3.4 A SUMMARY OF PHYSICAL OCEANOGRAPHY AROUND NEW ZEALAND

Philip J.H. Sutton*, Stephen M. Chiswell, Melissa M. Bowen, Michael J.M. Williams
National Institute of Water and Atmospheric Research, New Zealand

1. INTRODUCTION

New Zealand is situated in a diverse oceanographic environment. A long, relatively narrow landmass, mainland New Zealand spans from the southern half of the South Pacific subtropical gyre to the northern limits of the Southern Ocean and Antarctic Circumpolar Current. Several Pacific and global features interact with New Zealand, including the western boundary current of the South Pacific gyre, the Subtropical Front and the Subantarctic Front.

Physical oceanographic research in New Zealand focuses on the role of the ocean and its variability in local climate and on the impact of the physical environment on the biology. While our knowledge of the mean state and variability has considerably improved over the past decade, there are still significant gaps.

2. THE EAST AUCKLAND / EAST CAPE CURRENT

The East Auckland Current / East Cape Current system is a southward boundary current flowing down the northeast coast of New Zealand. It is the western boundary current of the South Pacific subtropical gyre south of 34°S and is an unique example of a western boundary current (the East Australian Current) reattaching to a landmass.

The East Auckland Current has been heavily studied for the past decade. The mean state of the current system consists of a southwards flow nestled against the continental shelf break with a series of three permanent eddies along its offshore flank (Roemmich and Sutton, 1998). The eddies vary in size and strength, but are normally present and have clear signatures in the mean. The eddies dominate the local current fields and impact mixed-layer depths and water-mass formation (Roemmich and Cornuelle, 1990).

The southward transport in the East Auckland Current off northern New Zealand has been estimated at between -5 and 24 Sv at different times (Stanton et al., 1997, Stanton and Sutton, in press), with a mean transport from climatological analysis of 9 Sv. An "Island Rule" analysis indicates that the mean transport can be explained by Sverdrup dynamics (Stanton, 2001). Analyses combining satellite altimeter and hydrographic data indicate that variability is broad-scale with periods longer than 100 days. The causes of the variability in the current strength are not fully understood.

The upper ocean temperature interannual variability is dominated by ENSO, with El Niños being typically associated with cooler conditions (Sutton and Roemmich, 2001).

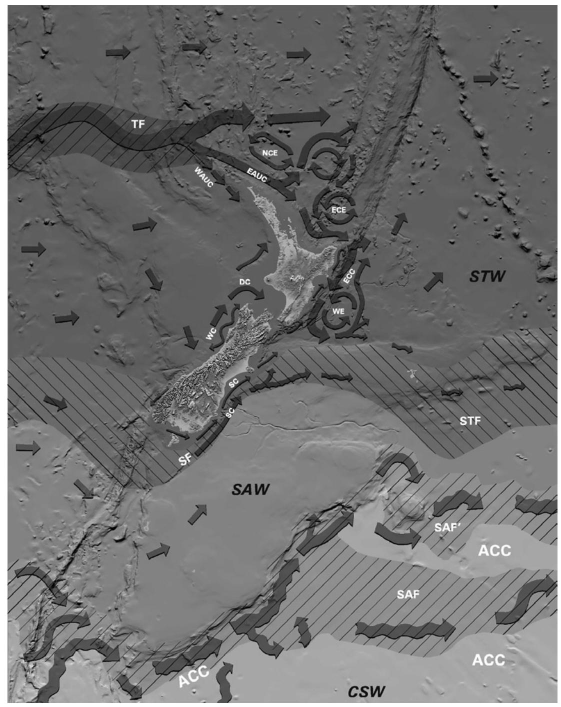

Figure 1. Surface currents and water masses around New Zealand. (T.F. = Tasman Front, WAUC = West Auckland Current, EAUC = East Auckland Current, NCE = North Cape Eddy, ECE = East Cape Eddy, ECC = East Cape Current, WE = Wairarapa Eddy, DC = D'Urville Island, WC = Westland Current, SC = Southland Current, SF = Southland Front, ACC = Antarctic Circumpolar current, STF = Subtropical Front, SAF = Subantarctic Front, STW = Subtropical Water, SAW = Subantarctic water, CSW = Circumpolar surface water. From Carter et al., 1998.

3. THE SUBTROPICAL FRONT

The Subtropical Front (STF) crosses the Tasman Sea at about 45°S before meeting the New Zealand continental shelf off the southwest coast of South Island. The front is then displaced to the south of New Zealand before following the continental shelf break to the north along the southeast coast. This portion of the STF is locally known as the Southland Front and has an

* *Corresponding author address:* Philip J.H. Sutton, NIWA, P.O. Box 14-901, Kilbirnie, Wellington, New Zealand; email: p.sutton@niwa.co.nz

associated current called the Southland Current. The Southland Current advects roughly 8 Sv of water of mainly Subantarctic origins. The variability in the Southland Current has been found to result from variations in the local wind field (Chiswell, 1996).

The STF turns east at about 43°S to run along the crest of Chatham Rise, a ridge running east hundreds of kilometres from South Island. The subtropical water north of Chatham Rise is carried into the area by the southern extreme of the East Cape Current while SAW is advected into the area south of Chatham Rise by the Southland Current. These two flows on the flanks of the narrow ridge constrain the STF to the ~100 km wide, 300m deep crest of Chatham Rise (Sutton, 2001). Therefore the STF over Chatham Rise is relatively narrow (100 km c.f. ~500 km elsewhere) and shallow (300 m c.f. 500 m elsewhere). The location of the STF is also constant, locked over Chatham Rise and is the southernmost location of the STF in the South Pacific.

The area of the STF over Chatham Rise area is highly productive, supporting large commercial fisheries. The physical and biological processes supporting this productivity are the focus of an ongoing interdisciplinary study.

4. THE SUBANTARCTIC REGION

A band of Subantarctic Water (SAW) lies south of the STF and north of the Subantarctic Front (SAF). The SAF diverts southward around the New Zealand continental platform to flow around a bathymetric platform called Campbell Plateau. The result is a wide band of relatively homogeneous SAW southeast of New Zealand.

The SAF along the southern flank of Campbell Plateau is associated with strong flows. Mean surface flows on the southern flank of Campbell Plateau reach 40 cm/s, and the full-depth transport is 90 Sv (Morris et al. 2001). This region is associated with intense eddy activity, in fact some of the largest observed around the globe. Further downstream, the strong currents separate from Campbell Plateau in several branches (Fig. 1).

In contrast to the strong flows and variability in the SAF, the Campbell Plateau is a relatively quiescent region with weak mean flow and variability.

Subantarctic Mode Water (SAMW), characterised by weak stratification and low potential vorticity, is formed by deep mixing along the northern side of the SAF. Deep mixed layers are found immediately north of the SAF south of New Zealand, and SAMW is present across Campbell Plateau (Morris et al. 2001). The SAMW over Campbell Plateau is colder (7°C) than in the Tasman Sea (8-9°C). This is likely to result from flow path restrictions. However, this region does not appear to be a significant formation area for SAMW because the annual mean surface buoyancy flux over Campbell Plateau in mainly into the ocean, implying that, for steady-state conditions, water is made lighter not denser over the plateau (Morris et al. 2001).

Warm core eddies of subtropical origin have been observed in this region. The presence of these eddies has important implications on water mass properties and also on the local marine biology, with the STW mixing iron into the iron limited SAW.

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