layers and inversions. Features such as fossil layers and inversions were demonstrated to be ubiquitous in regions of

Roemmich, D.R., M.Y. Morris, W.R. Young, and J.R. Donguy, 1994: Fresh equatorial jets. J. Phys. Oceanogr., 24:3, 540–558.

Geostrophic Transports of the Major Current Systems in the Tropical Indian and Pacific Oceans

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Due to their large size, the variation of the general circulations of both the Pacific and Indian Oceans have rarely been described in their totality using hydrographic data. However, the development of the expendable bathythermograph (XBT) programme, particularly since the mid 1980s as a result of the Tropical Ocean Global Atmosphere (TOGA) Programme and the World Ocean Circulation Experiment (WOCE), has provided the basinwide observations of the thermal structure required to describe the major current systems. This paper summarises some recent work (Donguy and Meyers, 1995 and 1996; Meyers *et al.*, 1995; Meyers, 1996) which uses this widely dispersed sampling to document the variability of the major, tropical currents throughout the Indian and Pacific Ocean basins. The studies are based on frequently repeated XBT lines which were, if fully implemented, monitored at least 18 times per year with an XBT drop every 60 nmiles.

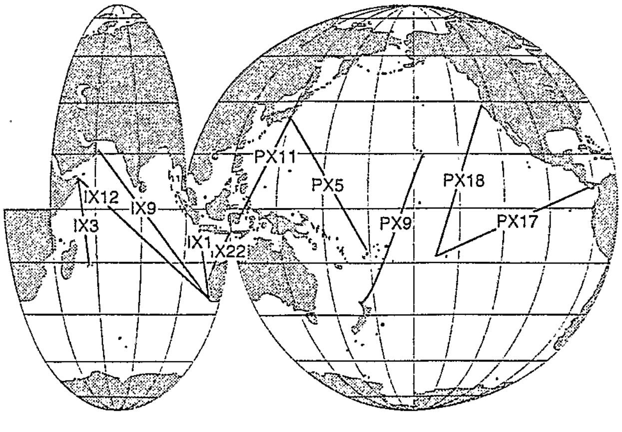

Figure 1. Location of XBT lines.

The method

XBT data and the climatological temperature/salinity relationship were used to calculate the mean annual and seasonal cycles of dynamic height and geostrophic transport of major currents relative to 400 db along 9 shipping tracks (Fig. 1) covering a large part of the tropical Indian and Pacific Oceans. The data were selected in bands centred on the most frequently repeated XBT tracklines for the period 1967 to 1988 for the Pacific Ocean, and for the period 1983 to 1994 for the Indian Ocean. The data were in general processed by the procedures described by Bailey *et al.*, 1995. Longterm bimonthly mean temperature was calculated in 1° latitude bins along the tracks, except near coastal boundaries where bins were adjusted to have one in shallow water (<500 m) when possible. The transport function (vertically integrated dynamic height) was then calculated using the mean temperature/salinity relationship. The stochastic errors in bimonthly mean transports were 1 to 2 Sverdrups on the most sampled tracks.

Tropical Pacific Ocean

The mean annual cycle of transport of the North Equatorial Current (NEC), the North Equatorial Countercurrent (NECC) and the South Equatorial Current (SEC) (south of 2.5°S) were determined between the ridges and troughs of the transport function (Donguy and Meyers, 1996). Mean transports of the NEC and NECC increase regularly with longitude from east to west, as discussed in detail in the paper. The NECC has a large annual cycle with a transport-maximum during northern fall and winter. Seasonal variations of the NEC are small. Seasonal variations

of the SEC are slightly smaller than variations of the NECC, and they have considerably different phase from track to track (Fig. 2a, page 21). The SEC is described in more detail here because it was covered by several lines in both oceans.

Tropical Indian Ocean

In the northern hemisphere, low dynamic heights prevail during the NE monsoon and high dynamic heights during the SW monsoon inducing an alternating Somali Current (Donguy and Meyers, 1995). In the southern hemisphere, at 7°–8°S a trough of low dynamic height occurs during the whole year. Empirical orthogonal function (EOF) analysis was used to document the variation of these features. The geostrophic transports calculated on the XBT routes show spatially coherent patterns with strong seasonal variations, particularly in the Arabian Sea and along the equator. The mean transport of the South Equatorial Current (Fig. 2b) increases regularly with longitude from east to west in all months. It has small annual variations and the phase of the annual maximum progresses consistently westward, something which is not evident in the SEC in the Pacific (Fig. 2a). As expected, the SEC in the Indian Ocean is much weaker compared to the SEC in the Pacific Ocean.

Variability of the Indonesian throughflow

The XBT line Fremantle–Sunda Strait transects the eastern Indian Ocean between northwestern Australia and Java. It was established in 1983 with low-density sampling and upgraded to a frequently repeated line (>18 times per year) in 1987 to monitor currents. Variation of the thermal structure during 1983 to 1994 shows a rich mixture of annual, semiannual, and interannual timescales (Meyers *et al.*, 1995; and Meyers, 1996). EOF analysis of anomalies of sea surface temperature (SST), dynamic height, and depth of the 2°C isotherm D20 identifies two distinctive signals (see Fig. 3). The Variation of Indonesian throughflow and the El Niño Southern Oscillation (ENSO) signal (EOF 1) appears throughout the region and is strongest off the coast of Australia. A modulation of the annual signal (EOF 2) appears off the coast of Java. EOF 2 has a shorter timescale than the ENSO signal, and its temporal coefficients are correlated to zonal winds over the equatorial Indian Ocean. For both EOFs, anomalously low SST and dynamic height occur at the same time as anomalously shallow D20 and *vice versa* for opposite anomalies. The XBT data, used with a climatological temperature-salinity relationship, gives the net, relative (0/400 dbar) geostrophic transports T through the section. For long timescales, T is representative of Indonesian throughflow. The variations associated with ENSO show a maximum during the La Niña of 1988–1989 and minima during the El Niños of 1986–1987 and 1991–1994. The peak-to-trough amplitude of the ENSO signal is 5 Sv. For the shorter timescales, T is representative of currents from the Indian Ocean flowing in and out of the region between northwestern Australia and Indonesia, changing the volume of upper layer water stored there. Associated with EOF 2, a sharp peak in westward transport developed during May to October 1994. When the XBT data is combined with available hydrographic data to investigate the deeper currents and the total throughflow, the maximum net, relative transport toward the west between Australia and Indonesia is 12 Sv in August/September (Meyers *et al.*, 1995).

Conclusions

XBTs have provided a cost-effective way of providing widescale sampling of the upper ocean thermal structure for geostrophic transport as well as heat storage studies. The challenge for the future is to combine such subsurface information with widescale surface topography data provided by the latest satellite missions such as TOPEX/POSEIDON and ERS-1&2.

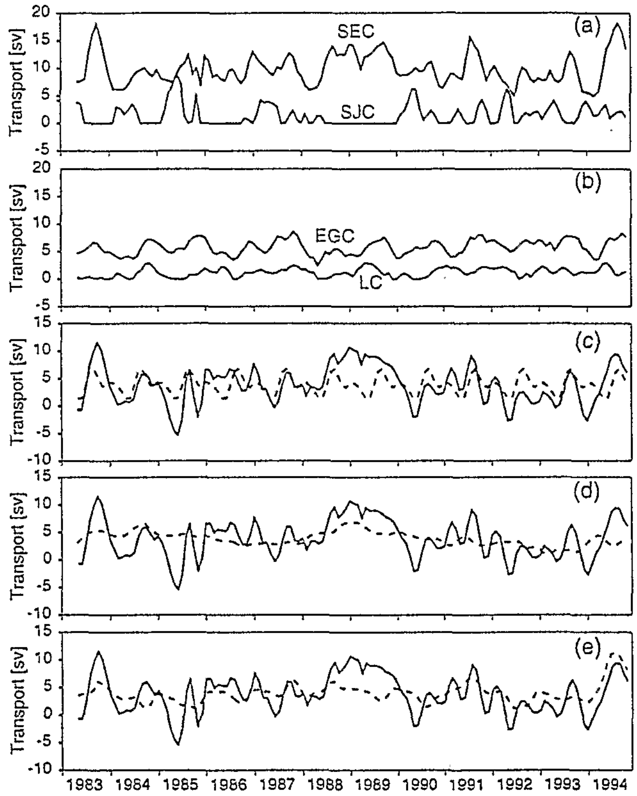

Figure 3. Geostrophic transport (0/400 dbar) in Sverdrups (10^6 m^3/s): (a) South Equatorial Current SEC and South Java Current SJC and (b) Leeuwin Current LC and Eastern Gyral Current EGC. Positive values indicate westward flow for the SEC, eastward for the SJC and EGC, and southward for the LC. (c) Net geostrophic transport (0/400 dbar) through IX1 from Shark Bay to Sunda Strait (solid line) and mean annual cycle for the period 1983–1994 (dashed). (d) Same as (c), but with the ENSO signal in throughflow estimated by regression analysis with joint EOF1 (dashed), (e) Same as (c), but with the flow through line IX1 estimated by regression analysis with joint EOF2 (dashed).

Acknowledgements

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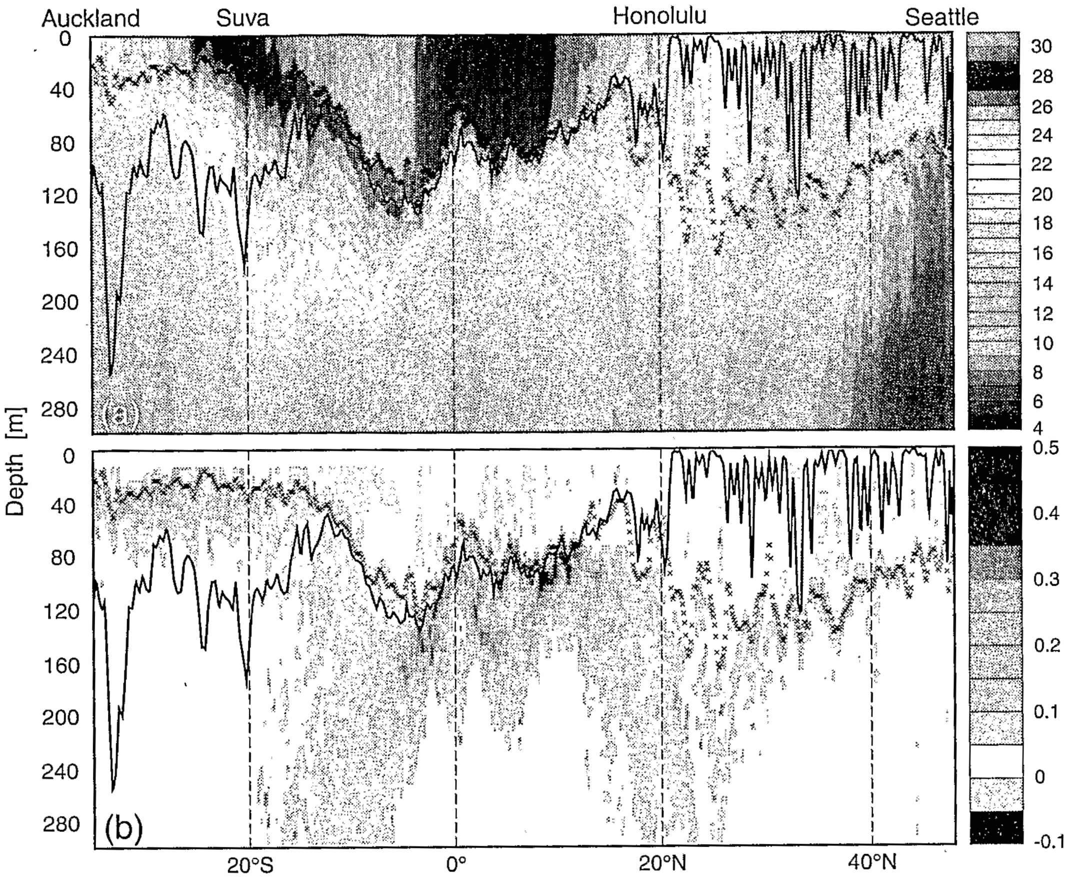
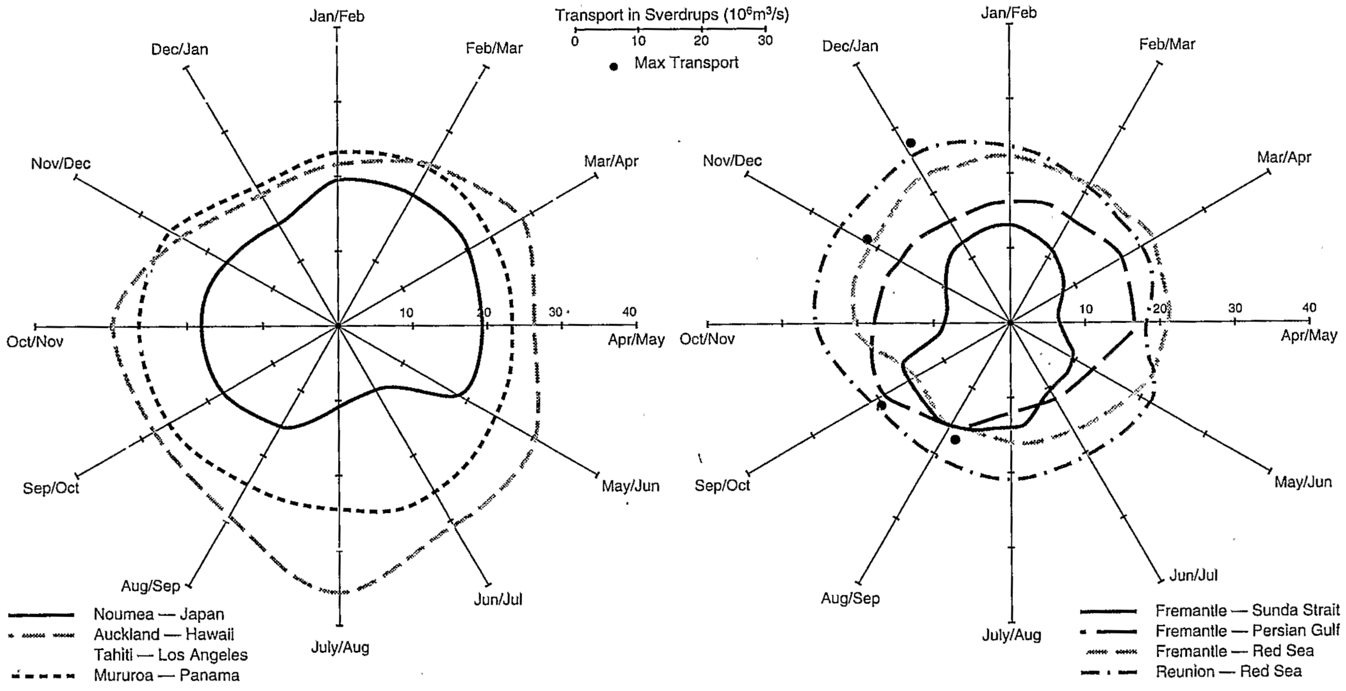


Sprintall and Roemmich, page 3 *Figure 2. Temperature (a) and it's derivative with depth (b) along Auckland–Seattle in March 1995. The solid line indicates the depth of the surface layer. The crosses indicate the depth of SST-1 °C.*



Meyers et al., page 7 *Figure 2. Annual cycle of the geostrophic transport of the South Equatorial Current in Pacific Ocean (left), and Indian Ocean (right), calculated from bimonthly mean temperatures using a mean temperature salinity relationship. The transports in Sverdrups are indicated by distance from the origin. The shipping track is indicated in the legend.*

International WOCE Newsletter

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We hope that colleagues will see this Newsletter as a means of reporting work in progress related to the Goals of WOCE as described in the Scientific Plan. The SSG will use it also to report progress of working groups, experiment design and models.

The editor will be pleased to send copies of the Newsletter to institutes and research scientists with an interest in WOCE or related research.

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