SIO 210: Indian Ocean and monsoons (severely condensed)

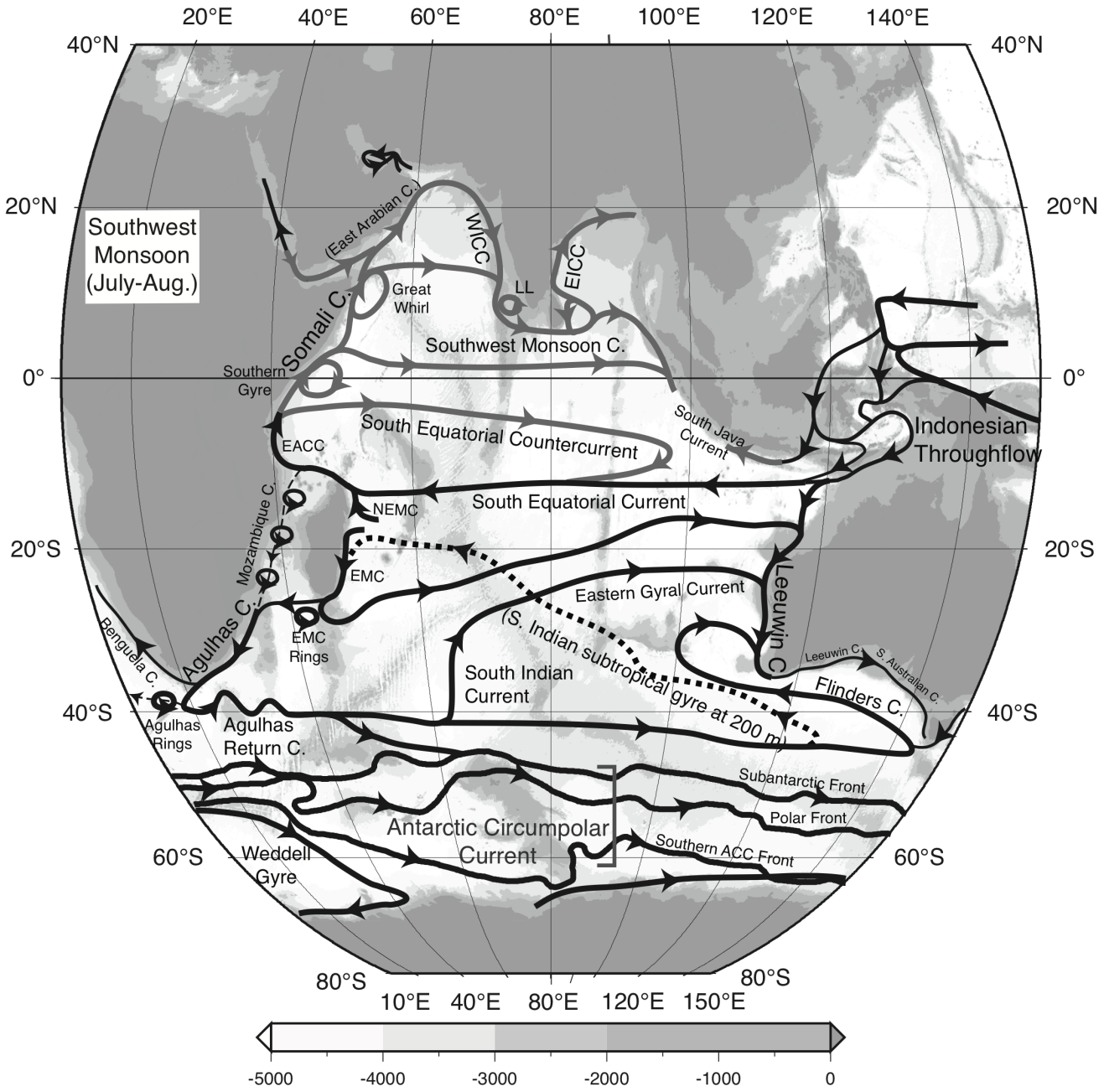
Fall, 2013

L. Talley

- Indian Ocean monsoons & associated circulation
- Indonesian Throughflow
- Subtropical gyre, Agulhas and Leeuwin Currents
- ~~Indian Ocean water masses~~

Reading:
DPO Chapter 11
(11.1, 11.2, 11.4,11.5,11.7, 11.8)

Indian Ocean circulation (mean and SW monsoon)



DPO Fig. 11.1

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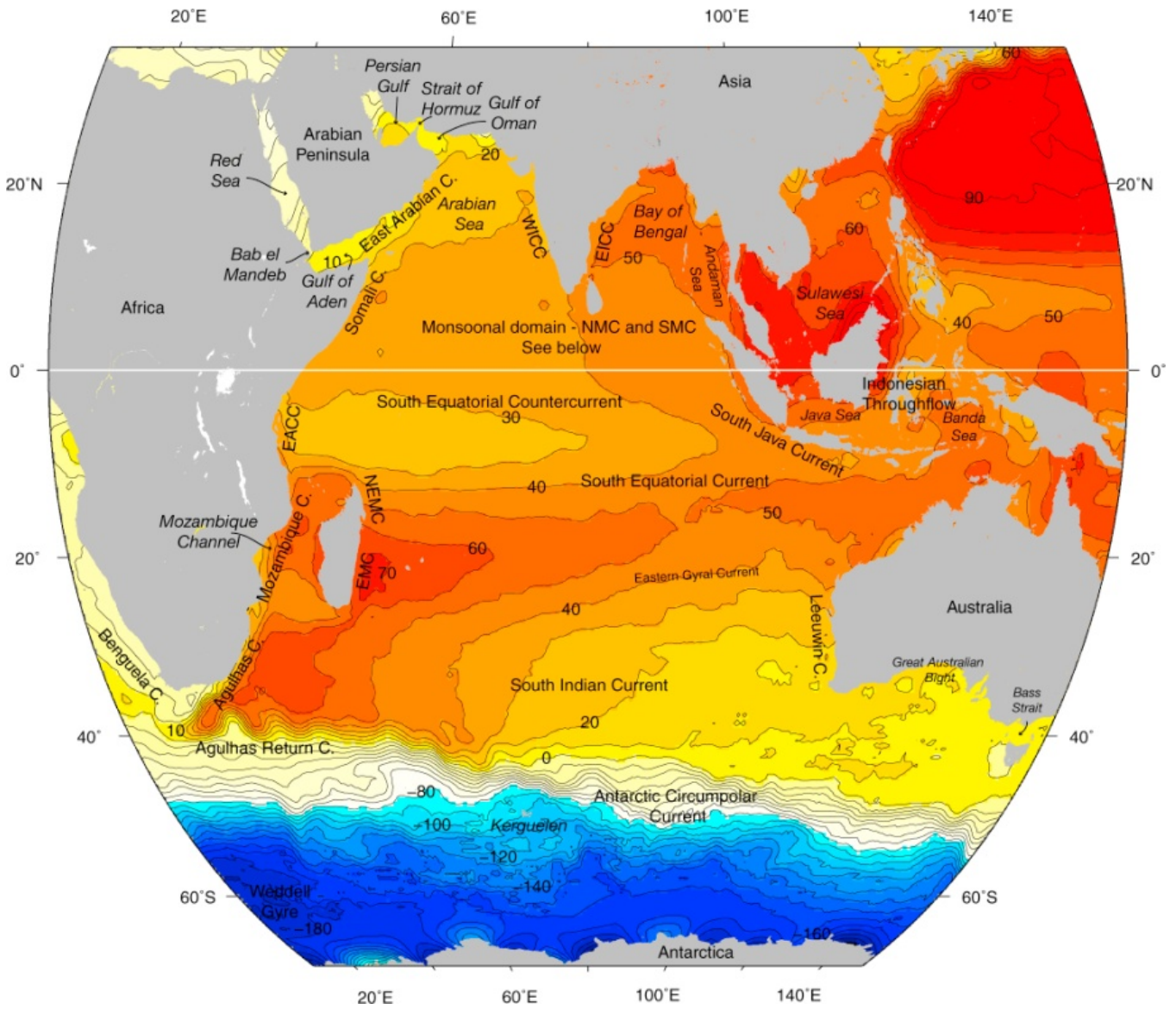
Indian Ocean circulation (mean and SW monsoon)



DPO Fig. S11.1

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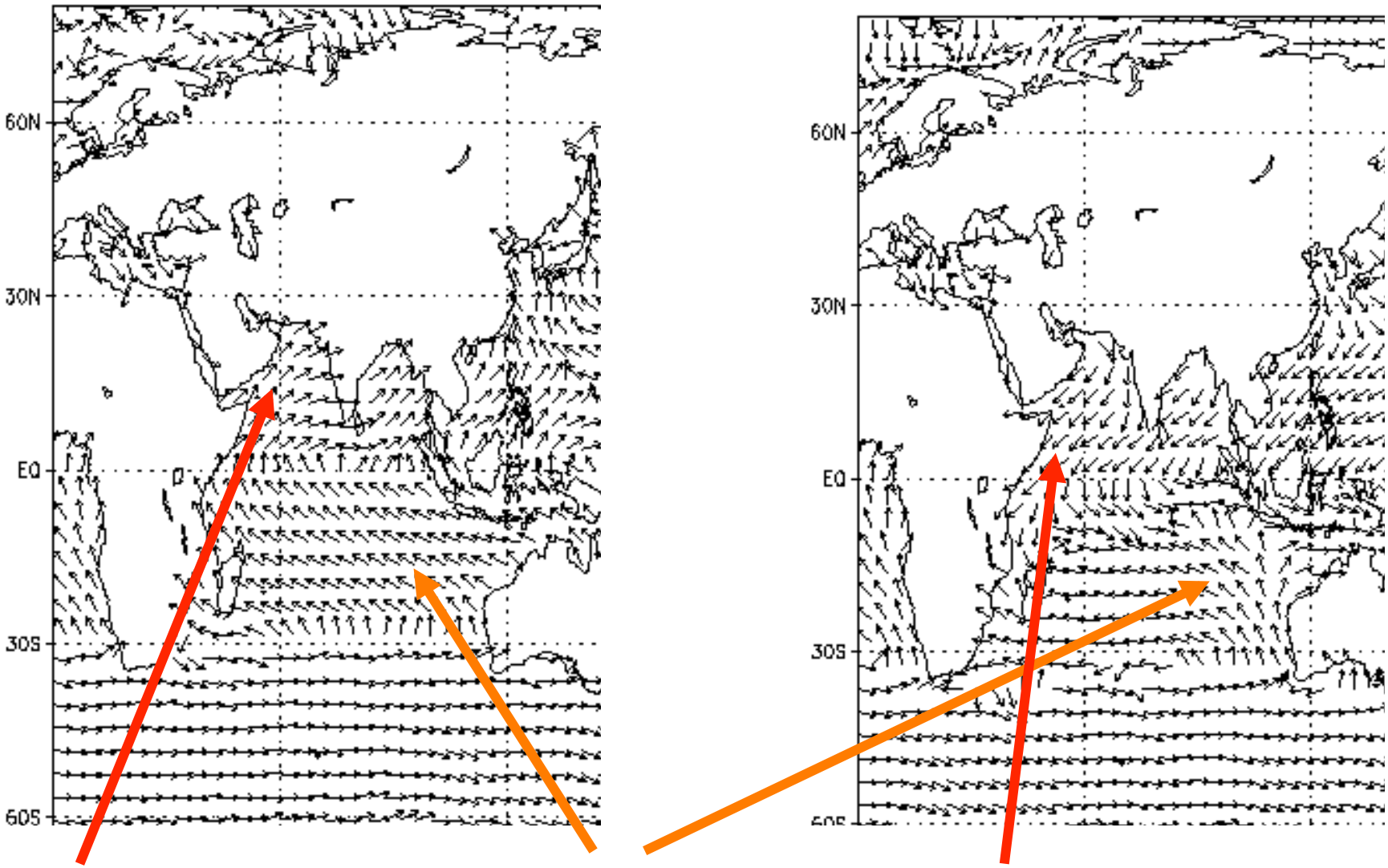
June-August winds
(SW monsoon)

Dec-Feb winds
(NE monsoon)

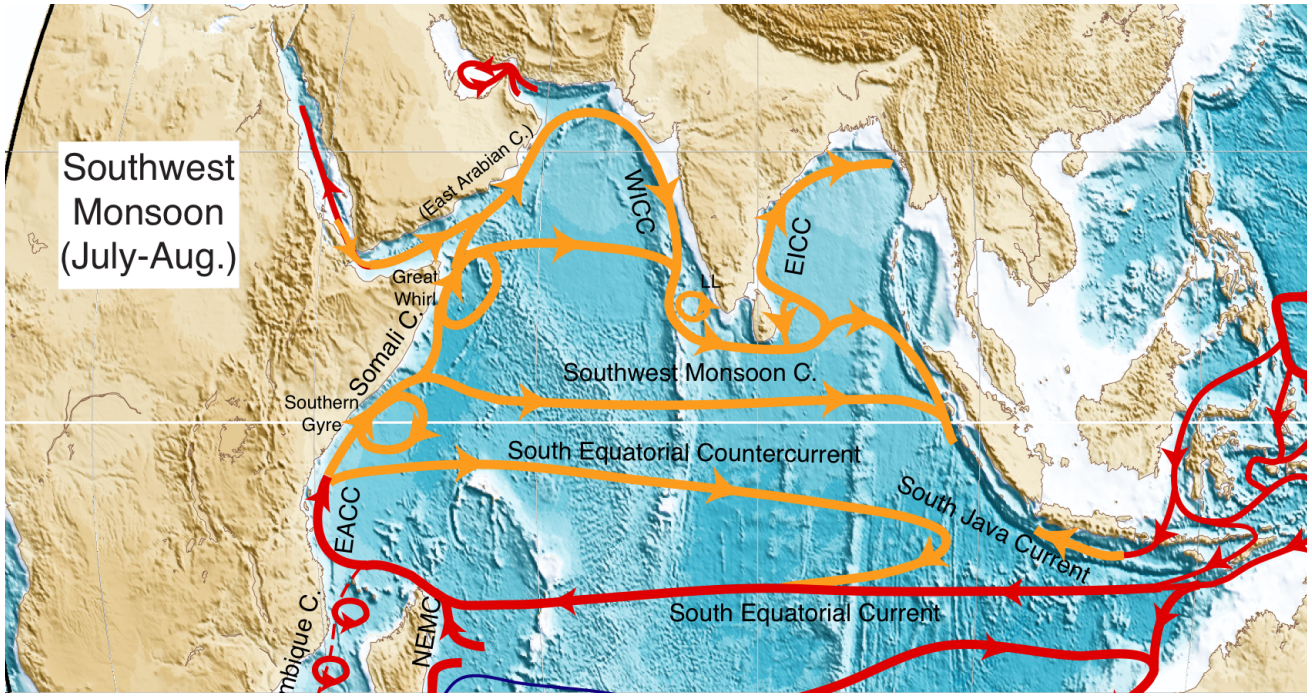


SW monsoon winds

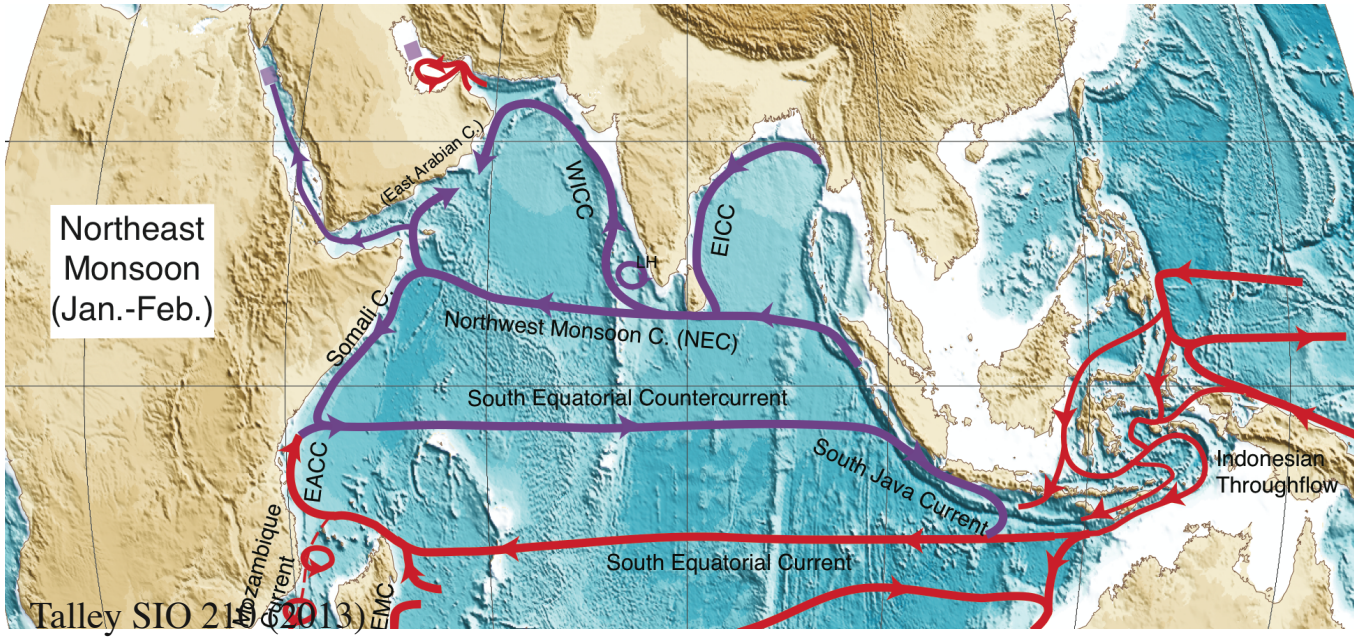
Trade winds

NE monsoon winds

Monsoonal circulation

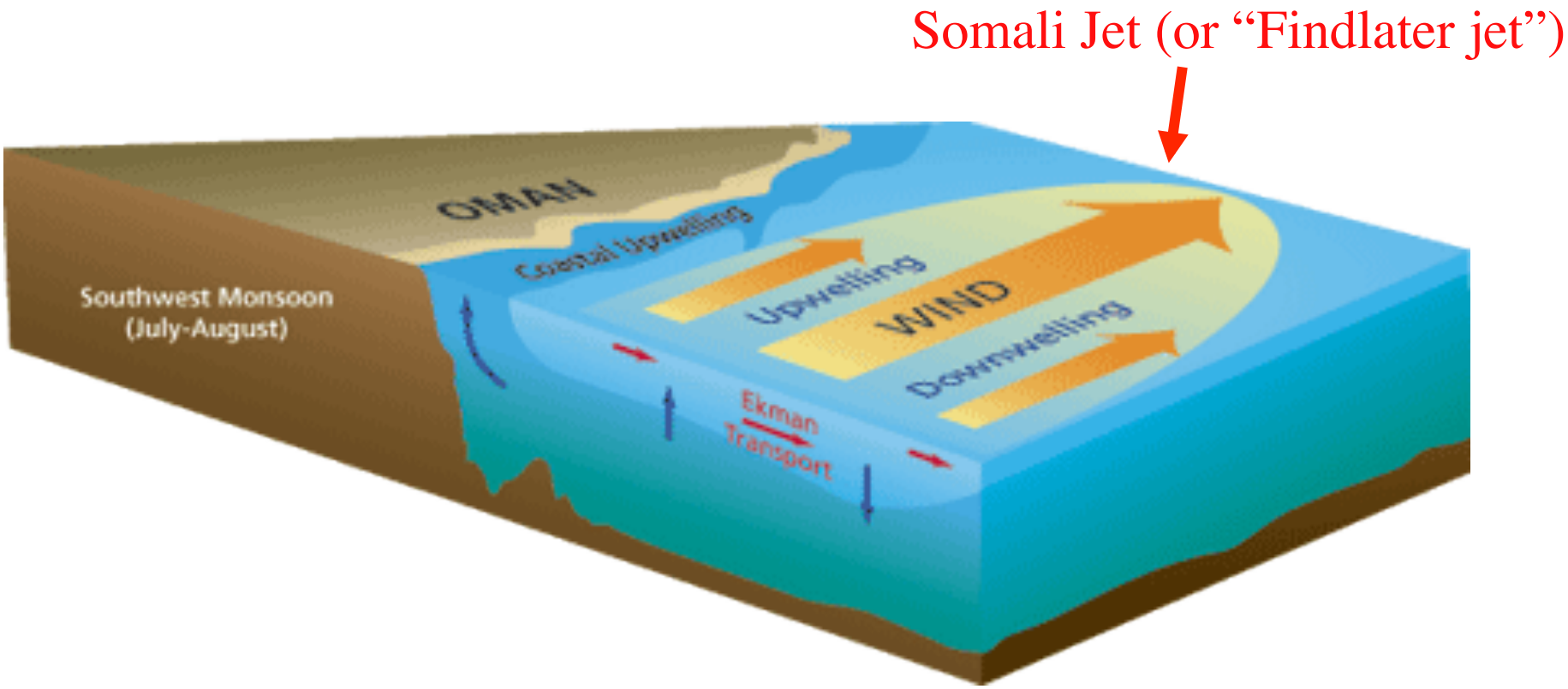


Somali Current (WBC) reverses direction

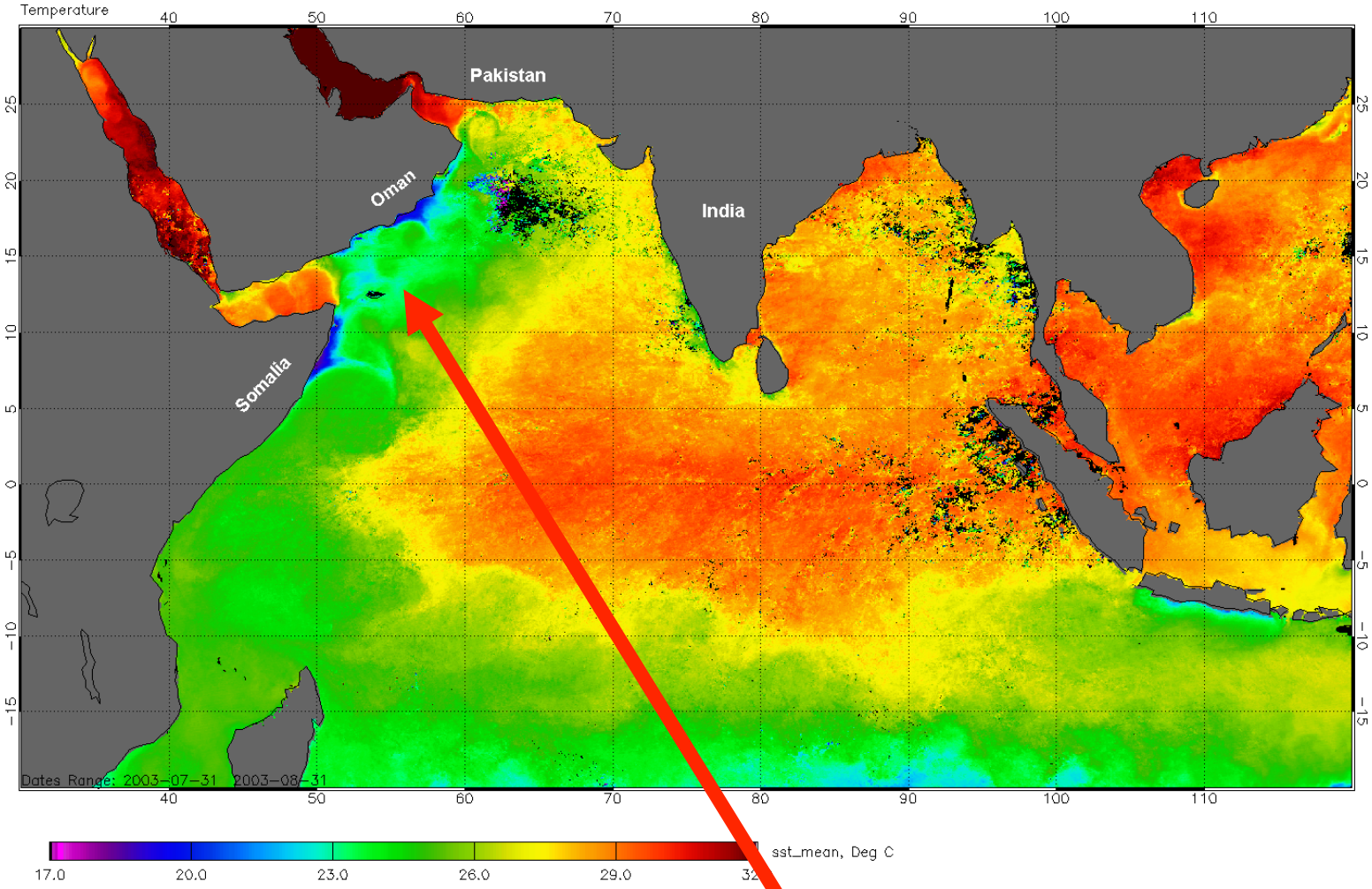


Also the zonal tropical NH currents

Arabian Sea upwelling during the SW Monsoon - coastal effects

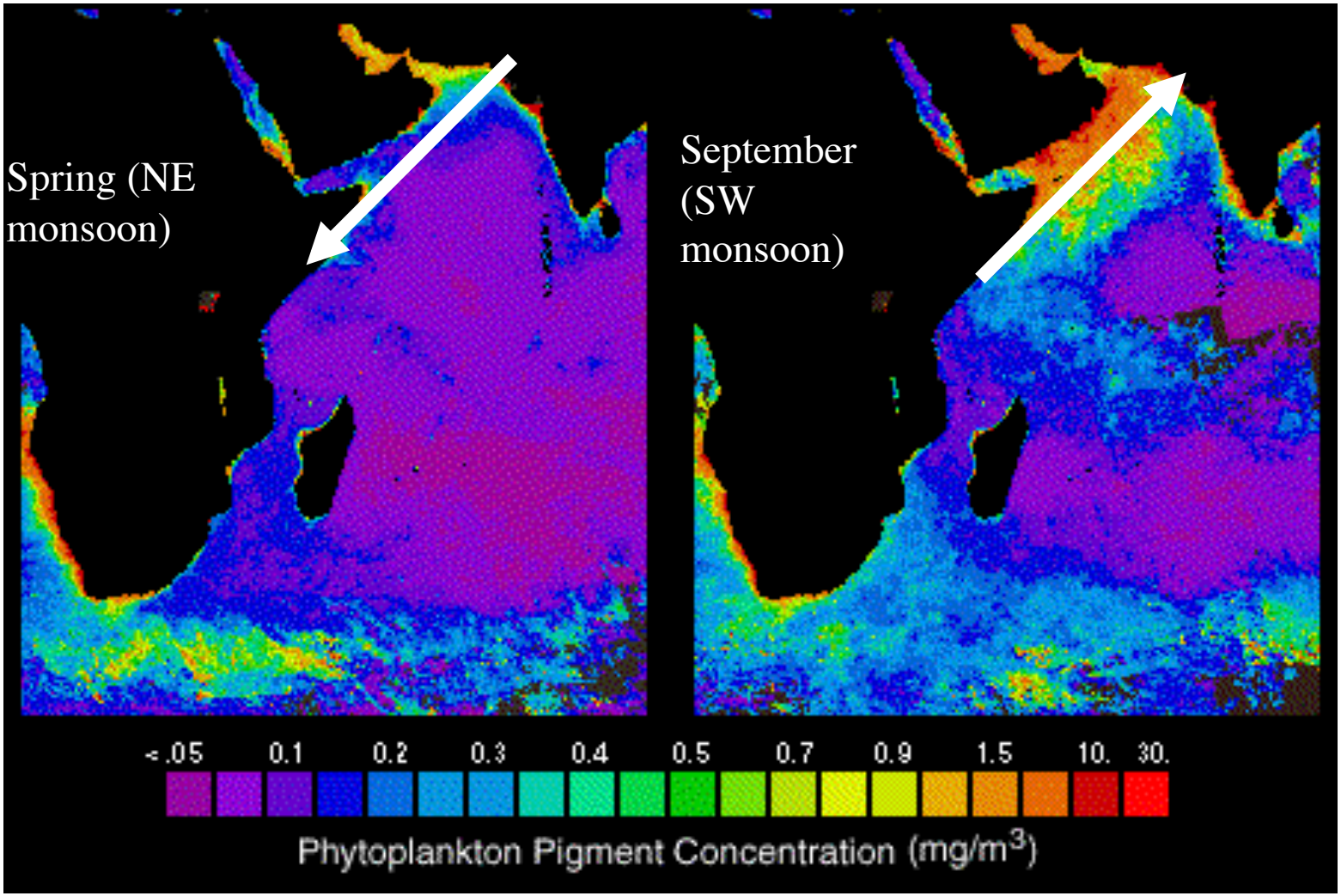


Asian (Indian) monsoon - effect of SW monsoon upwelling on surface temperature



July 2003 SST: Low along Somalia and Arabian peninsula during SW monsoon. (NASA MODIS satellite, NASA GSFC)

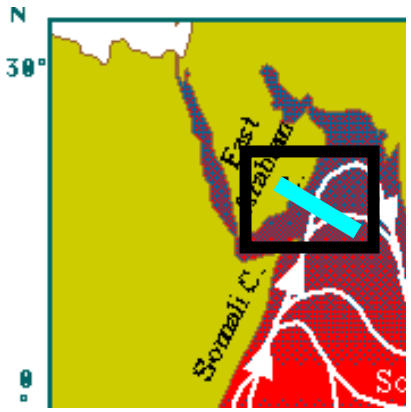
Asian (Indian) monsoon - effects of upwelling on biomass

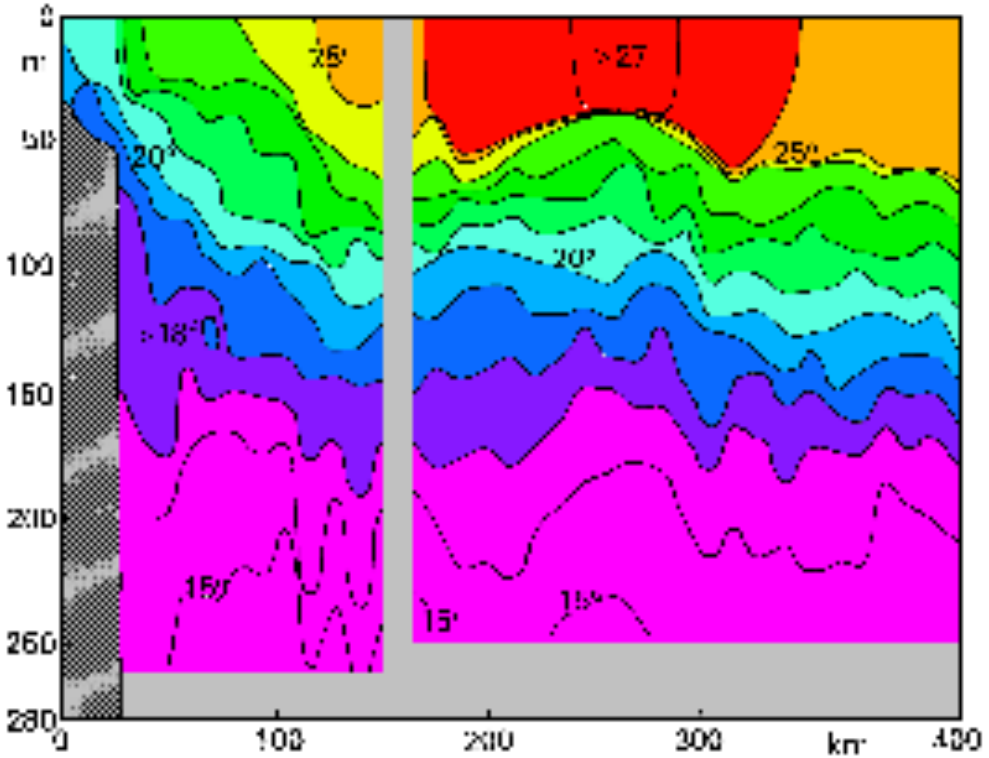


Ocean color: high values indicate more phytoplankton. Note Arabian Sea upwelling signature during the SW monsoon. (NASA SeaWifs ocean color project)

Arabian Sea upwelling during SW monsoon

- Upwelling along coast of Arabia during southwest monsoon (due to offshore Ekman transport)





- Results in decrease in temperature and increase in biological productivity

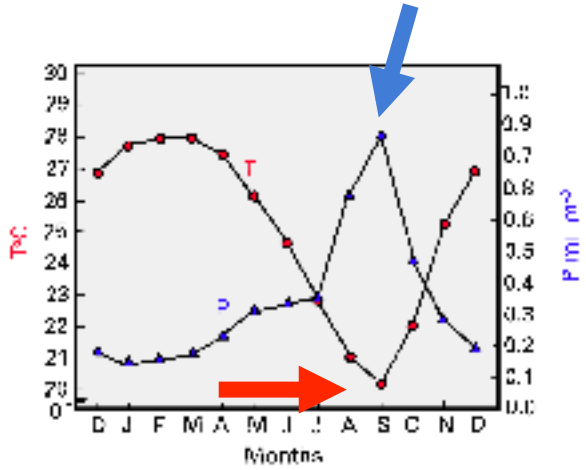


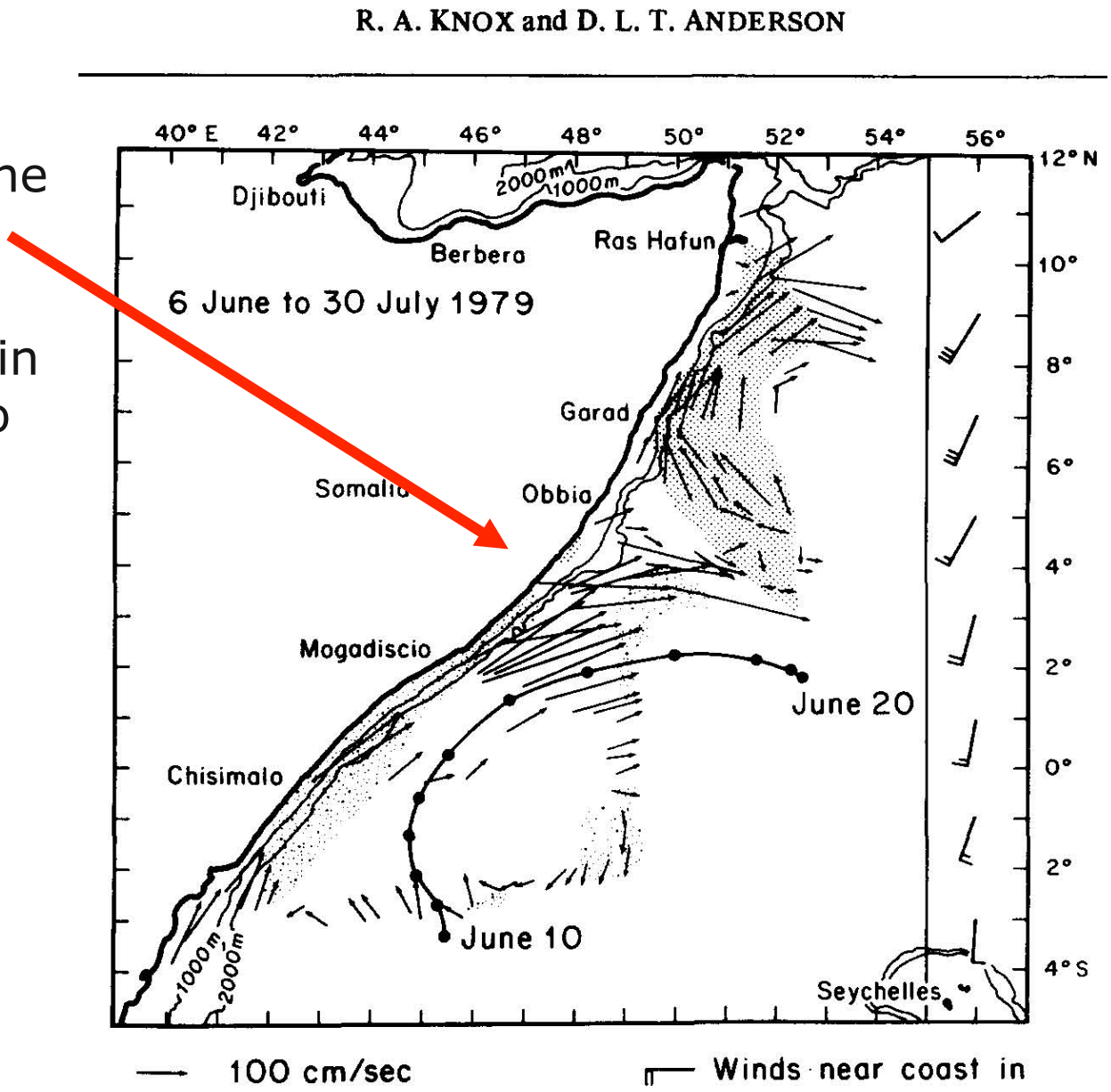
Fig. 11.9. Monthly mean temperature at 50 m depth (T) and zooplankton biomass (P) on the western Indian shelf between 8°N and 15°N. From Murty (1987).

(Figs. from Tomczak & Godfrey)

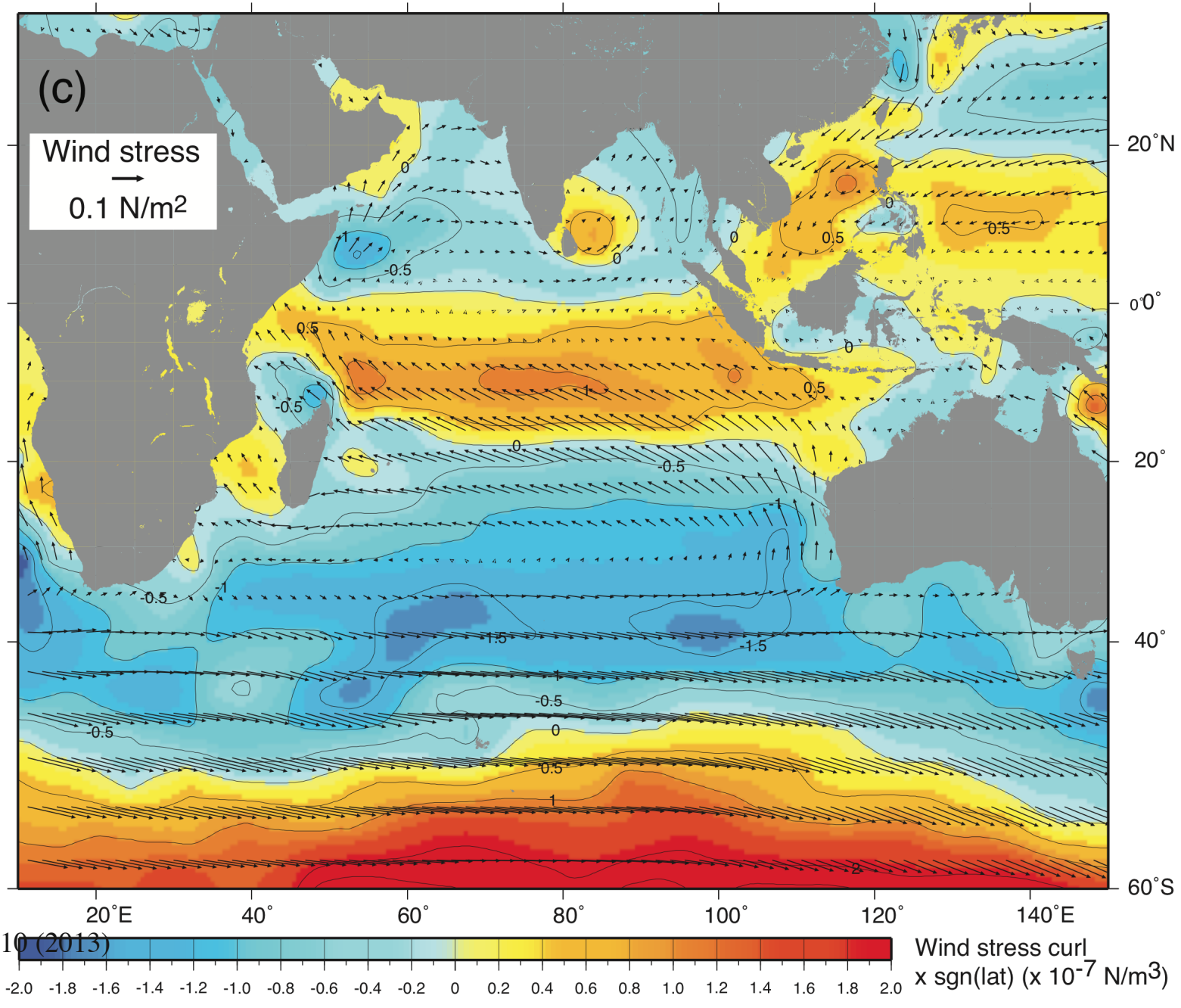
See also DPO Fig. 11.6

Arabian Sea circulation

- Somali Current is the (reversing) western boundary current of the Arabian Sea
- NE monsoon - southward SC, starts in Dec, until April. Up to 1 m/sec. Only found south of 10N.
- SW monsoon - northward SC, May-June. Up to 3.5 m/sec (very strong).



Subtropical (South) Indian Ocean - wind driven gyre circulation
Annual mean wind stress and Ekman pumping DPO Fig. S11.3



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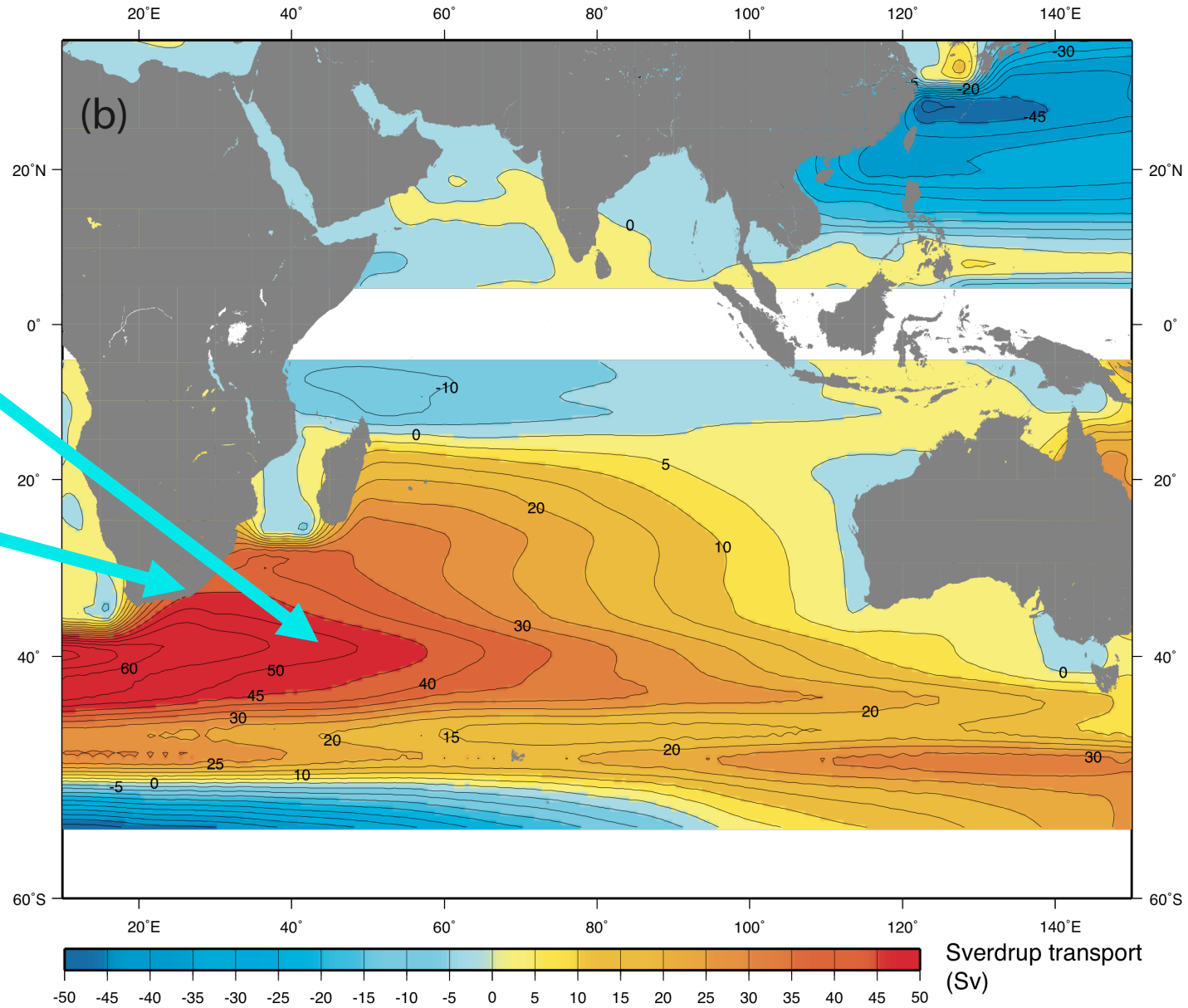
Sverdrup transport (DPO Figure S11.3)

Subtropical gyre: WBC is the Agulhas Current

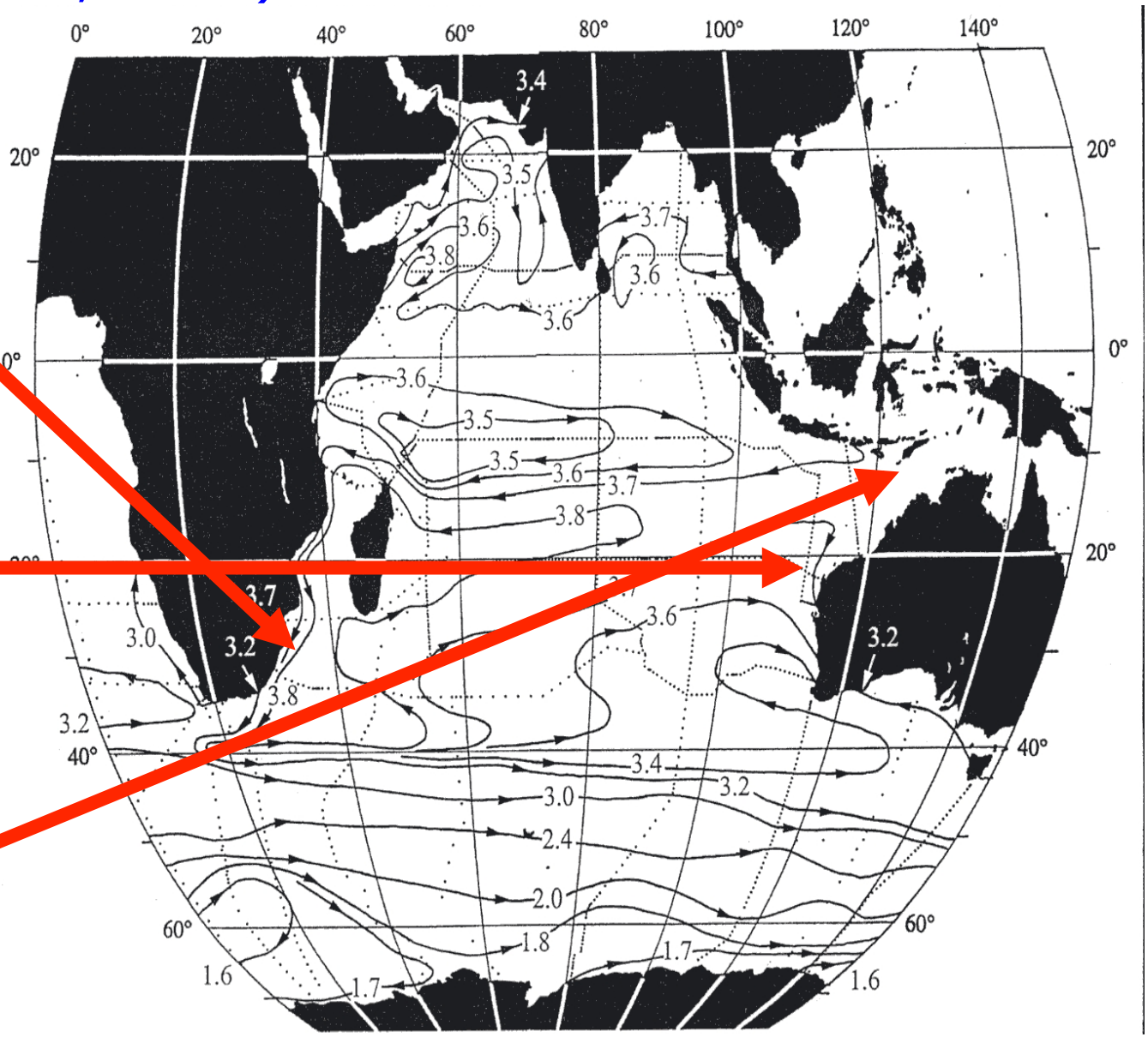


Indian surface circulation (adjusted steric height) (Reid, 2003)

Subtropical gyre (Agulhas is the WBC)

Leeuwin Current

Indonesian Throughflow (from Pacific)

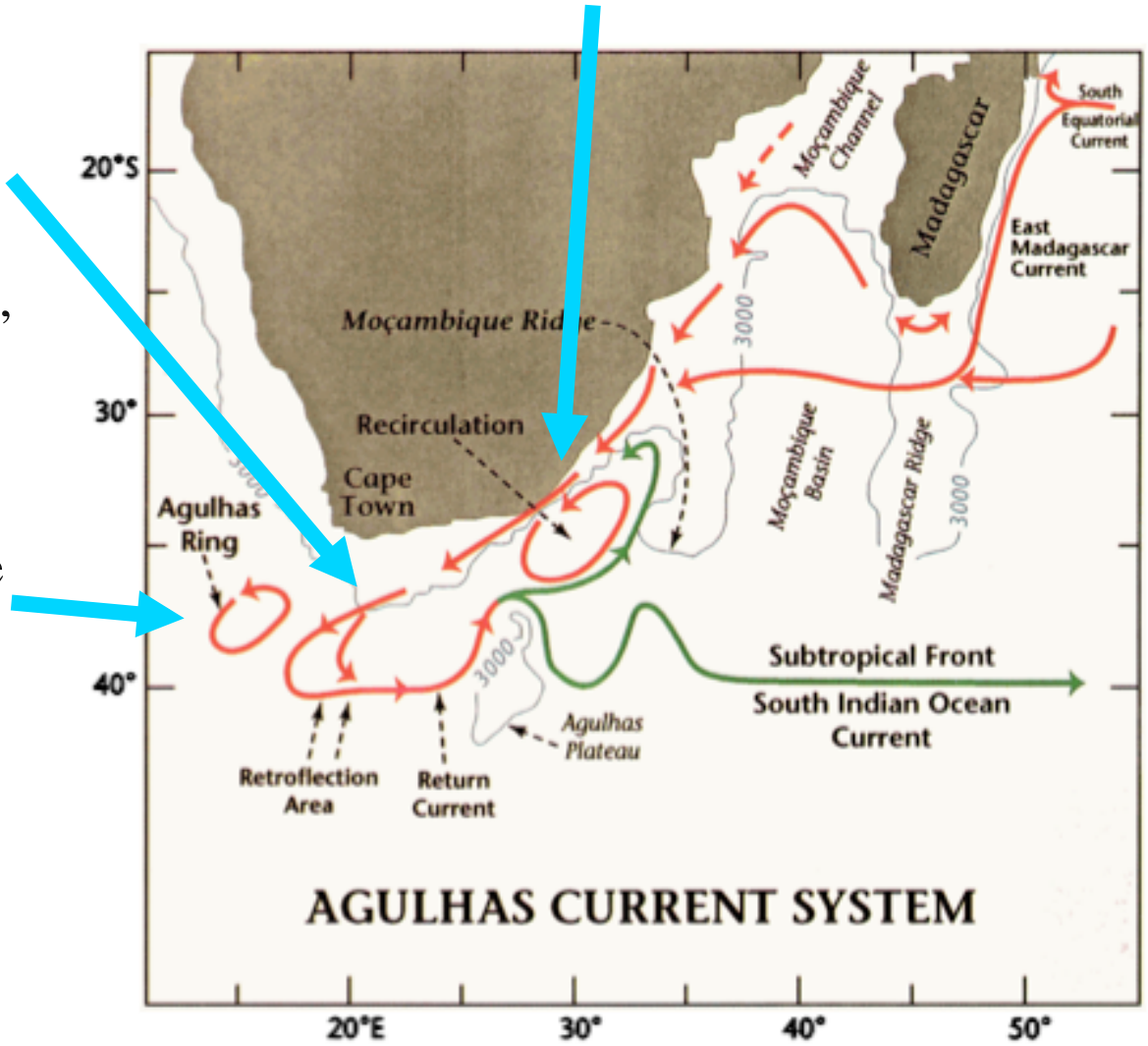


Subtropical gyre WBC: Agulhas

Agulhas retroflection: Western boundary current wishes to continue further southward, but Africa ends, so current passes to the west, retroflects back to the east.

Agulhas rings: shed at the retroflection.

Rings and part of transport continue westward into the South Atlantic, including Benguela Current



Agulhas

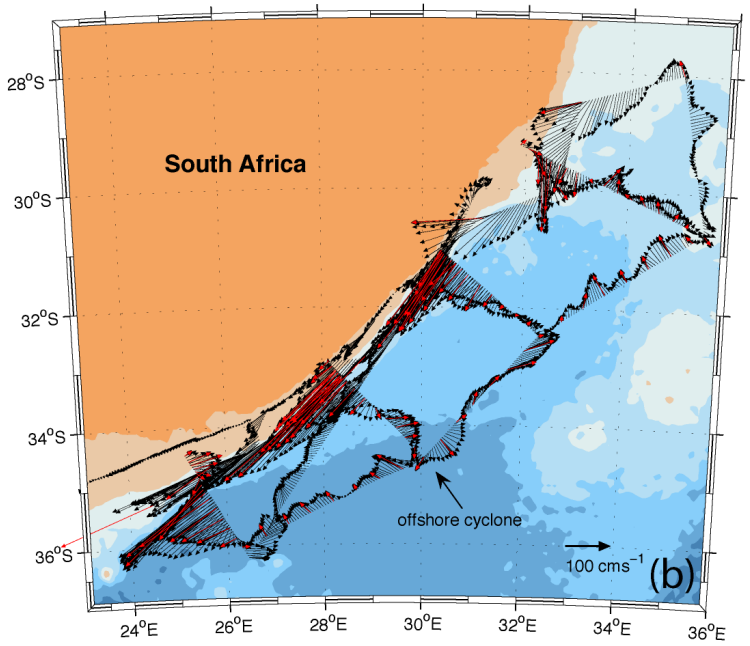
Strong western boundary current

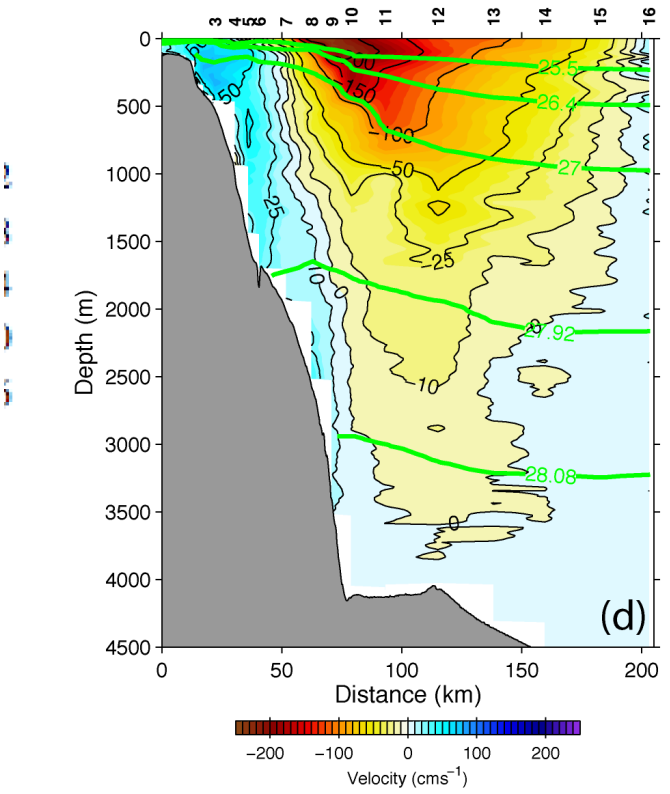
> 200 cm/sec at surface

~ 100 km width

Southward flow extends to bottom

Northward countercurrent inshore



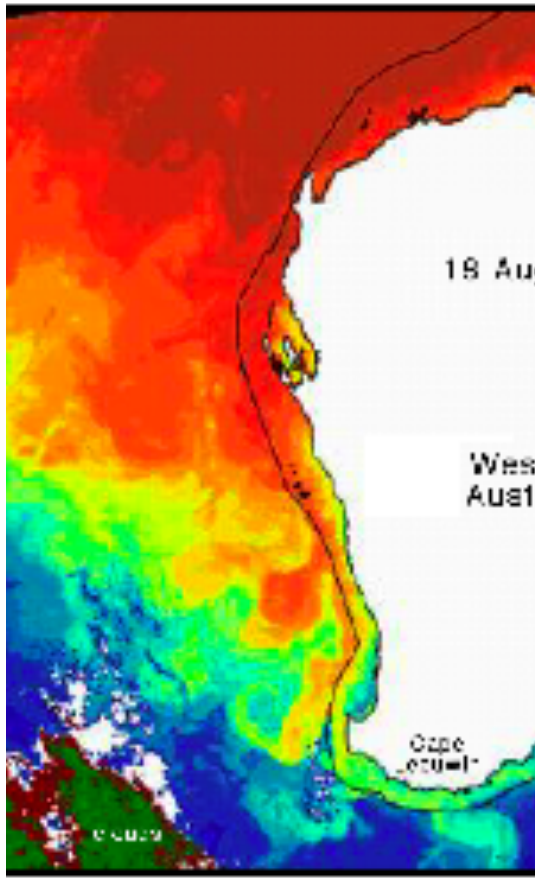


(DPO Fig. 11.12 from Beal et al., 2006)

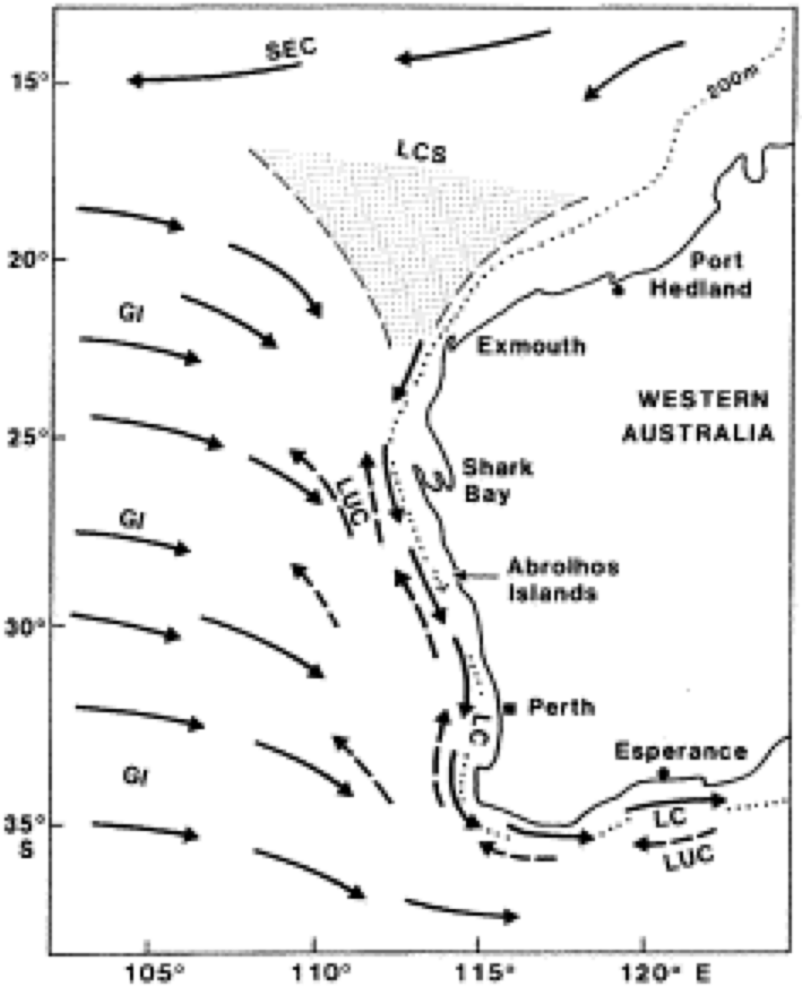
Eastern Boundary Current: Leeuwin Current

The ONLY eastern boundary current that flows poleward (despite the usual EBC equatorward winds!).

Poleward flow due to pressure gradient around Australia, partially driven by Indonesian Throughflow



SST showing southward advection of warm water (Tomczak and Godfrey online text)



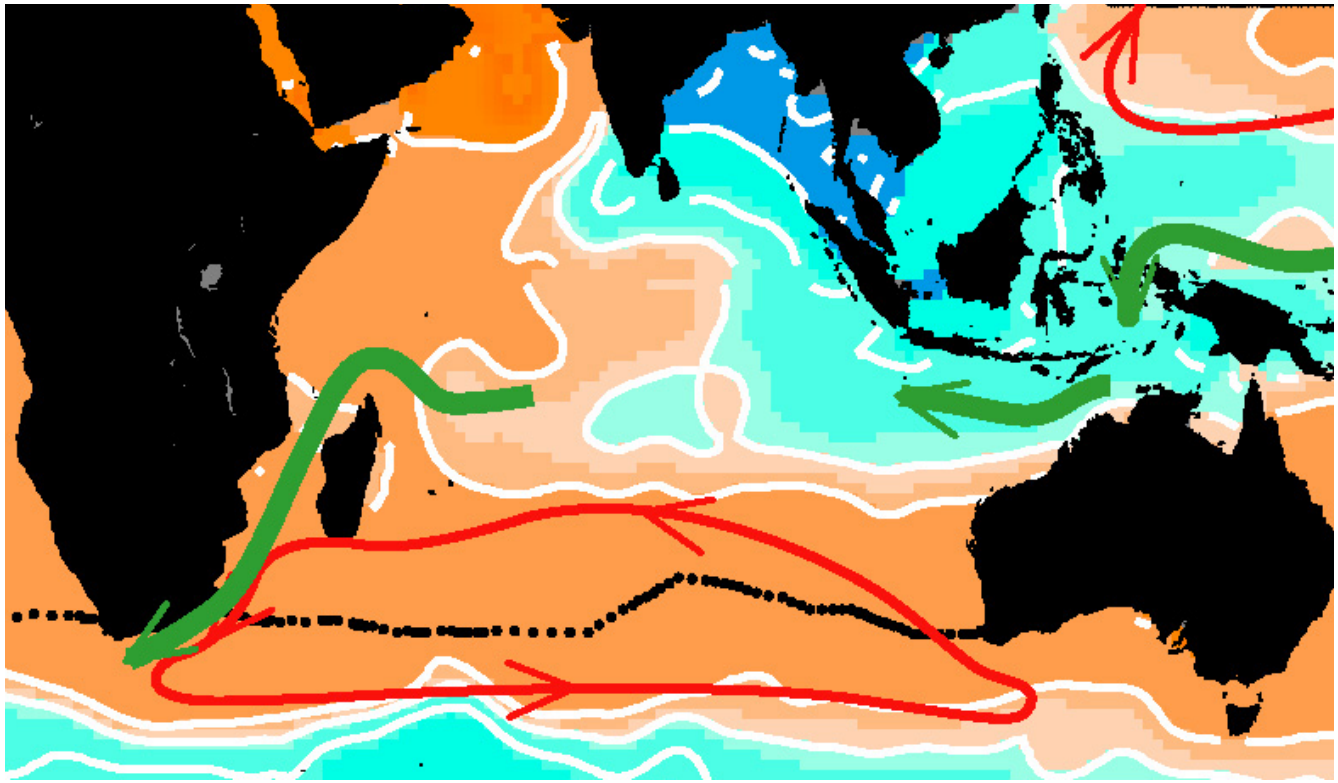
DPO Fig. 11.9 from Schott and McCreary, 2001

Indonesian Throughflow

Connection of upper ocean waters from Pacific to Indian Ocean.

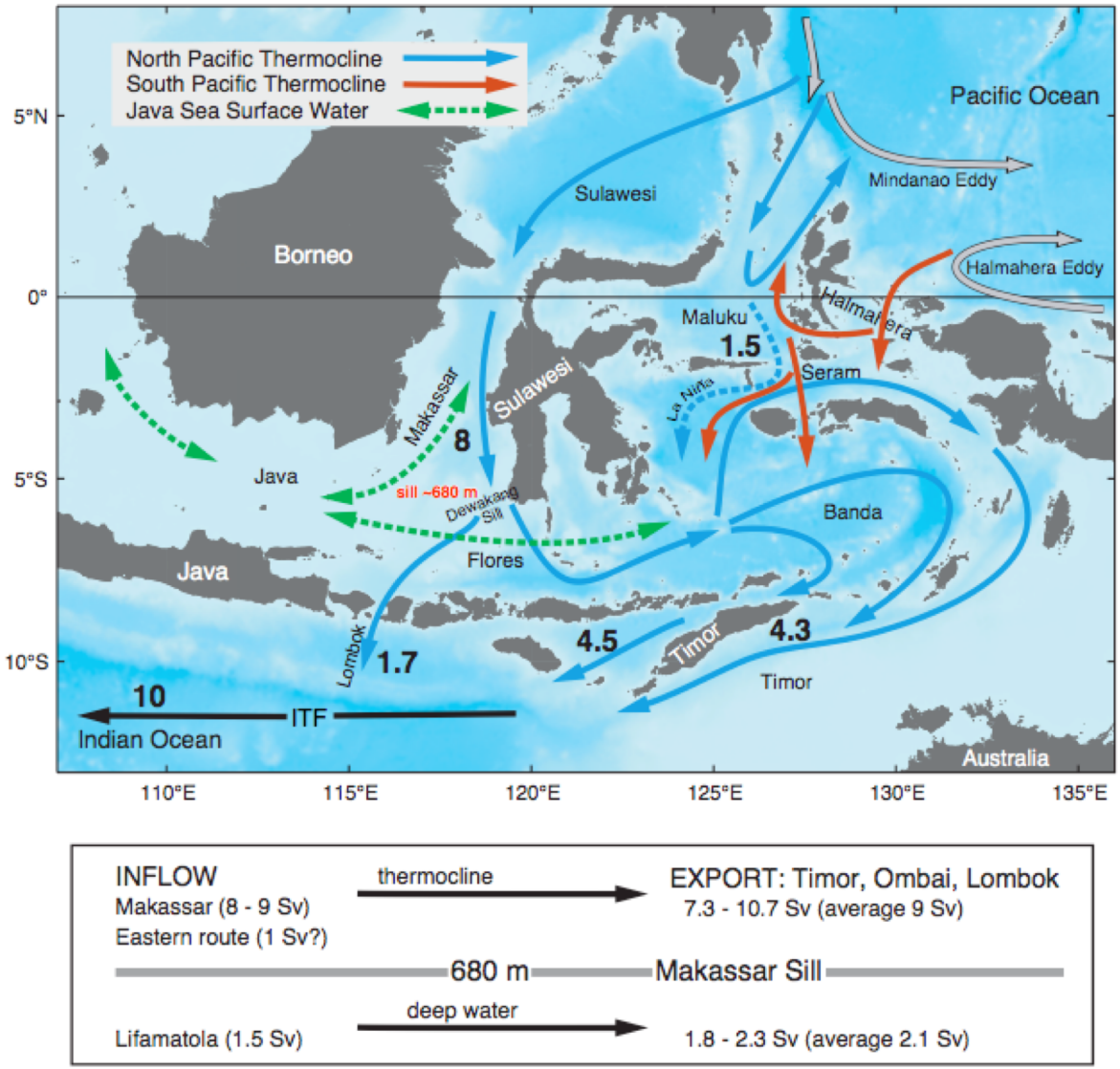
Complicated set of straits, maximum depth about 1200 m.

Low salinity Pacific water evident in zonal jet across Indian tropical region, following the South Equatorial Current



Talley (2008)

Indonesian Throughflow

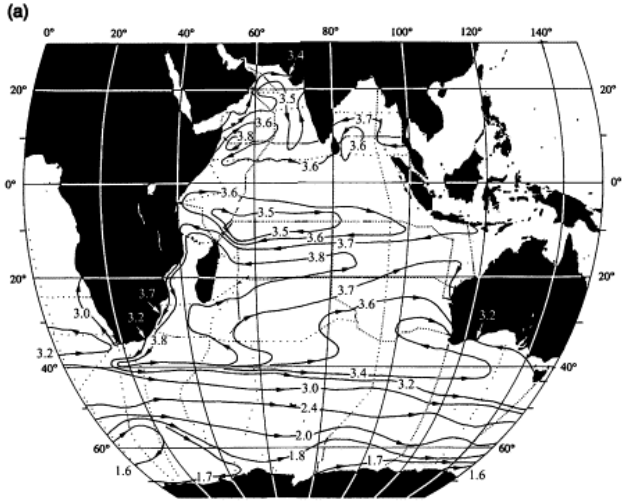


Complex flow that is only in 1 direction, from Pacific to Indian. Some of the water (warmer) is from N. Pacific and deeper is from S. Pacific

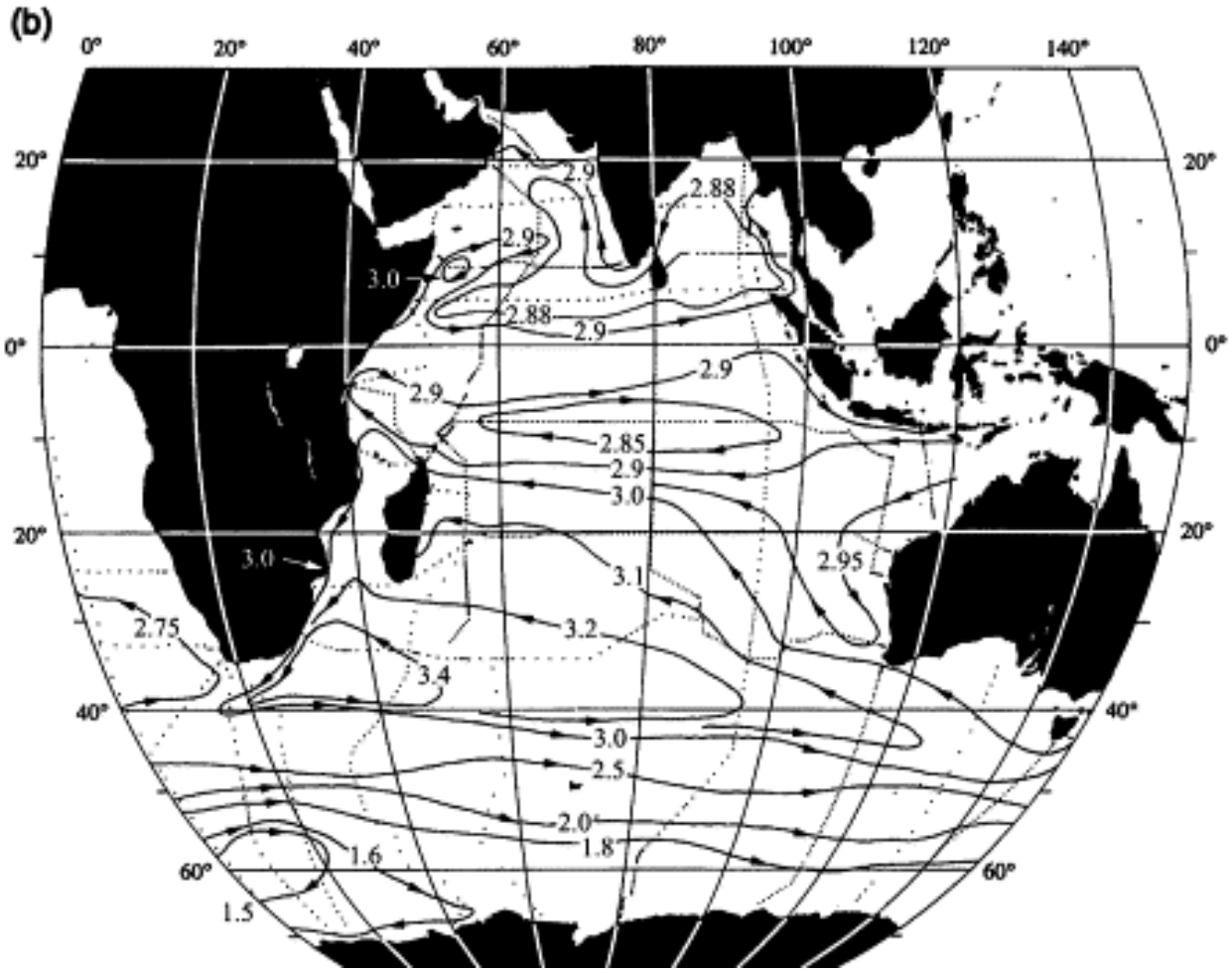
10 to 15 Sv

DPO Fig. 11.11 from Gordon et al. (2005)

Depth dependence of subtropical gyre (Reid, 2003)

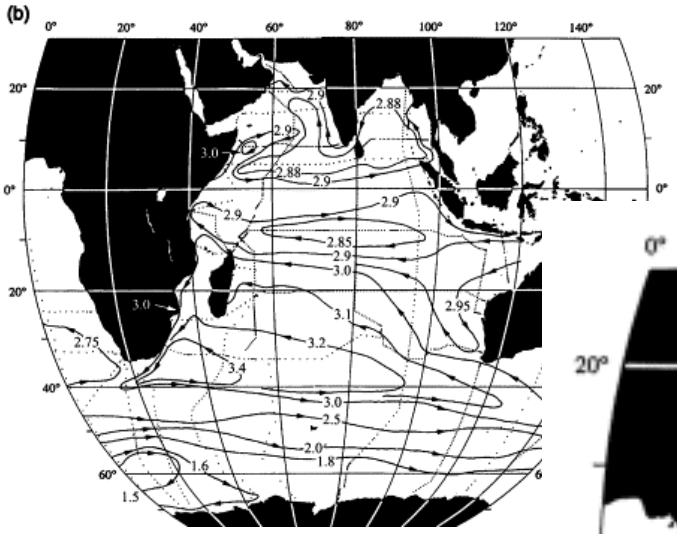


surface flow

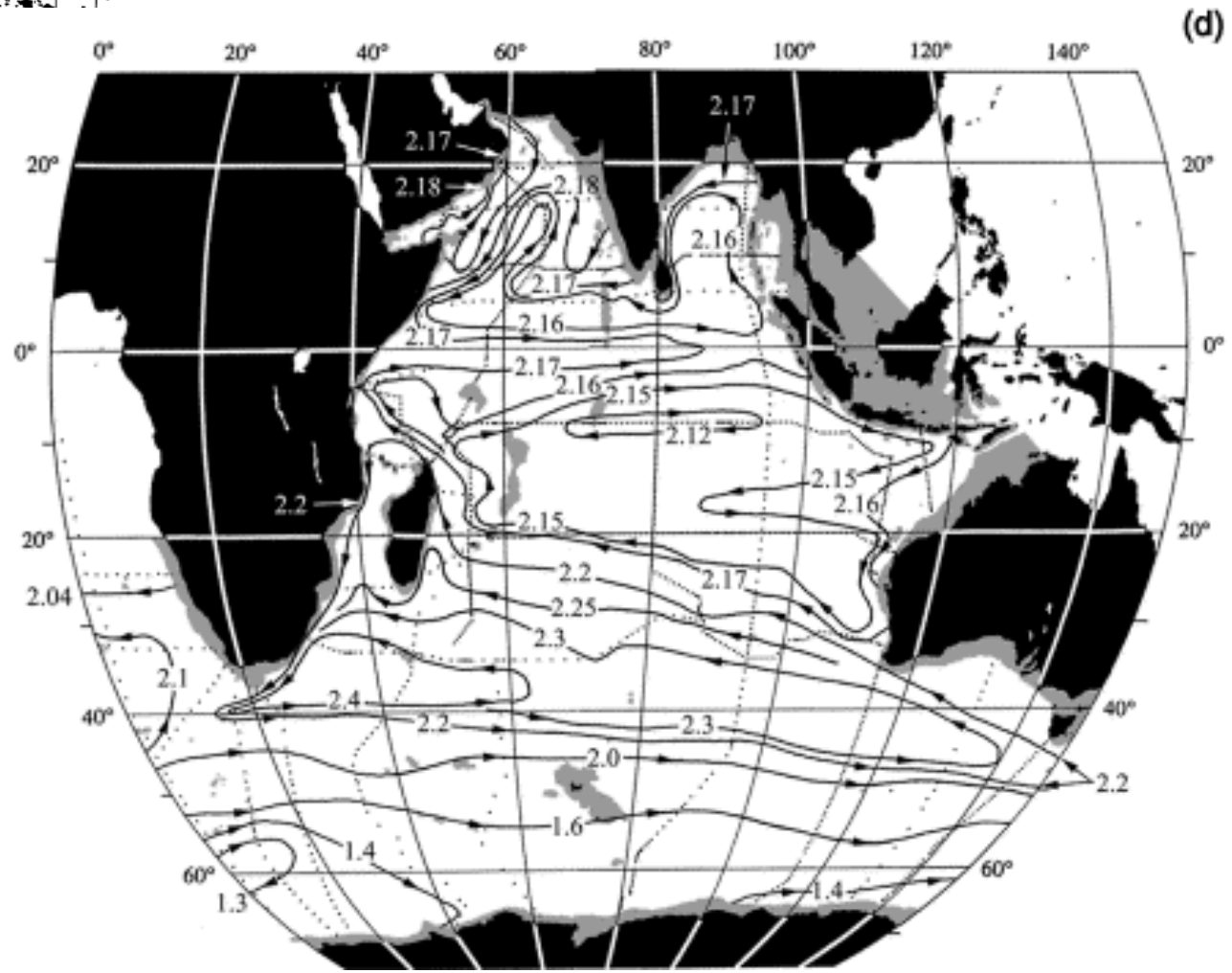


200 dbar flow:
more “gyre-like”

Shrinkage of Indian subtropical gyre with depth (200 to 800 dbar) (Reid, 2003)

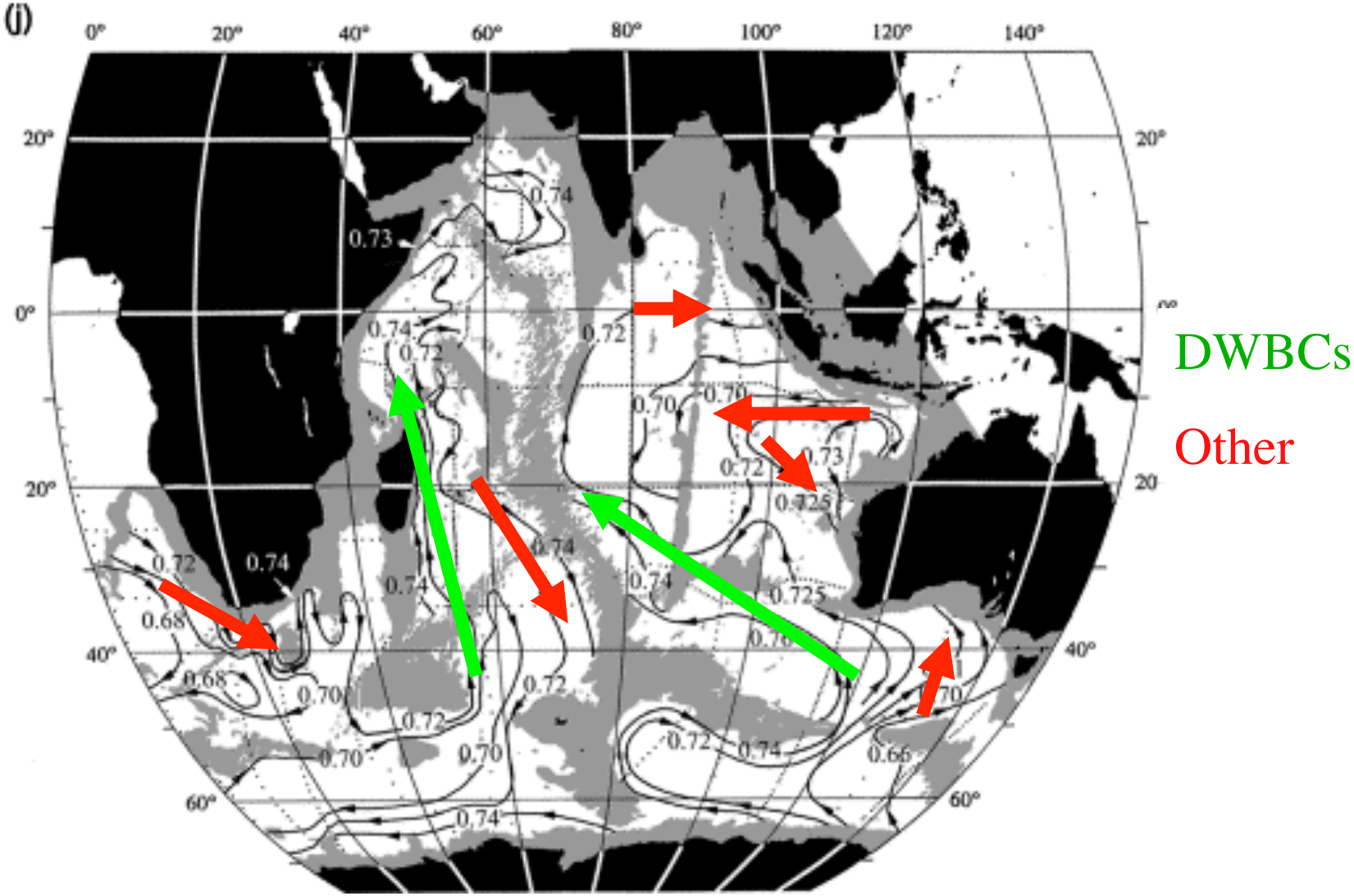


200 dbar flow



800 dbar flow: shift to south and west

Indian Ocean abyssal circulation



3500 dbar steric height based on hydrographic data (Reid, 2003)