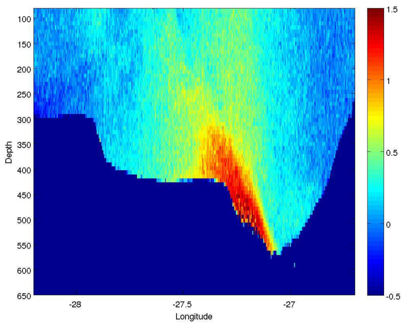
Regionale Ozeanographie

13 – Randmeere des Atlantischen Ozeans

Literatur:

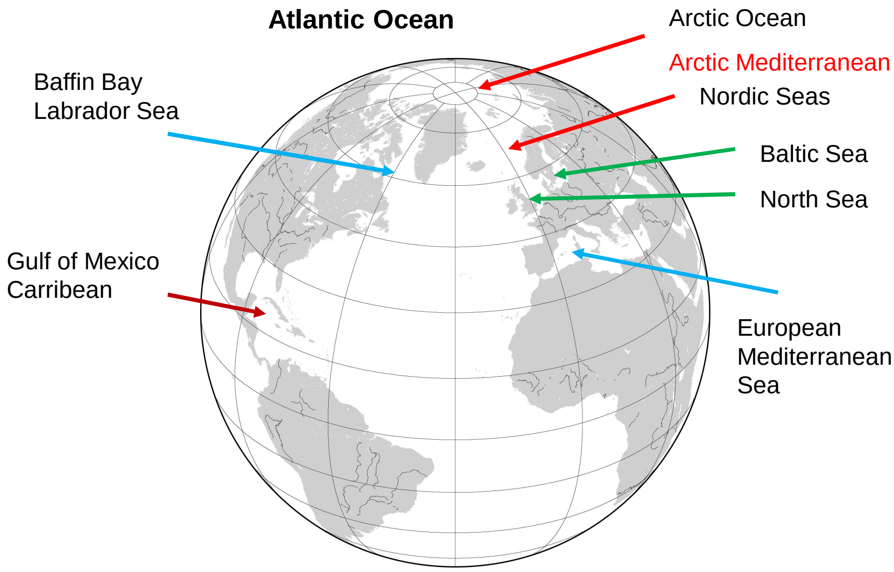
Tomczak, M. and S.Godfrey (2002): Regional Oceanography: An Introduction.

Kostenloser download unter *http://www.es.flinders.edu.au/~mattom/regoc/pdfversion.html*



Denmark Strait Currents

Mediterranean seas



Mediterranean seas

Thermohaline forcing

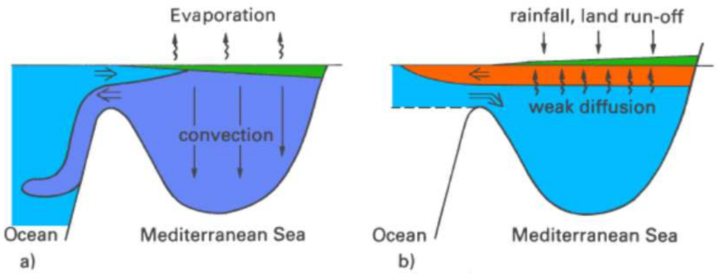


Fig. 7.1. Schematic illustration of the circulation in mediterranean seas; (a) with negative precipitation - evaporation balance, (b) with positive precipitation - evaporation balance.

Tomczak & Godfrey, 2005

Arctic Mediterranean bathymetry

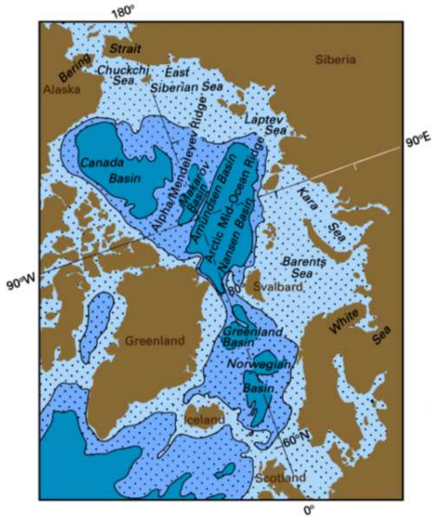


Fig. 7.2. Bottom topography of the Arctic Mediterranean Sea. The 1000, 3000, and 5000 m isobaths are shown, and regions less than 3000 m deep are shaded. Sv: Svalbard island group.

& Godfrey, 2005

Arctic meteorology

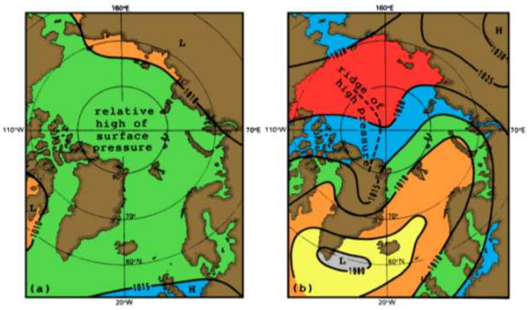


Fig. 7.3. Air pressure (hPa) at sea level over the Arctic Mediterranean Sea. (a) July mean, (b) January mean, both for the period 1950 - 1980. Data from University of East Anglia (1992).

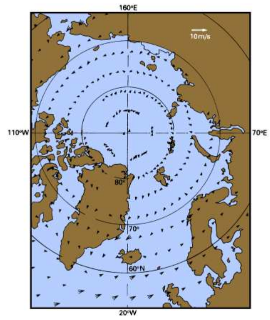


Fig. 7.4. Surface winds over the Arctic Mediterranean Sea.

(a) annual mean,

(b, page 87) July mean,

(c, page 87) January mean. See Figure 1.2 for data sources.

Tomczak & Godfrey, 2005

Arctic surface circulation

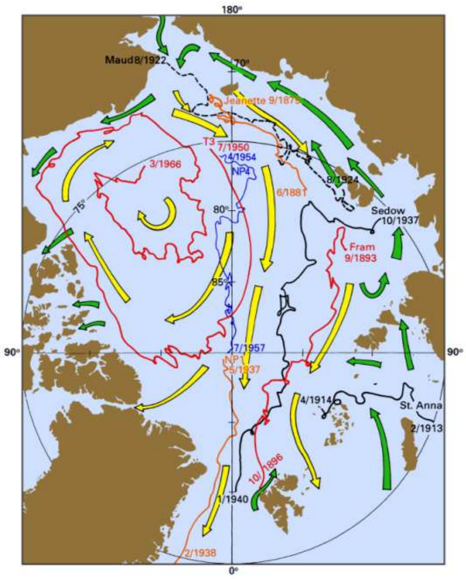


Fig. 7.5. Mean circulation of surface waters, with some tracks of vessels and ice stations.

Tomczak & Godfrey, 2005

Sea ice cover

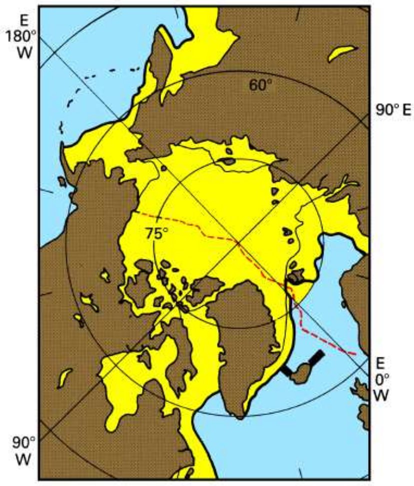
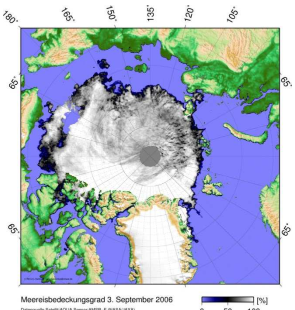


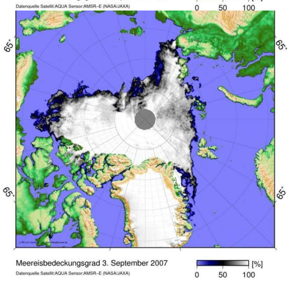
Fig. 7.6. Ice coverage in the Arctic ocean, based on satellite data from 1974 - 1976. The thick line shows the extent if sea ice in late winter (March), the thin line the ice extent in late summer (September). The heavy bars near Iceland give the southern ice limit during March 1968; they are included to indicate the degree of interannual variability. The broken line shows the location of the section shown in Fig. 7.8.

Tomczak & Godfrey, 2005

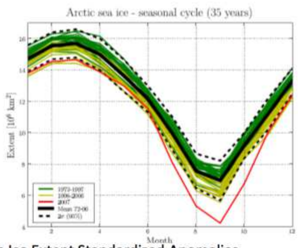
Ice coverage

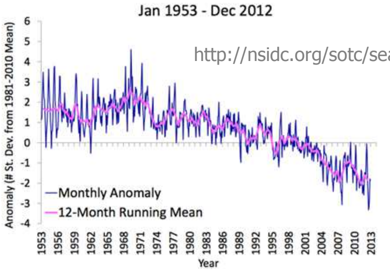


2006



2007





http://nsidc.org/sotc/sea_ice.html

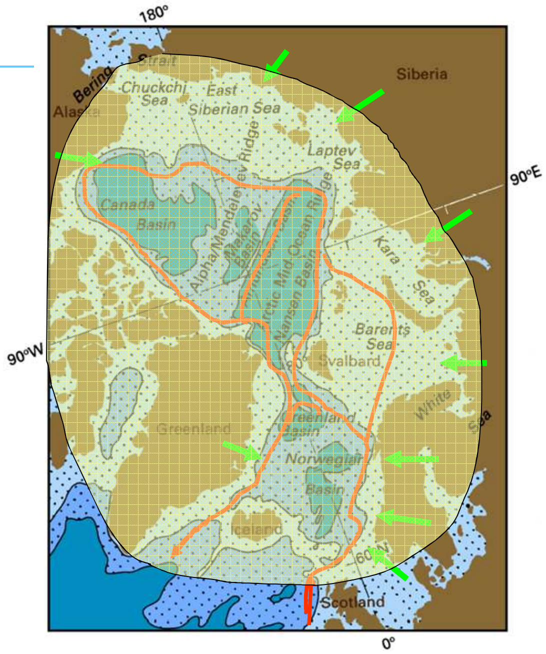
L. Kaleschke

Circulation & forcing

Spreading of Atlantic Water, cyclonic wind forcing

Freshwater input

Cooling



Arctic hydrography

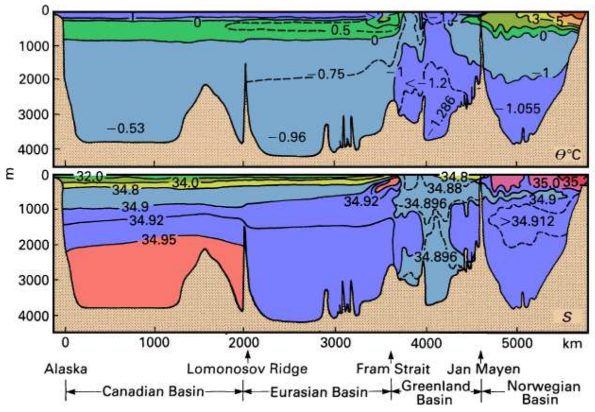


Fig. 7.8. Potential temperature and salinity along a section from the Norwegian Sea into the Canada Basin. The penetration of Atlantic Water - from the surface in the Norwegian Sea to the depth range between Surface and Bottom Water - is indicated by the temperature and salinity maxima near 500 m depth. Note that the temperature and salinity increments between isotherms and isohalines are not constant over the respective ranges. See Fig. 7.6 for location of the section. From Aagaard *et al*. (1985b).

Tomczak & Godfrey, 2005

Arctic hydrography

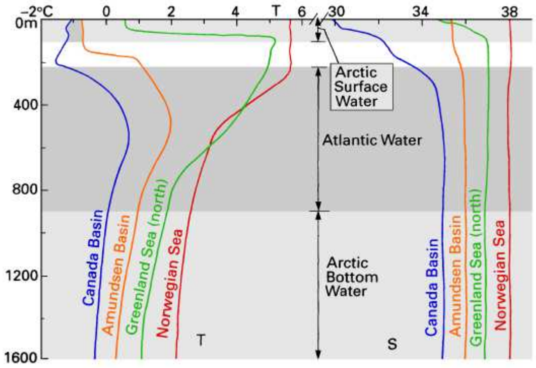


Fig 7.7. Temperature (T °C) and salinity (S) profiles in the Arctic Mediterranean Sea. The scale is correct for the Canada Basin; other profiles are offset by 1 unit from each other. Arctic Surface Water is not present in the Norwegian Sea, where inflow of Atlantic Water extends to the surface. From Coachman and Aagaard (1974) and Osborne *et al*. (1991).

Tomczak & Godfrey, 2005

Arctic hydrography

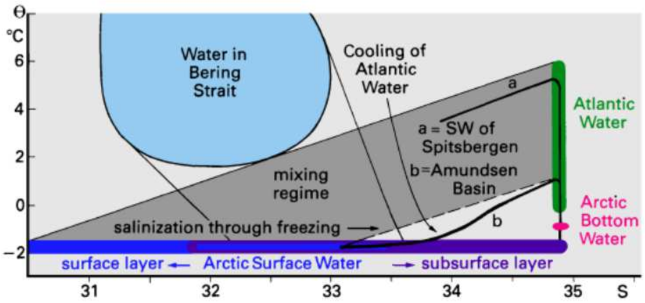
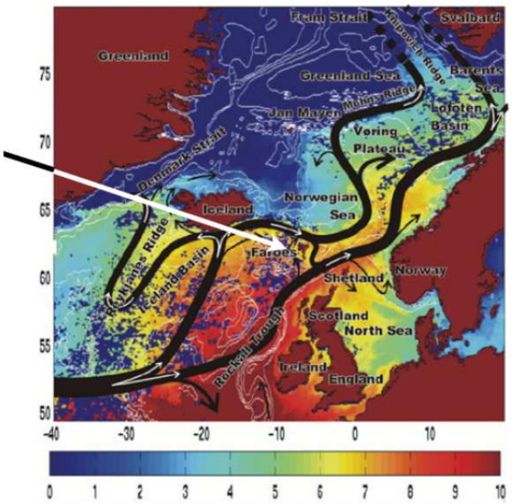


Fig. 7.11. T-S diagram of the Arctic Mediterranean Sea, showing the T-S properties of the water masses and two examples of station data (curves *a* and *b*). The hatched areas give T-S properties of source water masses; the thin lines limit the regions of all possible and observed T-S combinations produced by mixing. T-S curves from individual stations such as curves *a* and *b* generally follow straight mixing paths within the delineated range. Cooling of Atlantic Water through mixing with Surface Water of the subsurface layer is indicated by the departure of the T-S curve from a straight mixing line in the Amundsen Basin.

Tomczak & Godfrey, 2005

Atlantic Water inflow



Hansen & Østerhus, 2000

Atlantic Water in the Arctic

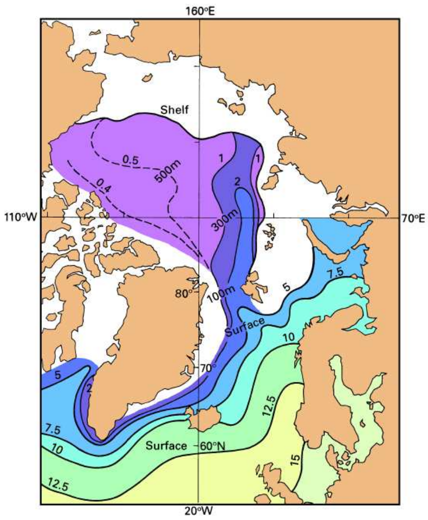


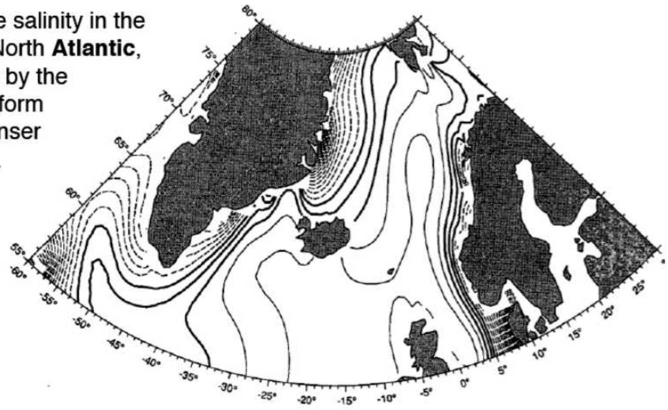
Fig. 7.10. Temperature (°C) at the depth of the temperature maximum caused by inflow of Atlantic Water during summer. Approximate depths are indicated.

Tomczak & Godfrey, 2005

Background stratification

Too fresh to convect : $S < 34.2$ psu
Salty enough with new criteria, not with old...
Salty enough to convect : $S > 34.7$ psu

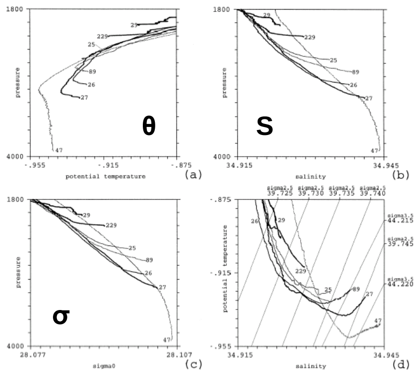
Wintertime salinity in the northern North **Atlantic**, contoured by the criteria to form waters denser than 28 σ.



Prater, 2005

Convection

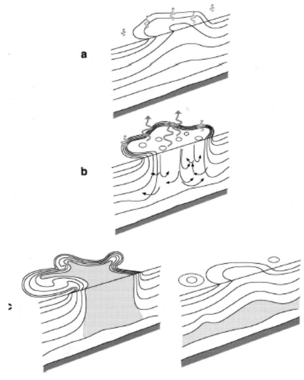
Shelf slope convection



Dense water formation on shelves
sinking down continental slopes
entrainment of ambient water

Rudels et al., 2000

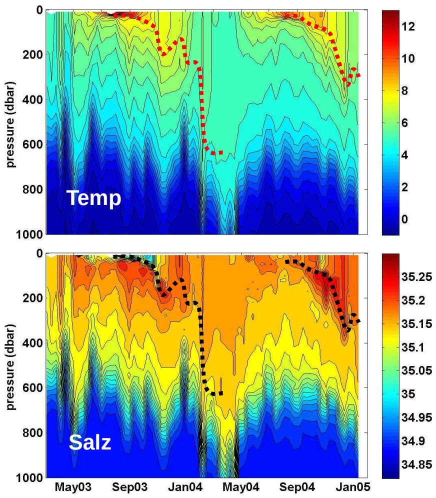
Open ocean convection



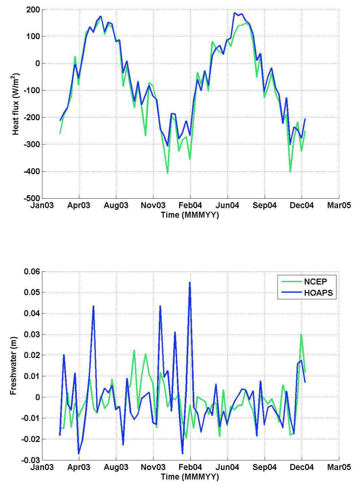
Dense mixed layer
penetrative & non-penetrative plumes
entrainment of ambient water
eddy formation

Marshall and Schott, 1999

Convection



Mixed layer deepening



Air-sea fluxes

Overflows

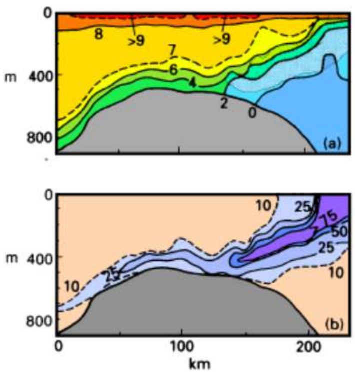


Fig. 15.8. A section across the Iceland-Scotland Ridge 150 km northwest of the Faroe Islands showing the spreading of Arctic Intermediate Water.
(a) Temperature (°C), with the region of low salinity (<34.9) shaded;
(b) presence of Arctic Intermediate Water (percentage of volume).
Adapted from Meincke (1978).

Hansen & Østerhus, 2000

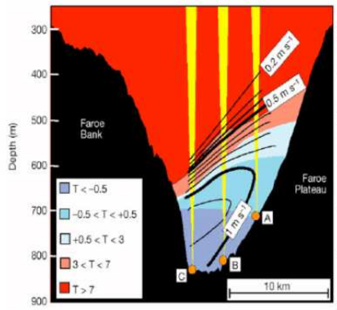
Faroe Bank Channel overflow

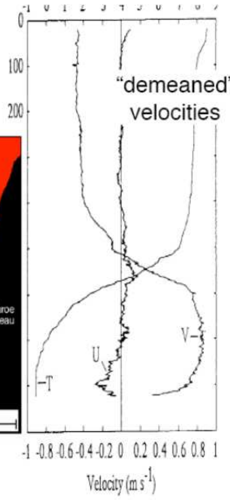
Direct velocity measurements from ADCPs and XCPs show the maximum velocities through the Channel to be confined to near the bottom, with the "thermocline" above.

Peak velocity of ~ 1.0–1.2 m/s.

Maximum temperature gradient of 7°C in 100 m.

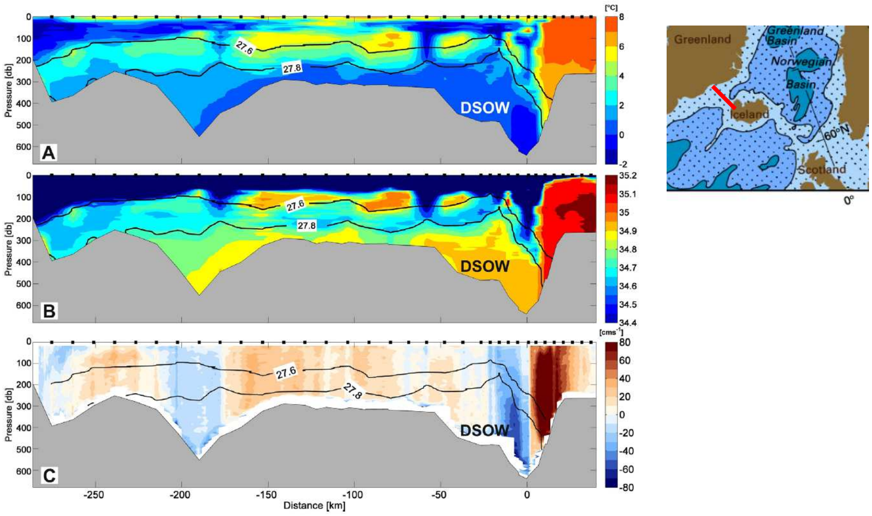
Cold water transport is about 1.5–2.0 Sv.





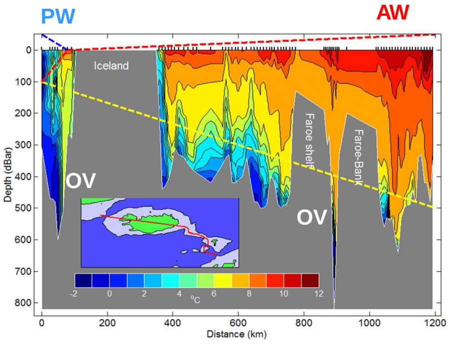
Hansen & Østerhus, 2000

Denmark Strait overflow



Jochumsen et al., 2014

Exchange across the GSR

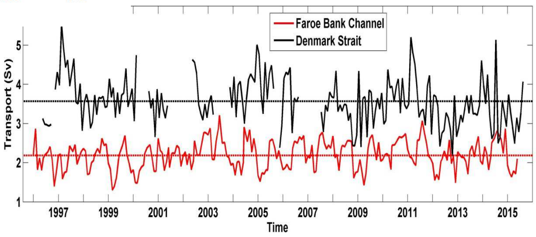


Temperature distribution

AW – Atlantic Water ~ 8 Sv
PW – Polar Water ~ 2 Sv
OV – Overflow Water ~ 6 Sv

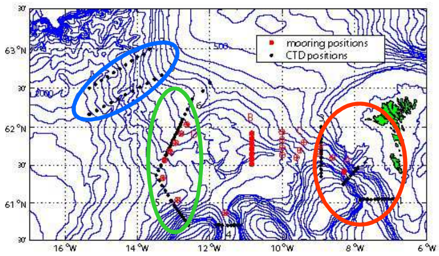
Observed overflow transports

DSO – Denmark Strait
FBC – Faroe Bank Channel



FBC large scale mixing

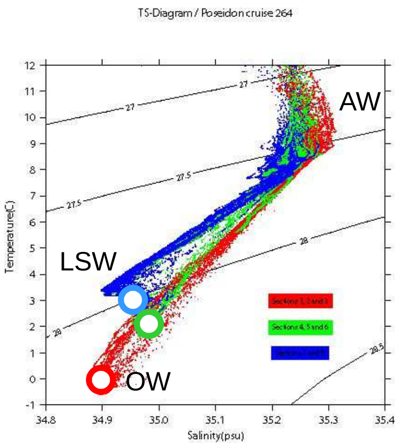
observations



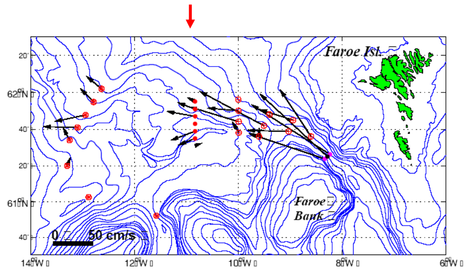
West
Central
Channel

OW Overflow Water
LSW Labrador Sea Water
AW Atlantic Water

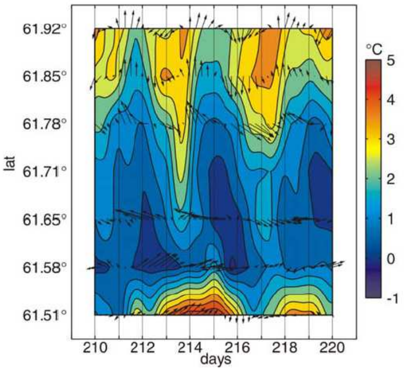
Temp – Sal diagramme



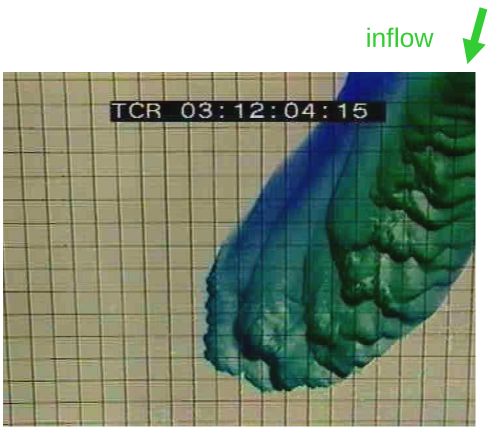
Faroe Bank Channel: Downstream flow



Eddy formation downstream of channel's exit, 3-5 d

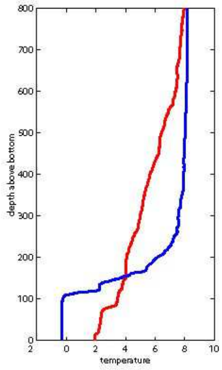


Mixing at interface



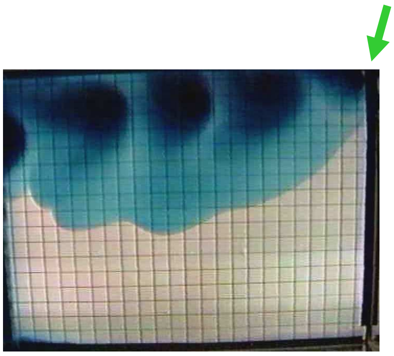
Rotating table plume experiment
strong density contrast

Plume temperature *in-situ*



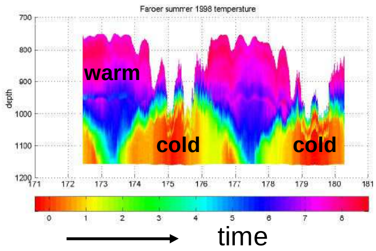
Diapycnal mixing requires K_z ~10^{-2} m^2/s

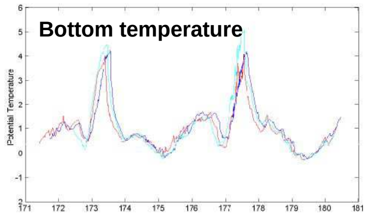
Stirring through eddies



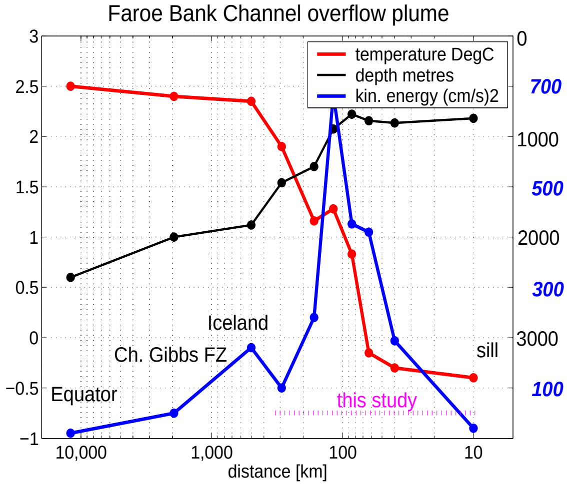
Rotating table plume experiment
weak density contrast

Mooring data in plume



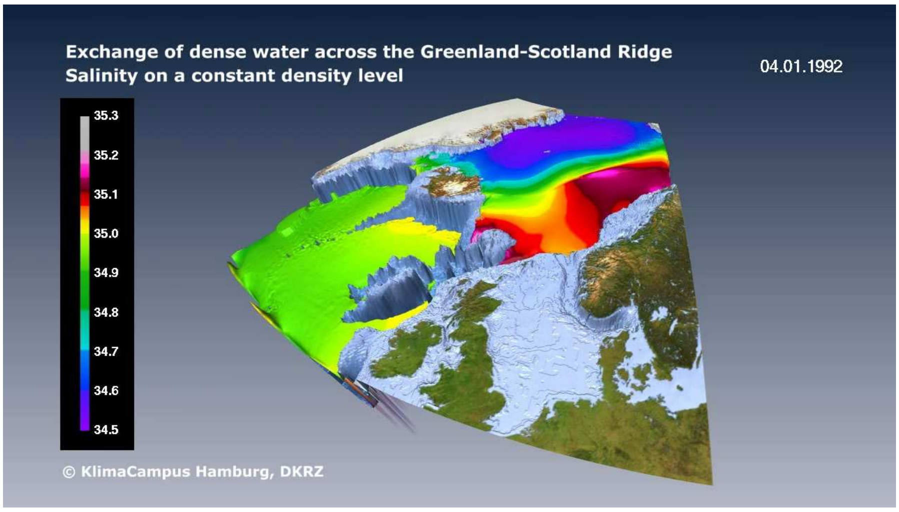


Faroe Bank Channel: Downstream mixing



- Strong vertical shear in the channel
- Cross circulation in the channel
- Stirring through eddies
  $A_H \sim 10^2\ m^2/s$

Overflow movie



Labrador Sea

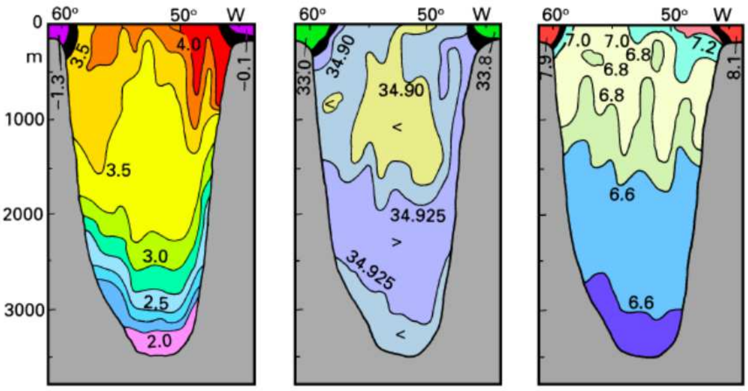
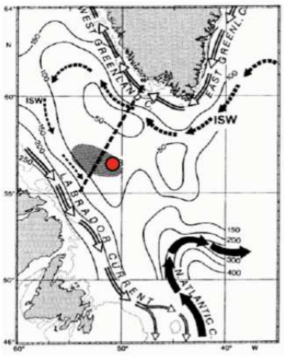


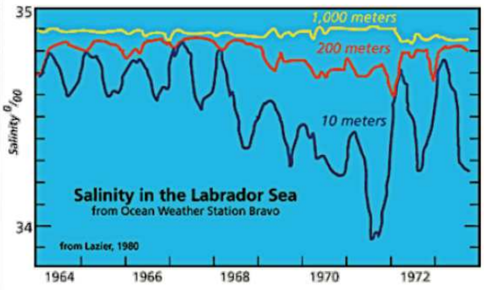
Fig. 15.3. A section through the southern Labrador Sea along approximately 60°N. (a) temperature (°C), (b) salinity, (c) oxygen (ml/l). Data from Osborne *et al*. (1991).

Tomczak & Godfrey, 2005

Great salinity anomaly

The surface salinity in a region can sometimes vary significantly from its typical climatological values. For example, in the Labrador Sea, a “Great Salinity Anomaly” was observed in the late 1960s to early 1970s.

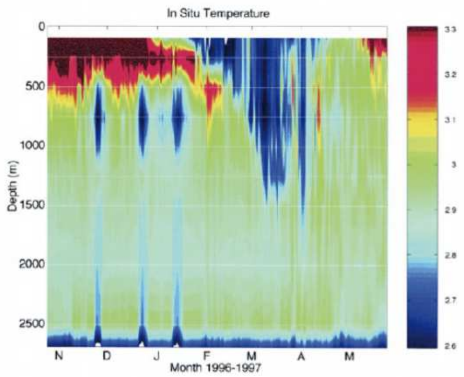




Prater, 2005

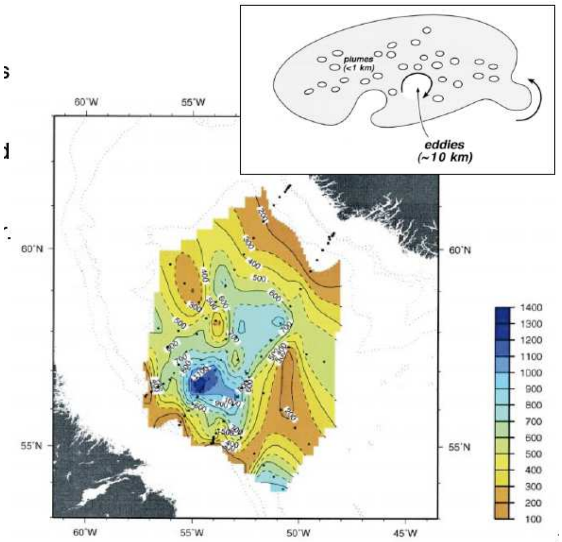
Labrador Sea convection

A time-series from a mooring near *Ocean Station Bravo* in the Labrador Sea, showing the cooling of the surface waters, the deepening of the mixed layer, and the restratification. Note the cold and warm isolated features -> eddies.



Prater, 2005

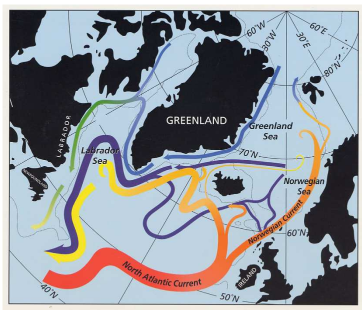
Labrador Sea convection



Prater, 2005

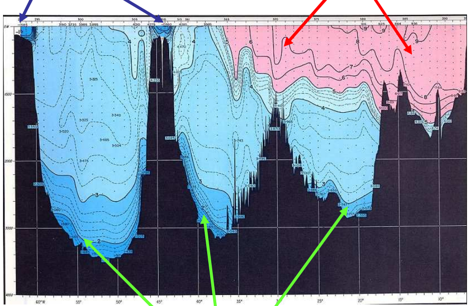
Downstream flow

McCartney, 1997



Polar outflow

Warm Inflow



Labrador *Scotland*

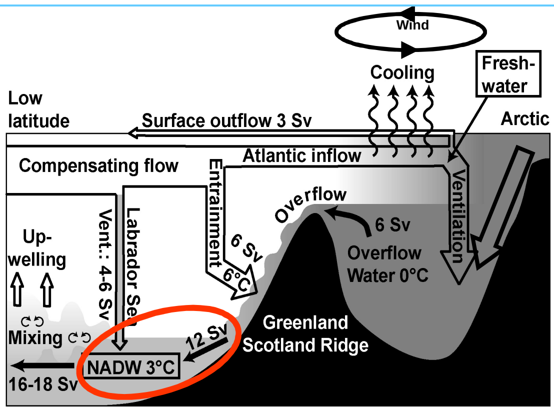
Deep outflows

Deep flows

Shallow flows

Vertical distribution of temperature at ~60°N

Northern AMOC



Arctic Mediterranean presently provides
about 2/3 to NADW at a very stable pace

Eurafrican Mediterranean

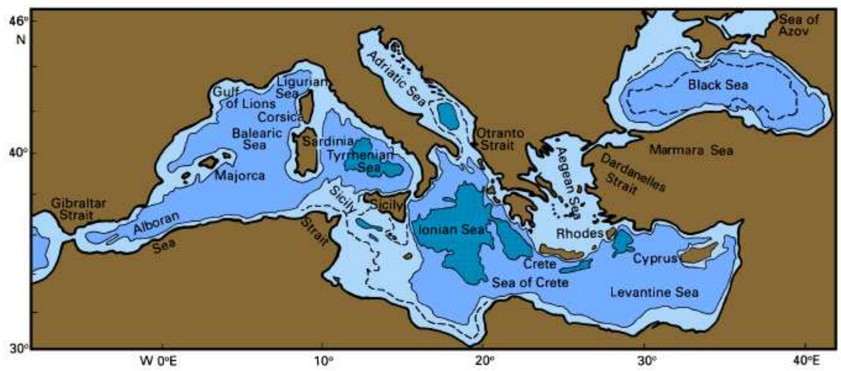


Fig. 16.3. Topography and subdivisions of the Eurafrican Mediterranean Sea. The 1000 m contour is shown, and regions deeper than 3000 m are shaded. The 200 m contour is shown as a broken line where it departs significantly from the 1000 m contour. In addition, the 2000 m contour is shown as a broken line in the Black Sea.

Tomczak & Godfrey, 2005

Surface circulation

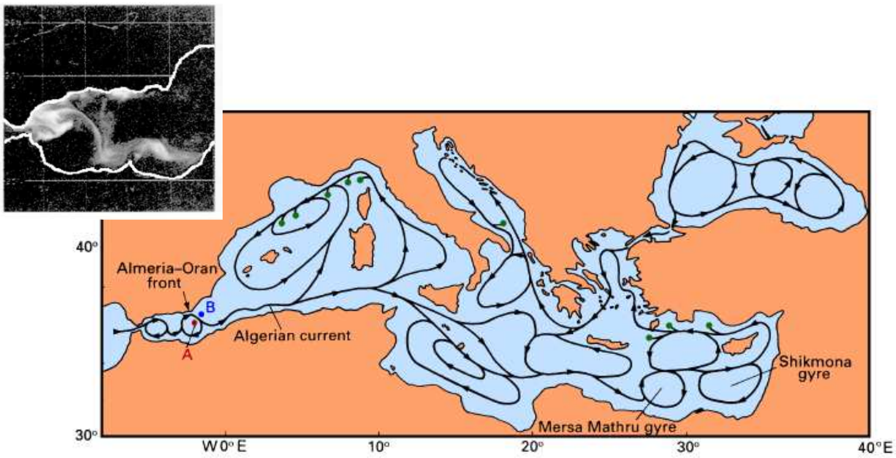


Fig. 16.6. Upper ocean currents in the Eurafrican Mediterranean Sea. Locations marked *A* and *B* in the Alboran Sea refer to the data shown in Fig. 16.5. Dots indicate areas of winter convection.

Tomczak & Godfrey, 2005

Salinity section

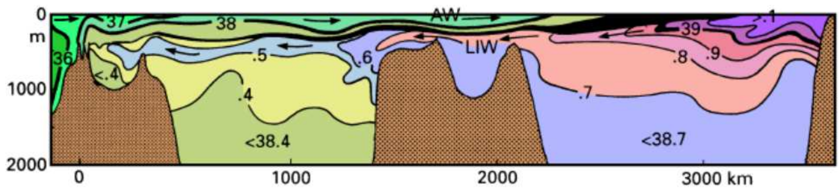


Fig. 16.9. Salinity section along the axis of the Eurafrican Mediterranean Sea. The black region indicates the salinity range 38.4 - 38.5 in the west and 38.4 - 39.1 in the east. Arrows indicate water mass movement; AW: Atlantic Water, LIW: Levantine Intermediate Water. After Wüst (1961).

Tomczak & Godfrey, 2005

Hydrography

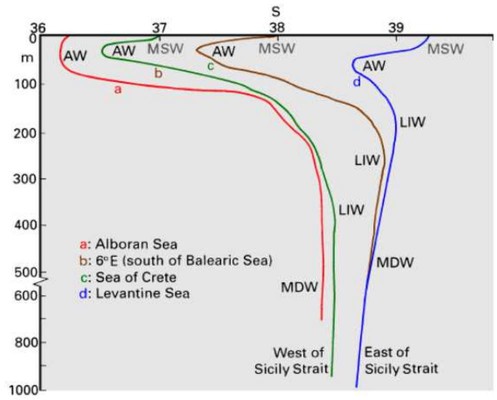


Fig. 16.8. Salinity against depth in the eastern and western Mediterranean Sea. MSW: Mediterranean surface water, AW: Atlantic Water, LIW: Levantine Intermediate Water, MDW: Mediterranean Deep Water. Note the difference in the salinity of MDW east and west of Sicily Strait; evaporation is higher in the eastern Mediterranean Sea, and the sill between Sicily and Tunisia prevents horizontal mixing between the basins.

Tomczak & Godfrey, 2005

Mediterranean outflow Water

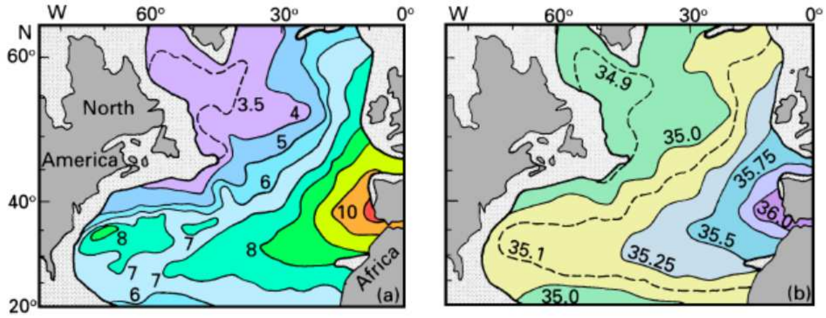
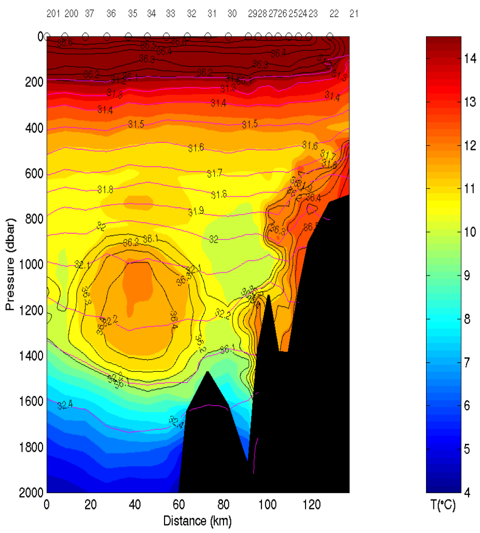
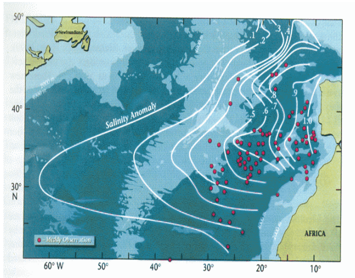


Fig. 15.4. Temperature (°C) (a) and salinity (b) in the North Atlantic Ocean at 1000 m depth.

Tomczak & Godfrey, 2005

Mediterranean eddies





Richardson et al. (2000)

Serra, 2004

Mediterranean eddies

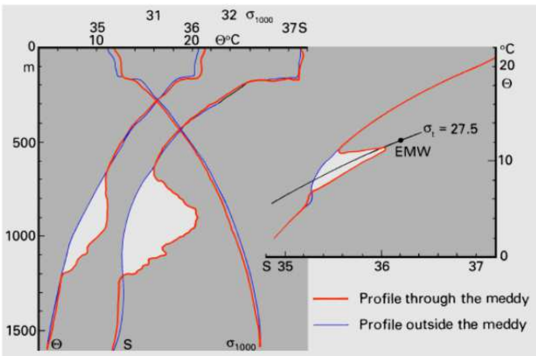


Fig. 15.5. An example of a "meddy", a rotating lens of Mediterranean Water found some 2500 km south-west of the Strait of Gibraltar near 26°N, 29°W. Note that the density profiles inside and outside are nearly identical. (σ_t gives density at atmospheric pressure, σ_{1000} at a pressure equivalent to 1000 m depth.) Adapted from Armi and Stommel (1983).

Tomczak & Godfrey, 2005

American Mediterranean Sea

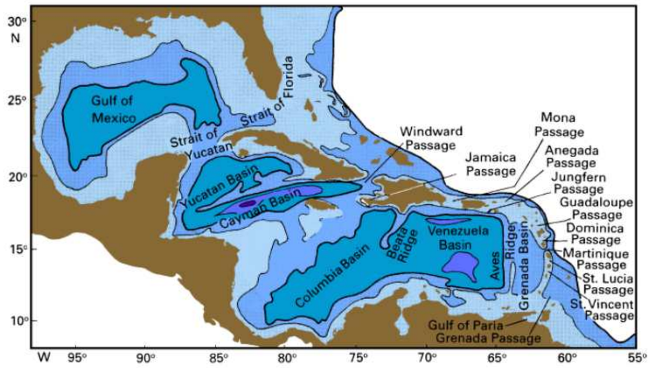
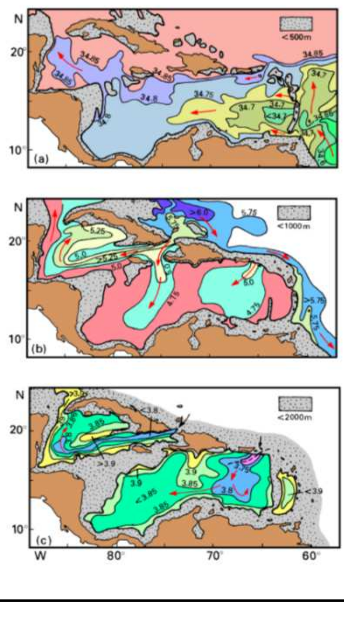


Fig. 16.12. Topography, subdivisions, and major passages of the American Mediterranean Sea. The 1000, 3000, and 5000 m isobaths are shown, and regions less than 3000 m deep are shaded.

Tomczak & Godfrey, 2005

Water renewal

Fig. 16.13 Intermediate and deep water renewal in the basins of the Caribbean Sea. (a) Salinity at the level of the salinity minimum near 700 - 850 m, indicating the path of Antarctic Intermediate Water; (b) oxygen (ml/l) at the level of the oxygen minimum near 2000 m, indicating movement in the upper range of North Atlantic Deep Water; (c) bottom potential temperature (°C), indicating renewal paths for the water in the deep basins. The broken line indicates the location of the section of Fig. 16.14. After Wüst (1963). (The data for (b) were obtained during 1954 - 1958. Data obtained during 1932 - 1937 show oxygen levels higher by 0.3 ml/l in the east and 0.7 ml/l in the west. The indicated flow pattern is the same in both cases.)



Tomczak & Godfrey, 2005

Surface circulation

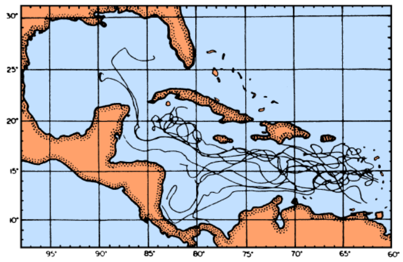


Fig. 16.16. Tracks of 19 satellite-tracked buoys for the period October 1975 - June 1976. From Kinder *et al*. (1985).

Tomczak & Godfrey, 2005

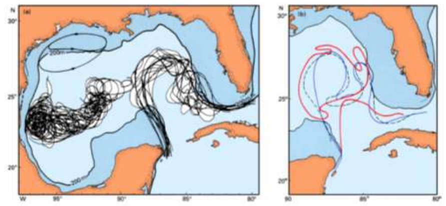
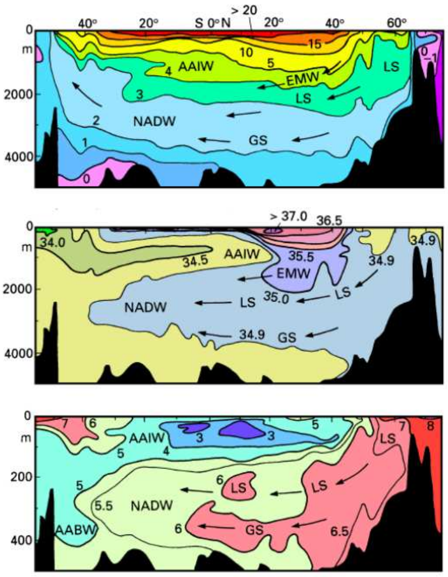


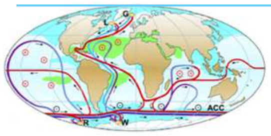
Fig. 16.18. Circulation in the Gulf of Mexico. (a) Mean position of the Loop Current during 1980 - 1984 (heavy line) and positions inferred from satellite observations of sea surface temperature, tracks of satellite tracked drifting buoys indicating eddy movement in the west, and schematic circulation on the northwestern shelf; (b) observed positions of the Loop Current just before (thin and dotted lines) and after eddy shedding (heavy lines). Areas shallower than 200 m are shaded.

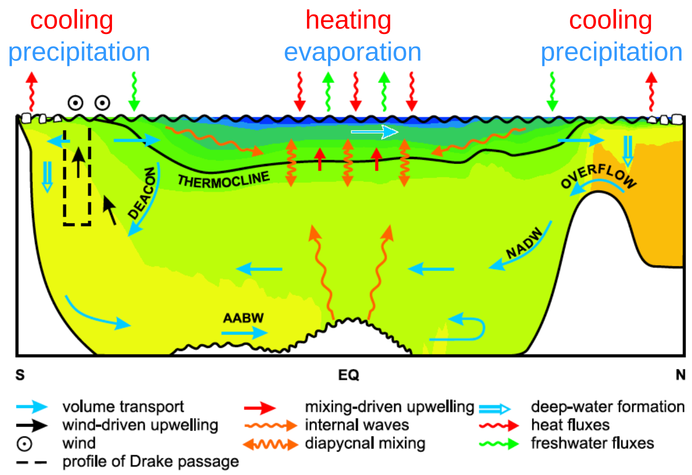
Atlantic overturning circulation



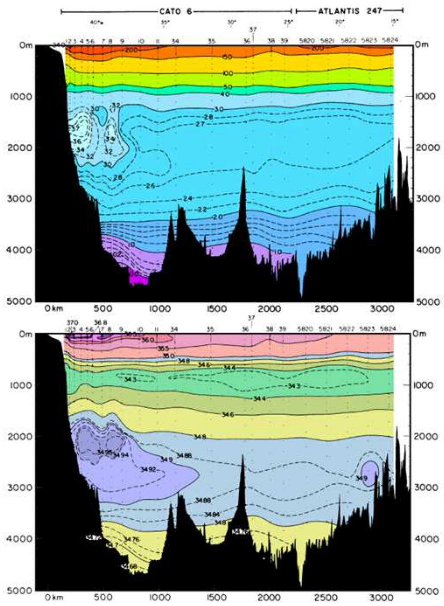
Tomczak & Godfrey, 2005

Ocean circulation (cartoon)





South Atlantic



Tomczak & Godfrey, 2005