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Review

A review of the shelf-slope circulation along Australia's southern shelves: Cape Leeuwin to Portland

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Abstract

A review is presented of the ocean circulation along Australia's southern shelves and slope. Uniquely, the long, zonal shelf is subject to an equatorward Sverdrup transport that gives rise to the Flinders Current – a small sister to the world's major Western Boundary Currents. The Flinders Current is strongest near the 600 m isobath where the current speeds can reach 20 cm/s and the bottom boundary layer is upwelling favourable. It is larger in the west but likely intermittent in both space and time due to possibly opposing winds, thermohaline circulation and mesoscale eddies. The Flinders Current may be important to deep upwelling within the ubiquitous canyons of the region.

During winter, the Leeuwin Current and local winds act to drive eastward currents that average up to 20–30 cm/s. The currents associated with the intense coastal-trapped wave-field (6–12 day band) are of order 25–30 cm/s and can peak at 80–90 cm/s. Wintertime winds and cooling also lead to downwelling to depths of 200 m or more and the formation of dense coastal water within the Great Australian Bight and the South Australian Sea. Within the Great Australian Bight, the thermohaline circulation associated with this dense water is unknown, but may enhance the eastward shelf-edge, South Australian Current. The dense salty water formed within Spencer Gulf is known to cascade as a gravity current to depths of 200 m off Kangaroo Island. This dense water outflow and meanders in the shelf circulation also fix the locations of a sequence of quasi-permanent mesoscale eddies between the Eyre Peninsula and Portland.

During summer, the average coastal winds reverse and surface heating leads to the formation of warm water in the western Great Australian Bight and the South Australian Sea. No significant exchange of shelf water and gulf water appears to occur due to the presence of a dense, nutrient-rich (sub-surface) pool that is upwelled off Kangaroo Island. The winds lead to weak average coastal currents (<10 cm/s) that flow to the north-west. In the Great Australian Bight, the wind stress curl can lead to an anticyclonic circulation gyre that can result in shelf-break downwelling in the western Great Australian Bight and the formation of the eastward, South Australian Current. In the east, upwelling favourable winds and coastal-trapped waves can lead to deep upwelling events off Kangaroo Island and the Bonney Coast that occur over 3–10 days and some 2–4 times a season. The alongshore currents here can be large (~40 cm/s) and the vertical scales of upwelling are of order 150 m (off Kangaroo Island) and 250 m (off the Bonney Coast).

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Increasing evidence suggests that El Nino events (4–7 year period) can have a major impact on the winter and summer circulation. These events propagate from the Pacific Ocean and around the shelf-slope wave-guide of West Australia and into the Great Australian Bight. During winter El Nino events, the average shelf currents may be largely shut-down. During summer, the thermocline may be raised by up to 150 m. The nature and role of tides and surface waves is also discussed along with uncertainties in the general circulation and future research.

Keywords: Shelf currents; Shelf-edge; Upwelling; Downwelling; Oceanic eddies; Boundary currents

Contents