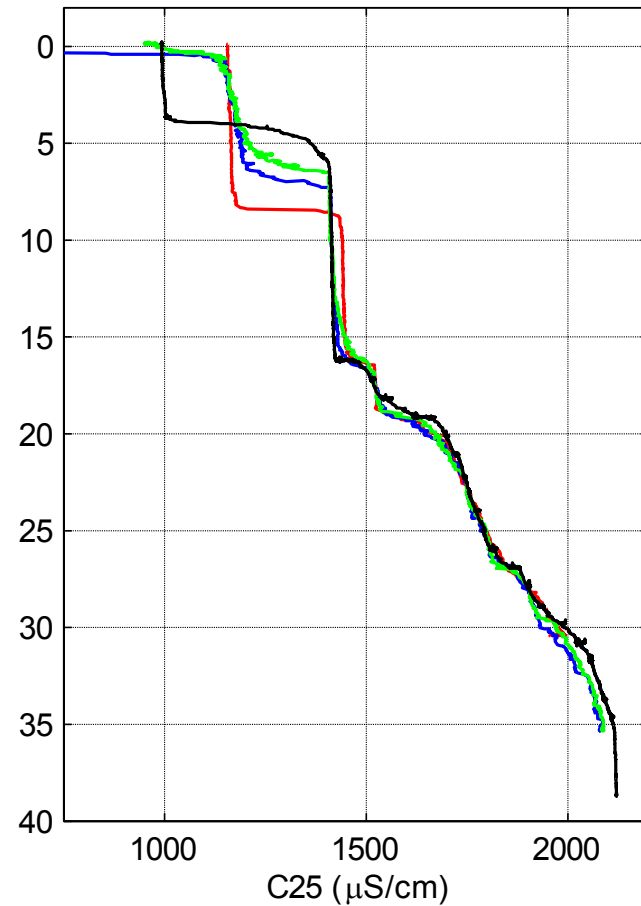
Equity Waterline



RED-Oct02 BLU-Jan03 GRN-Mar03 CYAN-Jun03



RED-Oct02 BLU-Jan03 GRN-Mar03 CYAN-Jun03



Equity Waterline Adits

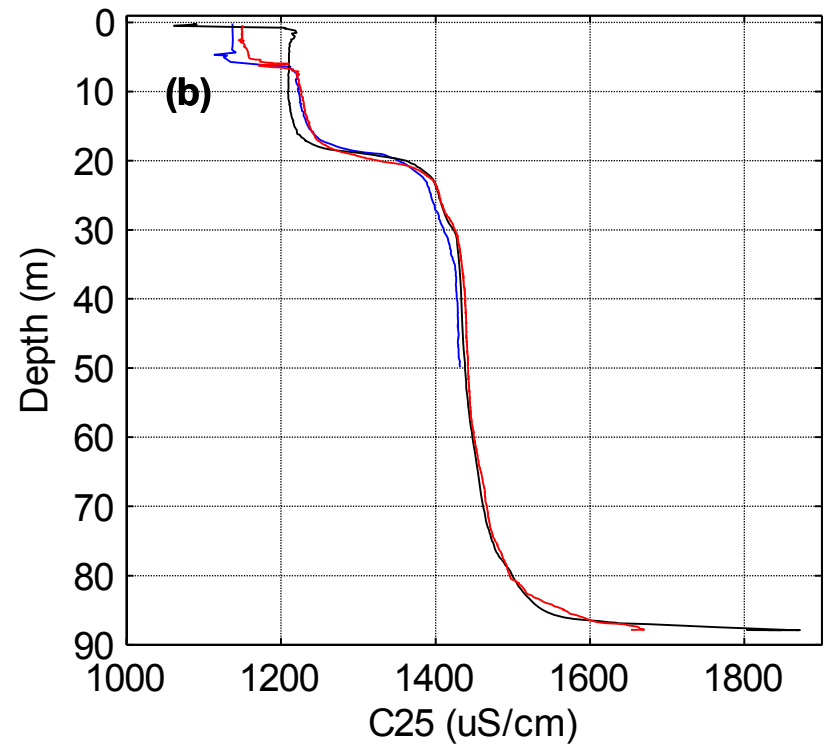
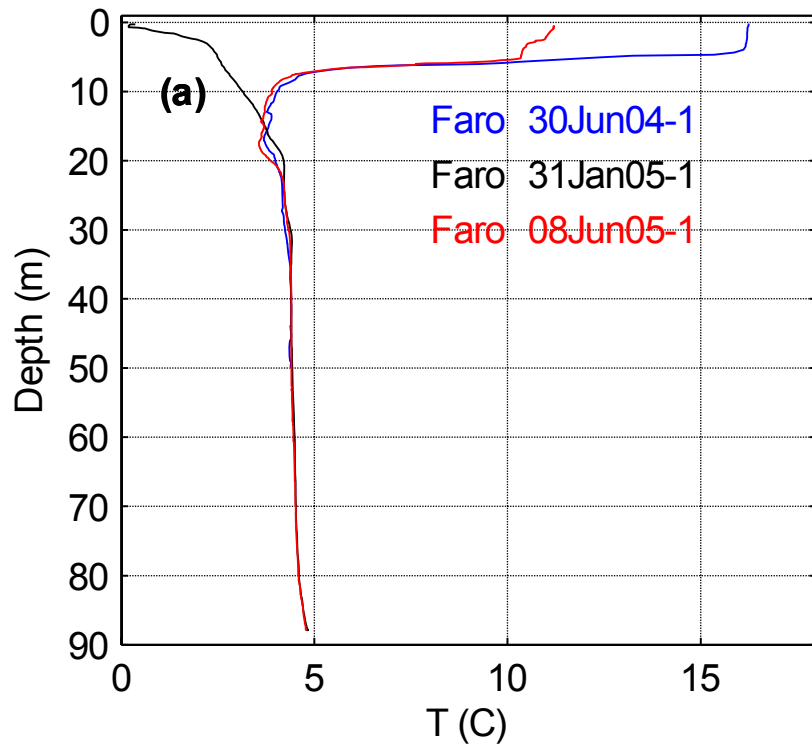


Courtesy of Mike Aziz

Faro

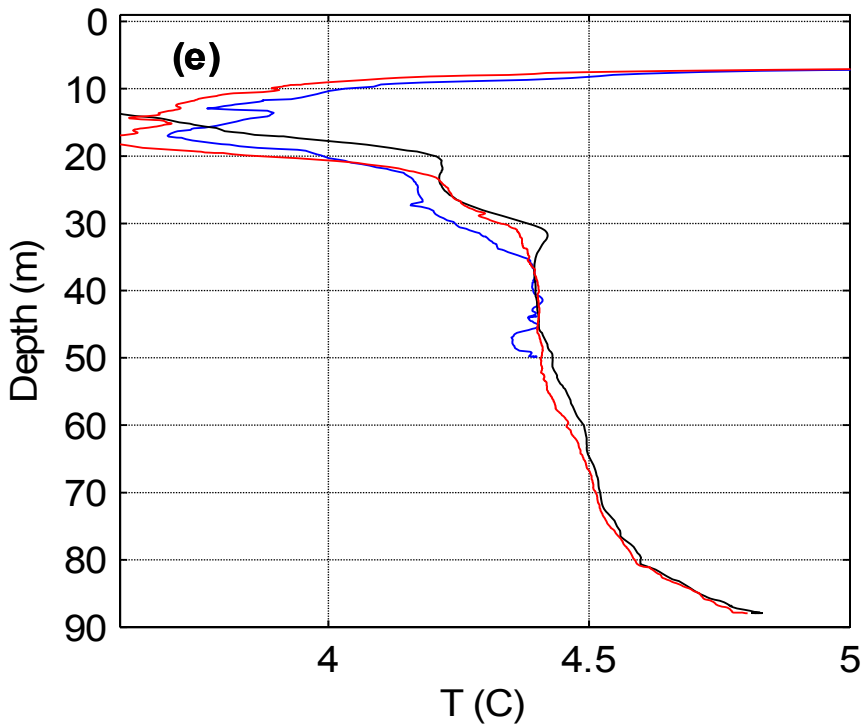


Figure 3 Faro Seabird Temperature and Conductivity Profiles, 2004 & 2005

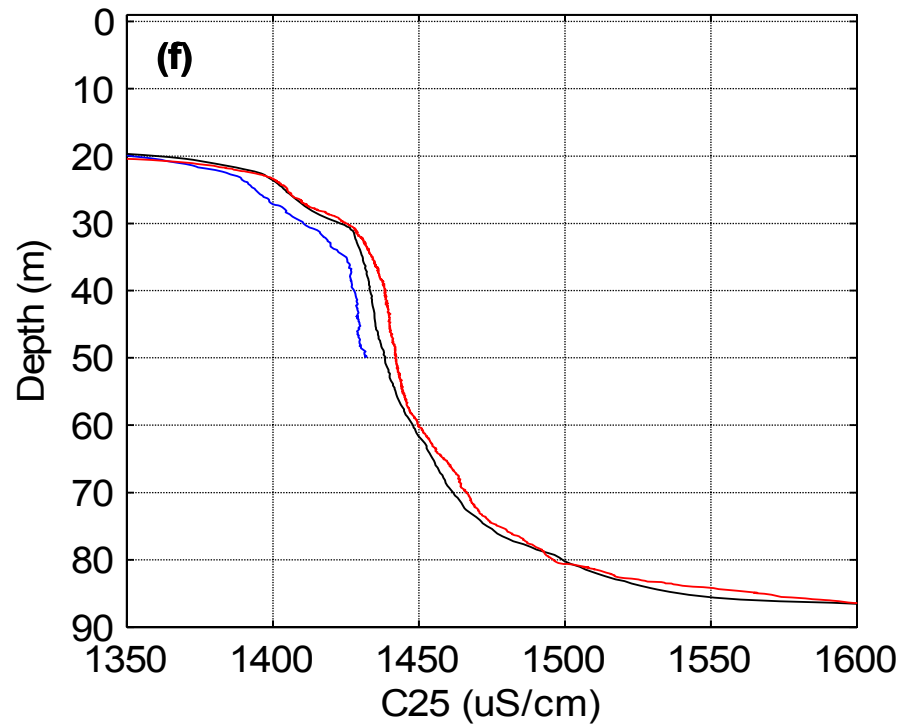


Faro Deep Water

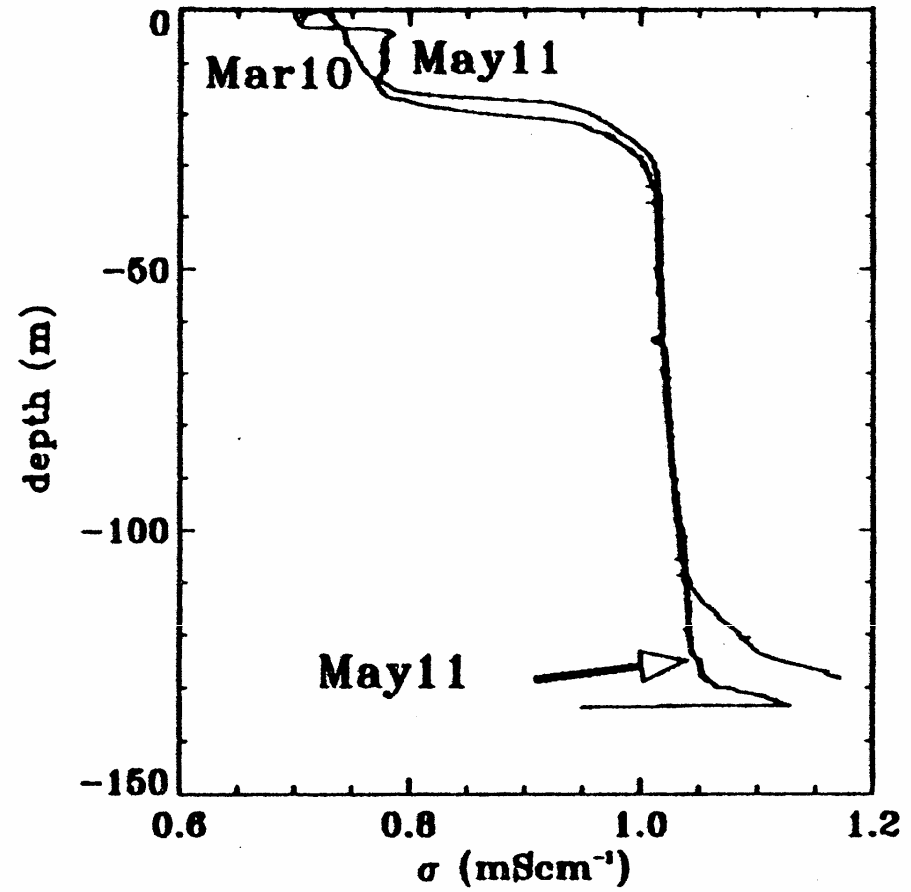
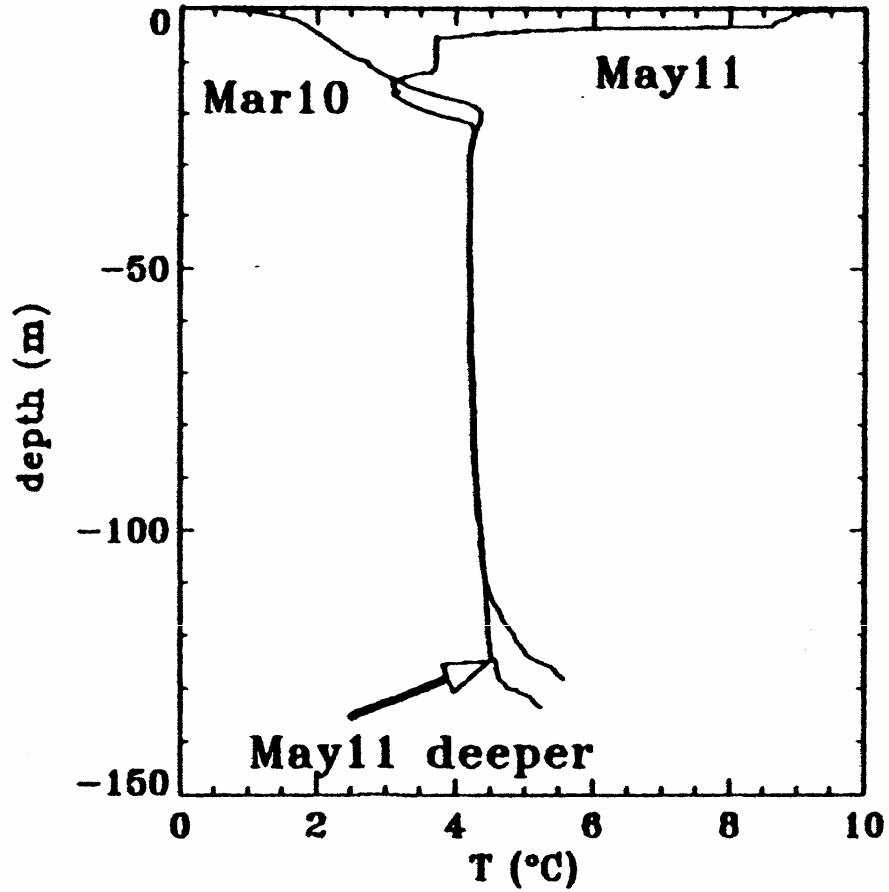
ZOOM ON DEEP:



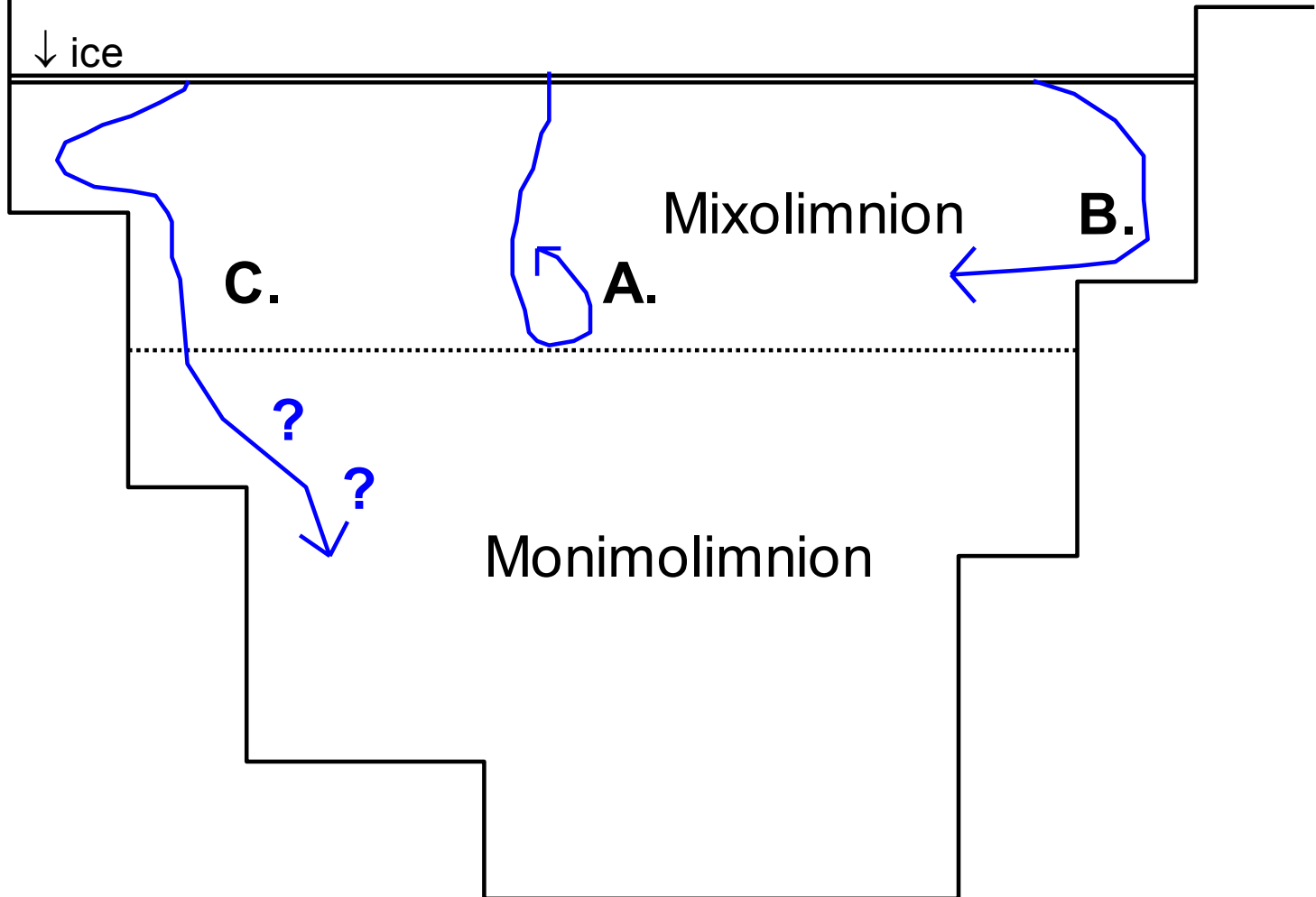
ZOOM ON DEEP:



Brenda



Salt expelled from ice



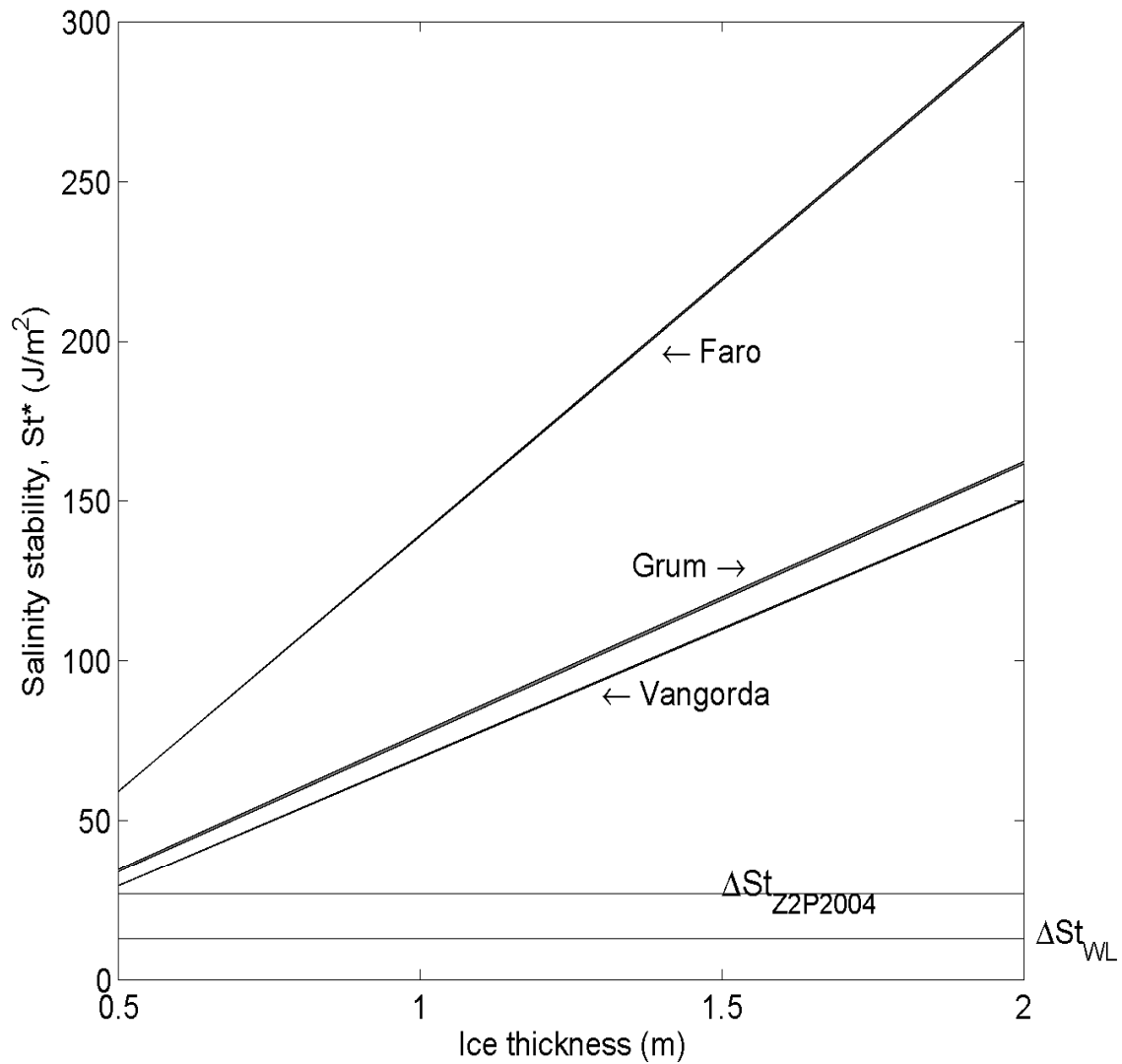
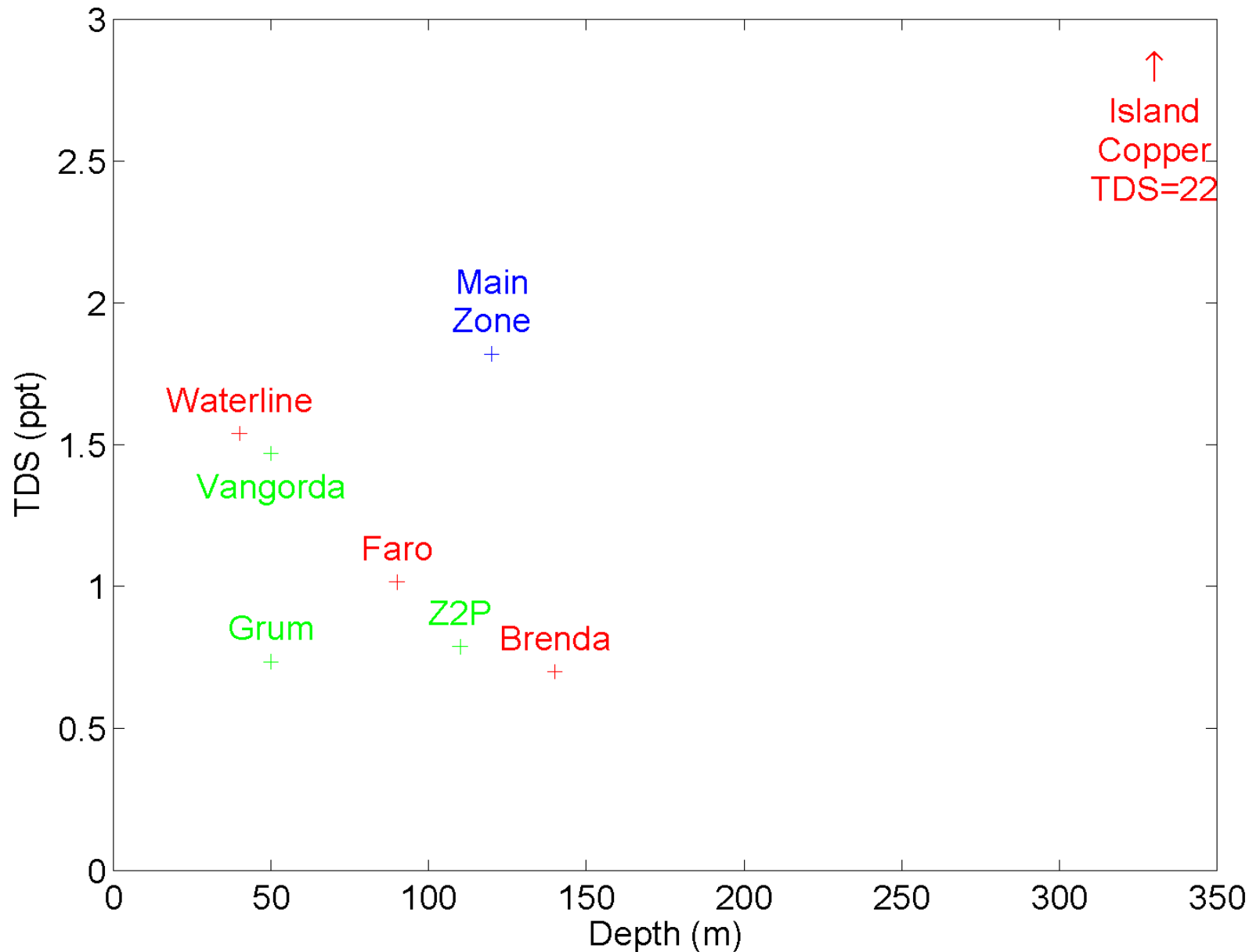


Figure 2. Predicted salinity stability at time of maximum heat content, St^* , for Grum, Faro and Vangorda pits with stream water diverted.

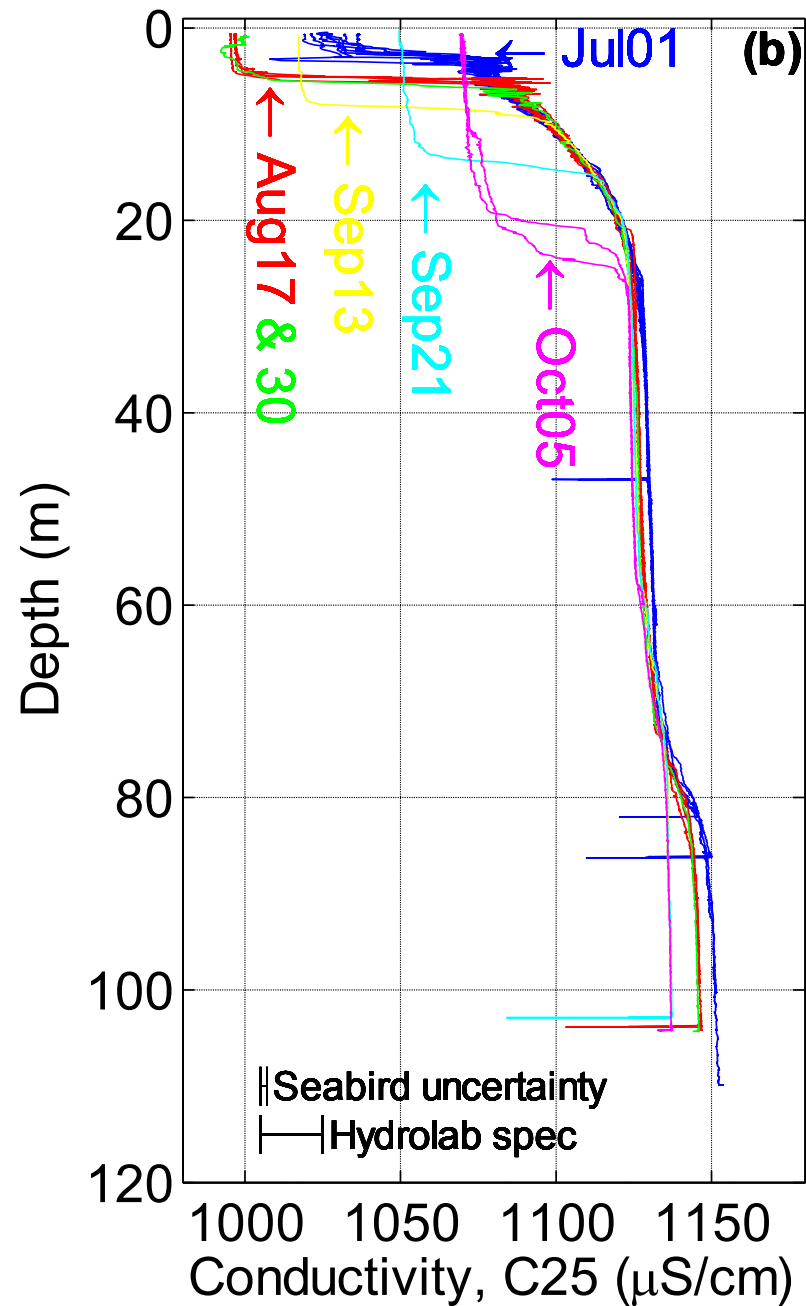
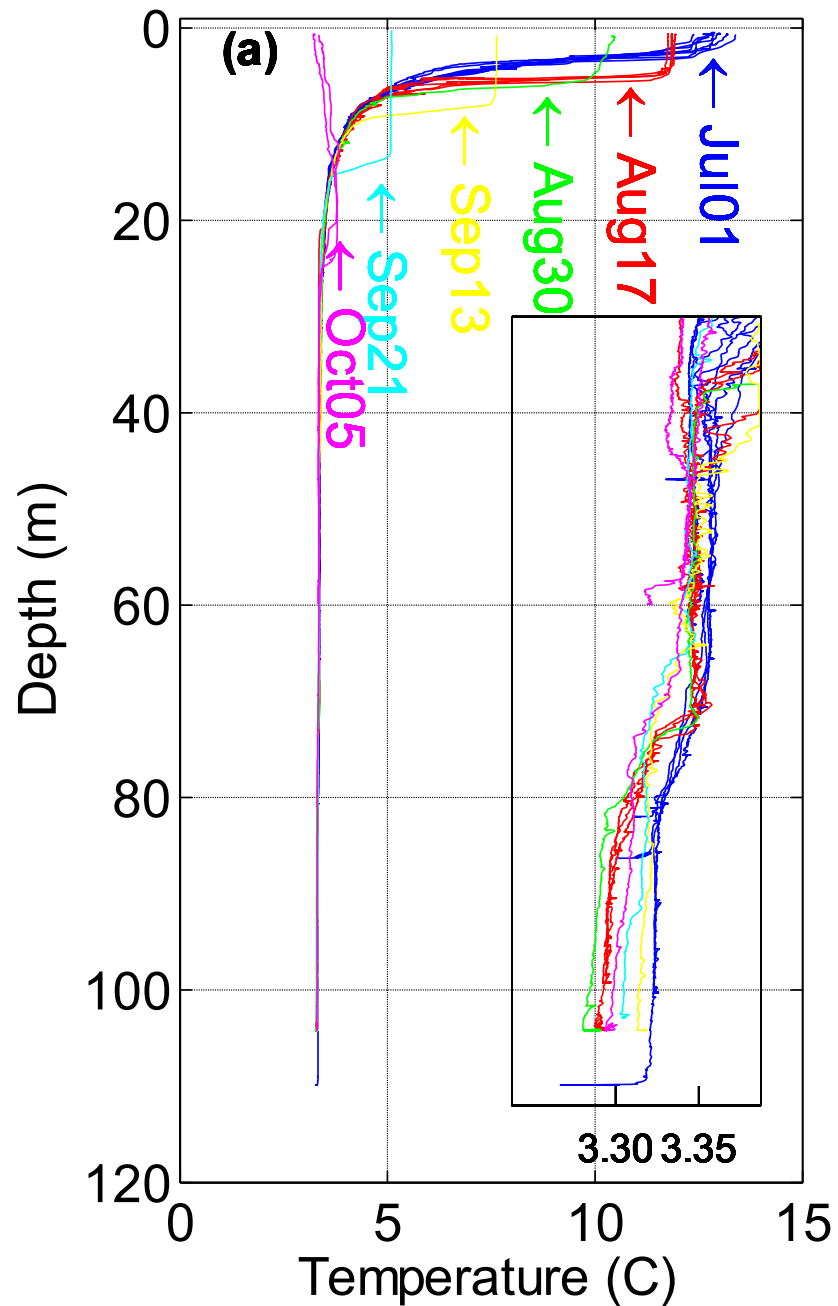
Impact of expelled salt

Pit-Lake	Expelled salt/ C25-deficit	Deep C25 Increase ($\mu\text{S}/\text{cm}$)
Faro	0.09	200
Waterline	0.3	500
Vangorda	0.7	10
Grum	1	7
Z2P	0.7	20

Deep and/or saline lakes not always meromictic



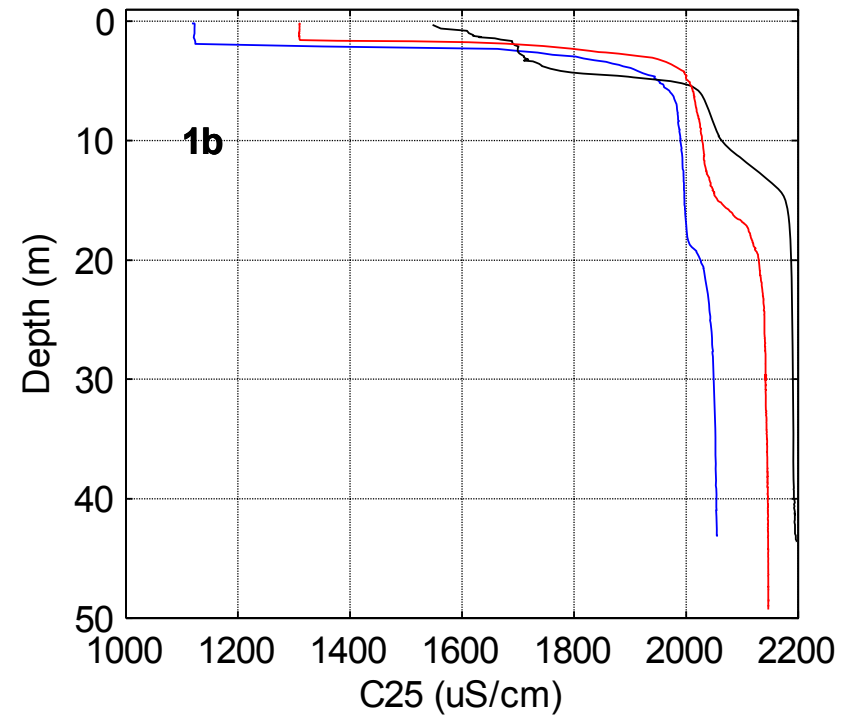
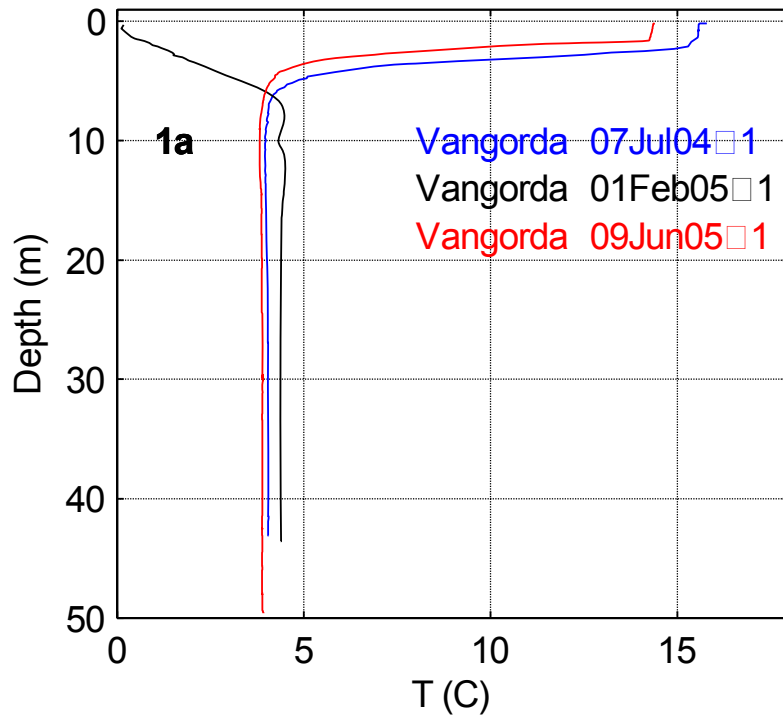
Zone 2 Pit Summer 2004



Vangorda high inflows?



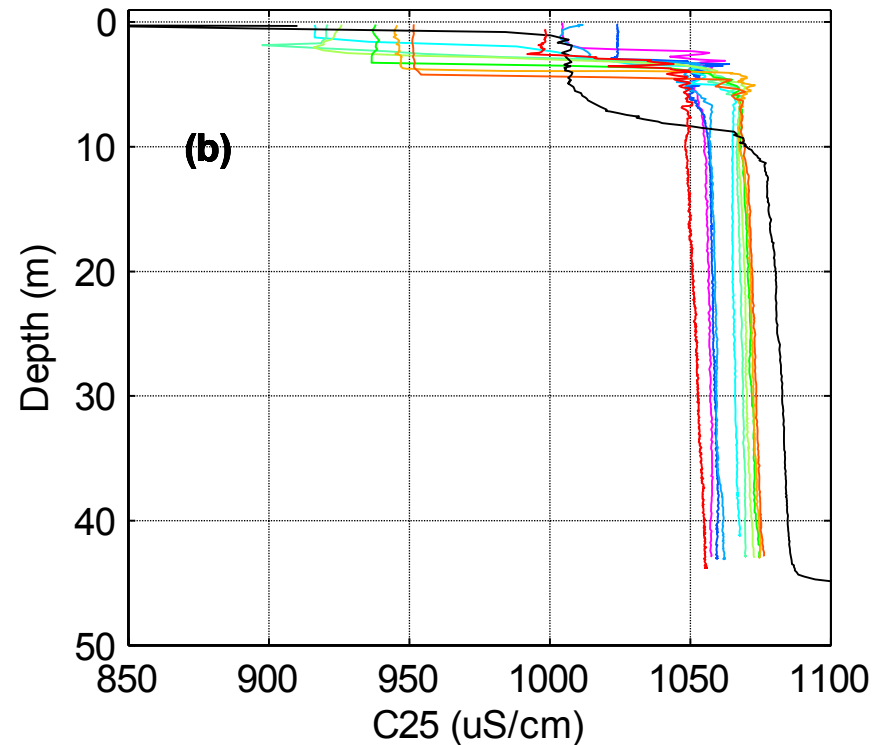
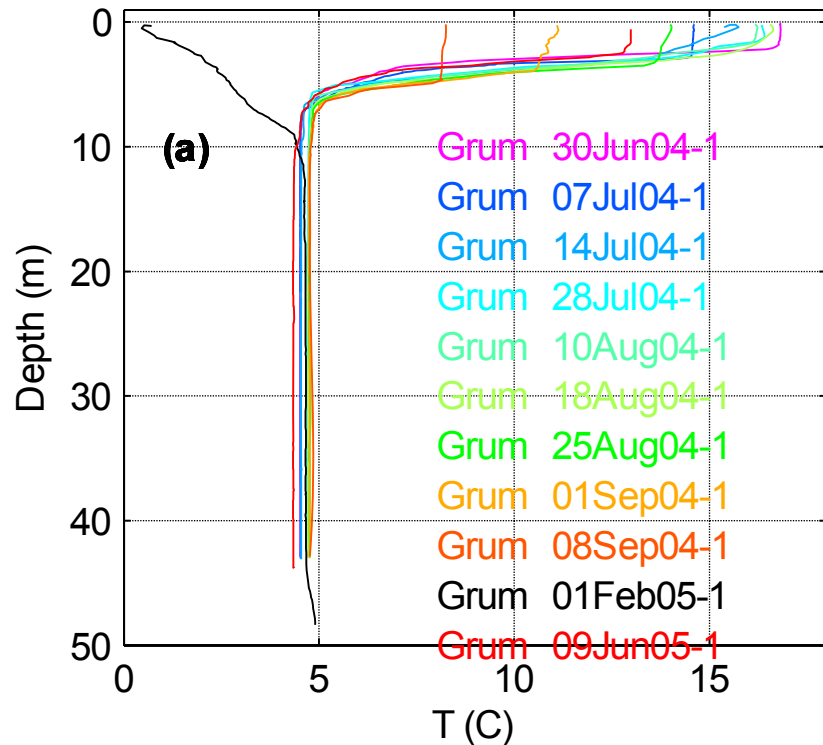
Figure 11 Vangorda Seabird Temperature and Conductivity Profiles, 2004 & 2005



Grum - creep



Figure 6 Grum Seabird Temperature and Conductivity Profiles, 2004 & 2005



CONCLUSIONS

- Several physical factor affect meromixis
- Deep saline lakes candidates for meromixis
- Heating/cooling and wind are always important
- Other factors (salt exclusion, inflows, wall failure, etc) can be very important if present