



## Regional Geology of the Sorell Basin

The Sorell Basin is a large transtensional basin that lies off the west coast of Tasmania and King Island (**Figure 1**). It is bounded by the Otway Basin to the north, the Tasmanian coast to the east, oceanic seafloor to the west; the South Tasman Rise lies to the south. The basin is largely underexplored, especially in the south. Despite this the presence of thick Cretaceous basin-fill, interpreted to contain organic-rich coaly, deltaic and marine facies that are mature for hydrocarbon generation in much of the basin, and minor oil indications in one well, indicate that active petroleum systems may be present in the basin.

### Basin outline

The Sorell Basin is a large transtensional basin that contains a largely siliciclastic Lower Cretaceous to Holocene succession, and lies offshore of western Tasmania (**Figure 1**) in water depths of 50–4500 m (Moore et al, 1992; Conolly and Galloway, 1995; Hill et al, 1997, 2000; Hill and Exon, 2004; Boreham et al, 2002; O'Brien et al, 2004; Gibson et al, 2011, 2012; Stacey et al, 2013). The basin contains five sub-basin depocentres: the King Island, Sandy Cape and Strahan sub-basins in the north, and the Port Davey and Toogee sub-basins in the south (**Figure 2**). Limited exploration activity has been focused entirely on the northern part of the basin, in the King Island, Sandy Cape and Strahan sub-basins. The southern part of the basin, including the Port Davey and Toogee sub-basins, is essentially unexplored and the geology of this part of the basin is poorly understood. In general, sediment thickness in the basin decreases to the south and maximum thicknesses vary from approximately 6000 m in the Sandy Cape and Strahan sub-basins, to 3000 m in the Port Davey Sub-basin. The Sorell Basin is structurally and stratigraphically contiguous with the Otway Basin.

Tectonic elements and wells are shown in **Figure 2**, **Figure 3** shows mapped sediment thickness, stratigraphy is shown in **Figure 4**, regional seismic lines are provided in **Figures 5, 6 and 7**.

### Basin evolution

The Sorell basin is one of a series of basins that developed along the southern margin of Australia during the breakup of eastern Gondwana from the Middle Jurassic to the Cenozoic and which together comprise the Southern Rift System. The margin evolved through repeated episodes of extension and thermal subsidence leading up to, and following, the commencement of seafloor spreading between Australia and Antarctica. Breakup took place diachronously along the margin, starting in the west at ~83 Ma and concluding in the east at 34 Ma. In general, breakup was not accompanied by significant magmatism and the margin is classified as magma-poor. Key references that discuss the geology and tectonic evolution of the southern margin include: Stagg et al (1990), Willcox and Stagg (1990), Exon et al (1997), Totterdell et al (2000), Norvick and Smith (2001), Hill and Moore (2001), Teasdale et al (2003), Totterdell and Bradshaw (2004), Krassay et al (2004), Blevin and Cathro (2008).

The Sorell Basin is structurally and stratigraphically contiguous with the Otway Basin. The structure of the eastern Otway and Sorell basins has been strongly influenced by the architecture and roughly north–south structural fabric of the underlying Proterozoic–early Paleozoic basement. This basement structure provided a fundamental control on the architecture of the southeastern part of the rifted margin and the northwest–southeast transition from extension, through transtension, to a predominantly strike-slip regime (Gibson et al, 2011). The architecture of the basins reflect variations in the structural regime and basement control across the southeastern part of margin. In particular, the narrow fault-controlled depocentres of the King Island and Strahan sub-basins, the along-margin changes in extensional fault strike (from east–west in the Nelson Sub-basin of the Otway Basin to predominantly north–south in the vicinity of the Avoca–Sorell Fault System), and the north to south diachroneity of extension (Stacey et al, 2013).

The Sandy Cape Sub-basin is the largest structural element in the basin. The main depocentre is located west of the approximately north–south striking, basement-involved Avoca–Sorell Fault System and contains up to 4.0 s TWT of fill (**Figure 3**; Gibson et al, 2011; Stacey et al, 2013). In the southern part of the sub-basin, the depocentre axis steps to the east-southeast across a series of faults. Early Cretaceous deposition was controlled by west-dipping extensional faults, which were reactivated during the Late Cretaceous. The Upper Cretaceous succession (**Figure 4**) is also characterised by east-dipping antithetic faults (**Figure 5**) and, locally, gravity-driven growth faulting. A period of structural inversion in the latest Cretaceous resulted in minor folding of the basin fill, and associated uplift and erosion. The overlying Cenozoic succession is relatively undeformed and onlaps pre-rift basement that consists of Paleozoic or older metamorphosed sediments. A series of north–northwest–south-southeast-oriented transtensional depocentres, including the King Island Sub-basin, lie to the east of the Sandy Cape Sub-basin; these comprise elongate and relatively isolated half graben.

The Strahan Sub-basin, located west of Macquarie Harbour, contains up to 4.5 s TWT of ?Lower Cretaceous to Cenozoic sediments(**Figure 3**). Cretaceous to early Cenozoic sedimentation was controlled by a large (40–50 km) arcuate fault system that forms the northern and eastern boundaries of the sub-basin (**Figure 6**). This fault system and the half-graben fill are interpreted to have formed in a north–south oriented transtensional or strike-slip stress regime (Stacey et al, 2013). The northern, east–west striking segment of the fault has a releasing bend, pull-apart geometry. The overlying post-rift Cenozoic section is relatively undeformed and onlaps basement.

The deep-water parts of the Sorell Basin, which are contiguous with the Nelson and Hunter sub-basins of the Otway Basin and lie to the west of the Sandy Cape and Strahan sub-basins, have poor data coverage and sub-basins have not been defined.

The Port Davey Sub-basin, in the southern part of the basin, is a narrow northwest-trending half graben bounded by landward-dipping faults. Based on analogy with the Strahan Sub-basin to the north, the half-graben fill is interpreted to be Late Cretaceous–Cenozoic in age. Exon et al (1997) identified an additional depocentre, the Toogee Sub-basin, on the lower continental slope southwest of the Port Davey Sub-basin (**Figure 7**). This depocentre, which is interpreted to contain a largely Cenozoic section, lies landward of a large northwest–southeast oriented strike-slip fault that has a strong seafloor expression (Toogee Ridge).

## Stratigraphy

From the Early Cretaceous to the Paleogene, the Sorell Basin evolved from a series of transtensional fluvio-lacustrine depocentres to an open seaway between Australia and Antarctica. The basin fill comprises five distinct and regionally mappable basin phases (**Figure 4**; Stacey et al, 2013); the Otway Basin sequence stratigraphy of Krassay et al (2004) has been adopted for the Sorell Basin as it is contiguous with the Otway Basin:

- Early Cretaceous extension and subsidence (Crayfish and Eumeralla supersequences)
- Late Cretaceous extension (Shipwreck Supersequence)
- Late Cretaceous subsidence/extension (Sherbrook Supersequence)
- Cenozoic subsidence/extension (Wangerrip Supersequence)
- Cenozoic subsidence and inversion (Nirrandra, Heytesbury and Whalers Bluff supersequences)

The basal Sorell Basin succession has not been intersected by drilling, but is interpreted to comprise Lower Cretaceous fluvial and lacustrine rocks, including coaly facies of the Eumeralla Supersequence (**Figure 4**). These rocks were deposited across much of the northern part of the basin, with deposition strongly influenced by the north–south oriented Avoca–Sorell Fault System. At this time, depocentres along the eastern margin of the basin were small and isolated. A period of structural inversion that affected most of the Otway Basin during the Cenomanian (Norvick and Smith, 2001; Krassay et al, 2004), resulted in only minor deformation in the Sandy Cape Sub-basin. No inversion is observed in the Strahan Sub-basin, where rifting was continuous.

Renewed extension in the early Late Cretaceous resulted in the deposition of fluvial and deltaic facies, and an increasing marine influence. During the Campanian–Maastrichtian a marginal marine to fluvio-deltaic succession accumulated throughout the northern Sorell Basin; coaly sediments of this age were intersected by Cape Sorell 1 in the Strahan Sub-basin. Correlation of the Port Davey Sub-basin succession with the Strahan Sub-basin suggests that the syn-rift fill is also Upper Cretaceous, although some authors have suggested this section is possibly Paleocene and younger (Moore et al, 1992).

The Late Cretaceous culminated in the commencement of breakup in the Otway Basin to the north. Regionally, the base of the Cenozoic is marked by uplift and erosion followed by a prolonged period of subsidence. The significant Cretaceous–Cenozoic unconformity seen in the Otway Basin can also be observed in the Sandy Cape Sub-basin, but in the Strahan Sub-basin, half-graben growth wedges indicate that extension continued up until the early Eocene, at which time a local inversion event occurred. The structural history seen in the Strahan Sub-basin is consistent with continuation of a transtensional regime inboard of the developing transform margin. The Eocene inversion event may be related to the proximity, and passing, of the spreading ridge at this time.

Australian–Antarctic clearance and establishment of an open seaway between the continents occurred during the Eocene (Exon et al, 2001a, 2004), with estimates of the exact timing ranging from 43 Ma (Holford et al, 2011; Norvick and Smith, 2001) to 33.7 Ma (Exon et al, 2001a). The Eocene to Holocene section in the Sorell Basin consists of a series of aggradational to progradational marine successions. Shallow-marine sandstones, marls and limestones of the Nirranda Supersequence are truncated by a major mid-Oligocene unconformity and overlain by upper Oligocene and younger shelfal marls and limestones of the Heytesbury and Whalers Bluff supersequences.

## Exploration history

The Sorell Basin is one of the least explored of Australia's southern margin basins. This frontier basin contains only three petroleum exploration wells—Clam 1, Cape Sorell 1 and Jarver 1 (**Figure 1**). Deep Sea Drilling Project (DSDP Leg 29 Site 282) and Ocean Drilling Program (ODP Leg 189 Site 1168) stratigraphic wells were drilled on the lower continental slope in the western Sorell Basin (Exon et al, 2001b). The focus of exploration has been on the northern sub-basins, where the three petroleum exploration wells have been drilled.

The exploration history of the Sorell Basin has been reported by numerous authors (e.g. Hill et al, 1997; Lodwick et al, 1999) and succinctly summarised by O'Brien et al (2004). Petroleum exploration began in the late 1960s, when Esso Exploration and Production Australia (Esso) and Magellan Petroleum Australia (Magellan) obtained reconnaissance seismic data on the west Tasmanian margin (O'Brien et al, 2004). Esso drilled three wells: Clam 1 (1969) in the King Island Sub-basin while Prawn A1 (1967) and Whelk 1 (1970) were drilled in the adjacent Otway Basin to the northwest. All wells were dry and were plugged and abandoned.

There was a relative hiatus in exploration activity during the 1970s. During this time, reconnaissance seismic surveys by the Bureau of Mineral Resources, Geology and Geophysics (BMR, now Geoscience Australia [GA]) and Shell International along the western margin of Tasmania were the only major studies undertaken.

A new phase of exploration began in 1981 when Amoco Australia Petroleum Company (Amoco) carried out a seismic survey in the Strahan Sub-basin, followed by the drilling of Cape Sorell 1 in 1982. This well tested a rollover structure and recorded minor amounts of free oil and residual oil traces, despite being drilled off structure (Amoco Australia Petroleum Company, 1982). In 1990, Maxus Energy Corporation (Maxus) acquired a dense seismic grid in the Strahan Sub-basin. Although Maxus (1993) identified a number of drilling prospects, it failed to attract farm-in partners and the permit was relinquished (O'Brien et al, 2004).

Multi-beam swath mapping of the seabed was carried out by the Australian Geological Survey Organisation (AGSO; now GA) in 1994 (Exon et al, 1994), followed by regional seismic surveys (Survey 148 and Survey 159) in 1995 and 1996, respectively. In early 2000, AGSO undertook seafloor swath mapping and seismic reflection profiling along the upper continental slope using the RV L'Atalante (AUSTREA 1; Hill et al, 2000).

In 2001, Seismic Australia and Fugro-Geoteam AS acquired 3612 and 2034 line-km of non-exclusive seismic data over the deep-water Otway and northern Sorell basins (DS01 and DS02 surveys respectively), rekindling interest in the area. Santos had a major presence in the region from 2002 operating permits T/32P, T/33P, T/36P and T/48P, drilling the dry hole Jarver 1 in T/33P in 2008 (Pitman, 2008). During this phase of exploration, Santos reprocessed the Maxus seismic and acquired a 2D infill and a 3D survey over the Strahan Sub-basin as well as acquiring several 2D infill surveys over the Sandy Cape Sub-basin. Subsequently, all of the Santos permits were relinquished with the exception of T/32P, where the Santos share was taken over by Perenco (SE Australia) Pty Ltd in 2010. In 2011, Perenco acquired 1000 km<sup>2</sup> of 3D seismic over the Wolseley prospect, but surrendered the permit in 2014. There are no permits currently operating in the Sorell Basin.

The seismic coverage in the Sorell Basin includes a mixture of government and industry data. The northern part of the basin is well covered by a mixture of regional industry 2D grids, 2D infill grids and two recent 3D surveys—those acquired by Santos in the Strahan Sub-basin in 2008 and Perenco in the Sandy Cape Sub-basin in 2011. Key 2D seismic data sets include the Fugro DS-01 survey in the Sandy Cape Sub-basin, and the Maxus and Santos SS04 surveys in the Strahan Sub-basin. In comparison, seismic coverage south of the Strahan Sub-basin is extremely sparse; most of the seismic lines in this region being shallow, low resolution datasets collected during research cruises in the 1980s (e.g. Hinz et al, 1985; Exon et al, 1989). There is a greater than 100 km gap between industry seismic surveys in the Strahan Sub-basin and GA line 159-01, which transects the Port Davey Sub-basin.

Several potential field datasets are available for the Sorell Basin. Pre-2008 gravity data was mostly acquired in conjunction with seismic surveys and, as for the seismic coverage, is sparse towards the south of the basin. In 2008, over 70 000 line-km of new aeromagnetic data was acquired by Geoscience Australia and Mineral Resources Tasmania (MRT) over the western Tasmanian margin (Morse et al, 2009). These data were merged with onshore aeromagnetic datasets to create a near continuous coverage of southeastern Australia (Morse et al, 2009).

Of relevance in the northern Sorell Basin is the Otway Basin 2D Multiclient Marine Seismic Survey acquired in 2021 (Otway Basin 2DMC MSS; NOPSEMA, 2019). The survey consists of 7000 line kilometres across the underexplored deep-water part of the Otway Basin and northern-most Sorell Basin. The new data will improve imaging of the sedimentary section, enabling a reassessment of the prospectivity. This survey is part of a major regional petroleum geological review of the Otway Basin, being carried out by Geoscience Australia. Parts of the review will focus on the distribution of petroleum systems elements in the Early and Late Cretaceous sequences. Of special interest is the recognition of possible marginal marine environments in the deep-water area, which might be an analogue to the Late Cretaceous section in the Bight Basin. On completion of the study, the results and related data sets will be made publicly available. Additionally, an open file Petroleum Systems model across the study area will be released in 2021.

Currently there are no active exploration permits in the Sorell Basin (**Figure 8**). However, the neighbouring Otway Basin is an important gas-producing region with recent gas discoveries, providing potential access to the southeastern Australian energy market (**Figure 9**).

## Regional petroleum systems

Only three petroleum exploration wells have been drilled in the Sorell Basin, and all were dry. However, the presence of a Cretaceous basin fill up to 6000 m thick, which is interpreted to contain organic-rich coaly, deltaic and marine facies that are mature for hydrocarbon generation in much of the basin, as well as minor oil indications in one well (Cape Sorell 1 in the Strahan Sub-basin), indicate that active petroleum systems may be present in the basin.

Hydrocarbon discoveries on the Australian southern margin are assigned to the Austral Petroleum Supersystem (Bradshaw, 1993; Summons et al, 1998; Edwards et al, 1999), in which three subsystems are recognised:

Austral 1: Upper Jurassic to lowest Cretaceous fluvio-lacustrine shales (Crayfish Supersequence);

Austral 2: Lower Cretaceous fluvial and coaly facies (Crayfish and Eumeralla supersequences); and

Austral 3: Upper Cretaceous to lowest Cenozoic fluvio-deltaic facies (Shipwreck and Sherbrook supersequences).

Interpretation of seismic data suggests that depositional sequences that host active petroleum systems in the Otway Basin (Austral 2 and 3) are likely to be present in the Sorell Basin (Stacey et al, 2013).

## Well control

### *Cape Sorell 1 (1982)*

Cape Sorell 1 was drilled in 94 m of water in the Strahan Sub-basin by Amoco Australia Petroleum Company (1982). The well reached a total depth of 3528 mKB and was drilled to determine the presence of equivalents to the Upper Cretaceous Waarre Formation and Lower Cretaceous Pretty Hill Formation, which are prospective in the adjacent Otway Basin. The well targeted a structure with mapped areal closure of approximately 77 km<sup>2</sup> and 120–250 m of vertical closure at the Upper and Lower Cretaceous levels.

The stratigraphic section encountered was much younger than anticipated with the oldest rocks found to be of early Paleocene to Late Cretaceous age. No shows were recorded in the well, however traces of free oil were identified in the Maastrichtian section below 3000 m, and several minor gas indications were also recorded.

Log analyses revealed several clean reservoir intervals were intersected, however these were water saturated and unproductive. The well was plugged and abandoned as a dry hole.

### *Jarver 1 (2008)*

Jarver 1 was drilled in 567 m of water in the Sandy Cape Sub-basin by Santos Limited (2008). It was drilled to test the Upper Cretaceous play that has been proven in the Thylacine and Geographe fields that lie to the north in the Shipwreck Trough (Otway Basin). The Jarver prospect is a moderate relief 4-way dip closure defined by elevated amplitude. Thylacine Member equivalent sandstones sealed by the Belfast Mudstone equivalent were the primary target. The secondary target was Paaratte Formation equivalent sandstones sealed by intraformational shale. The well was drilled to a total depth of 3062 mRT, penetrating the entire Sorell Basin succession and intersecting approximately 38 m of basement. The well intersected the predicted succession and was plugged and abandoned. Interpretative data for this well is currently confidential.

## Petroleum Systems Elements

Sources	<ul style="list-style-type: none"><li>Upper Cretaceous–lowest Paleogene fluvial-deltaic Sherbrook Group equivalents (Turonian Waarre Formation and Coniacian–Santonian Belfast Mudstone) and marginal marine basal Wangerrip Group equivalents (Austral 3 unproven)</li><li>Aptian–Albian lower coastal plain and peat swamp Sherbrook Group equivalents (e.g. Eumeralla Formation shale and coal, Austral 2)</li></ul>
Reservoirs	<ul style="list-style-type: none"><li>Paleogene sandstones of the Wangerrip Group and Nirranda Group equivalents</li><li>Upper Cretaceous sandstones of the Sherbrook Group equivalents</li><li>Lower Cretaceous sandstones of the Otway Group equivalents</li></ul>
Seals	<p><i>Regional seals</i></p> <ul style="list-style-type: none"><li>Paleogene–Neogene marls and fine-grained limestone in the Heytesbury Group equivalents</li><li>Upper Cretaceous claystones and siltstones of the Sherbrook Group equivalents</li></ul> <p><i>Intraformational seals</i></p> <ul style="list-style-type: none"><li>Paleocene–Eocene Wangerrip Group equivalents</li><li>Upper Cretaceous Sherbrook Group equivalents</li><li>Lower Cretaceous Eumeralla Group equivalents</li></ul>
Traps	<ul style="list-style-type: none"><li>Faulted anticlines, tilted fault blocks with cross-fault seal, stratigraphic pinch-outs</li></ul>

## Source Rocks

The Austral 2 petroleum system contains potential source rocks of the Lower Cretaceous Eumeralla Supersequence, which typically comprise Type III kerogen and were deposited in fluvio-lacustrine environments. The Austral 3 petroleum system is based on potential source rocks of the Upper Cretaceous Shipwreck and Sherbrook supersequences that were deposited in fluvio-deltaic to marine environments.

In the Strahan Sub-basin, lower Maastrichtian (Austral 3) potential source rocks were intersected in Cape Sorell 1 in the lower Sherbrook Supersequence. Measured Total Organic Carbon (TOC) ranging from less than 1% to 18.6% and Hydrogen Index (HI) values indicative of Type II/III and Type III kerogen, suggest good potential for both oil and gas (Lodwick et al, 1999; Boreham et al, 2002). The maturity of these lower Maastrichtian potential source rocks has been assessed as immature–marginally mature (Boreham et al, 2002; Stacey et al, 2013; **Figure 10**). Cape Sorell 1 was not deep enough to intersect potential source rocks of the Austral 2 petroleum system; however, modelling for the Strahan Sub-basin indicates that if these source rocks are present, they are gas to oil mature in the main half graben (Stacey et al, 2013). Minor amounts of free oil were recorded in the Sherbrook Group in Cape Sorell 1. Whether the oil was generated locally or from deeper Sherbrook or Otway groups is uncertain, but its presence is encouraging evidence of an active Cretaceous petroleum system in the basin (Boreham et al, 2002).

Little is known about potential source rocks in the Sandy Cape Sub-basin or in the deep-water regions to the west; the only well drilled in the Sandy Cape Sub-basin (Jarver 1) terminated in conglomeratic basement overlain by a Flaxman Formation equivalent at the base of the Shipwreck Supersequence. Seismic interpretation suggests that a coaly Eumeralla Supersequence, similar to the section that hosts Austral 2 source rocks in the Otway Basin, is present in the sub-basin. In addition, the Upper Cretaceous succession is well developed across the northern part of the Sorell Basin, raising the potential for the presence of marine-influenced Austral 3 source rocks. Petroleum systems modelling suggests that, if present, these potential source rocks are mature for oil and gas generation in the Sandy Cape Sub-basin (Stacey et al, 2013; **Figure 11**).

## Reservoirs and seals

By analogy with the offshore Otway Basin, the primary reservoirs in the Sorell Basin are likely to be sandstones in the Shipwreck (Waarre Formation, Flaxman Formation and the “Thylacine Member” at the base of the Belfast Mudstone) and Sherbrook supersequences, and Eocene and Paleocene sandstones of the Wangerrip Supersequence. In wells drilled on the flanks of the sub-basins, the dominantly sandy Sorell Basin succession lacks the mudstones that seal and separate sandstone reservoirs of the Otway Basin (Lodwick et al, 1999); however, results from Jarver 1 suggest that such sequences may be better developed to the west, away from the flanks of the sub-basins (Stacey et al, 2013).

Petroleum systems modelling in the northern part of the Sorell Basin, where no wells have been drilled, suggests that porosity at the Waarre Formation level could be a major risk in distal parts of the sub-basin; however, good porosities at this level are expected on the platform and terrace region on the eastern side of the basin.

Jarver 1, in the southern Sandy Cape Sub-basin, targeted potential reservoir units in the “Thylacine Member” at the base of the Sherbrook Group sealed by the Belfast Mudstone, as well as the Paaratte Formation, with top seal provided by intra-formational seals. However, the porosities encountered were poor to very poor and the well was dry (Pitman, 2008). Jarver 1 also intersected a thick (344 m) claystone, siltstone and sandstone unit overlying the basal Upper Cretaceous sandstones. This unit, which can be interpreted on seismic data away from the well, may provide a regional seal for any hydrocarbon accumulation within the Waarre Formation, Flaxman Formation or “Thylacine Member” reservoirs. The marls and fine-grained limestone in the Heytesbury Group could also provide seals to Nirranda and Wangerrip group reservoirs.

In the Strahan Sub-basin, Cape Sorell 1 intersected a generally sandy section with few potential seals. Porosities in the Wangerrip Group are excellent (20–>30%), but the lack of seal limits their reservoir potential (Conolly and Galloway, 1995). Porosity decreases with depth, falling to <15% near the base of the well. Shaly interbeds up to 20 m thick in the Wangerrip Group indicate that potential intraformational seal facies may be present near the sub-basin margin. It is important to note that as the well was drilled close to the basin-bounding fault, the lithofacies encountered in the well are unlikely to be representative of the rest of the sub-basin, which is likely to be more shale-prone further to the west. Basinward of the well, a potential sealing facies in the Wangerrip Group may be formed by an Eocene flooding surface overlain by downlapping progrades (O'Brien et al, 2004). The relatively thin marls and fine-grained limestones in the Neogene Heytesbury Group could also be potential seals.

While seal has been identified as an issue in proximal parts of the basin, Stacey et al (2013) postulated that seal quality should improve basinward away from the eastern margin of the basin. The presence of thick seal units at Jarver 1 provides some support for this prediction.

## Timing of generation

Petroleum systems modelling in the northern Sorell Basin has revealed that, if source rocks are present at the predicted levels, generation and expulsion would have commenced in the Albian and ceased in the Paleocene (Stacey et al, 2013). A proportion of accumulated hydrocarbons are likely to have been lost as a result of the latest Cretaceous–Paleocene structural event, however, migration and accumulation continued throughout the Cenozoic and the model predicts present-day accumulations in mostly fault-related traps.

Petroleum systems modelling in the Strahan Sub-basin indicates that, if Austral 2 and 3 source rocks are present at the predicted levels, generation and expulsion would have occurred from the Late Cretaceous onwards and more or less ceased in the Eocene (Stacey et al, 2013). A proportion of accumulated hydrocarbons are likely to have been lost as a result of Paleocene/Eocene uplift and erosion, however, migration, remigration and accumulation continued throughout the Cenozoic.

Hydrocarbons have been reported from seafloor samples acquired in the Sandy Cape and Strahan sub-basins, and deeper water locations in the basin (Hinz et al, 1985; Exon et al, 1989; O'Brien et al, 2004). Initial analyses indicated that the hydrocarbons were thermogenic and represented seepage. However, the geochemistry of the low concentrations of headspace gases in these samples suggests that they are more consistent with background levels of hydrocarbons (Abrams, 2005; Abrams and Dahdah, 2011) and an origin cannot be confidently inferred (C. Boreham, Geoscience Australia, pers. comm. January 2013).

## Play types

In the Strahan Sub-basin, petroleum systems modelling suggests that migration pathways are updip towards the western edge of the basin, where the most likely trap scenarios are high-side fault blocks, stratigraphic pinch-outs and, to a lesser extent, small rollover anticlines with updip closure (Stacey et al, 2013). Fault-block traps are predicted in the basal Shipwreck Supersequence (Waarre Formation) and at the base of the Wangerrip Group, charged by both Austral 2 and 3 source rocks. A pinch-out play is present along the western edge of the sub-basin where the sediments thin across the hinge of the half graben; such stratigraphic traps are likely to be charged by Austral 2 and 3 sources. Other potential traps in the sub-basin include rollover closures associated with major bounding faults, drape anticlines over canyons and fault blocks in the Wangerrip Group, and stratigraphic traps associated with Paleocene–early Eocene canyons.

The Sandy Cape Sub-basin partly underlies the continental shelf and attains a maximum thickness of approximately 6000 m. Similar sediment thicknesses underlie large areas of the continental slope in the southward deep water continuation of the adjacent Otway Basin (Nelson Sub-basin). These continental slope depocentres represent a vast, downdip, kitchen area where, if present, oil-prone Austral 3 source rocks are likely to be in the peak generation window (O'Brien et al, 2004). Petroleum systems modelling in the northern part of the basin indicates accumulations are most likely developed in structural traps (high-side fault traps and faulted anticlines) in the Waarre Formation and Sherbrook Groups (Stacey et al, 2013). Prospectivity of the deep-water basin is considered to be reliant on reservoir and seal pairs being present within the Sherbrook Supersequence. However, if these are at shallow depths, biodegradation may be a risk (Stacey et al, 2013). Paleocene–early Eocene canyons like those mapped in the Strahan Sub-basin also occur in the Sandy Cape Sub-basin, where they have the potential to form substantial stratigraphic traps if suitable seals are present. The canyons may also act as conduits for migrating hydrocarbons generated in the thick depocentres under the continental slope.

## Geoscience Australia products and data

A range of Geoscience Australia's publications, data and products cited throughout the text are available via the links provided in the references. Themes include basin geology, stratigraphy, organic geochemistry, petroleum systems and prospectivity.

### Regional geology and stratigraphy

- [Geoscience Australia's Basin Biozonation and Stratigraphy Chart Series](#): Otway and Sorrell Basins Biozonation and Stratigraphy, 2015, [Chart 34 by Kelman et al.](#)
- Petroleum geology inventory of Australia's offshore frontier basins. [Geoscience Australia Record by Totterdell et al, 2014.](#)
- Geology and hydrocarbon prospectivity of the deepwater Otway and Sorell basins, offshore southeastern Australia. [Geoscience Australia Record by Stacey et al, 2013.](#)
- Basement structure and its influence on the pattern and geometry of continental rifting and breakup along Australia's southern rift margin. [Geoscience Australia Record by Gibson et al, 2012.](#)
- Sorell Basin – Tasmania petroleum prospectivity bulletin. [Australian Geological Survey Organisation electronic resource by Lodwick et al, 1999.](#)
- AUSCAN seafloor mapping and geological sampling survey on the Australian southern margin. [Geoscience Australia Record by Hill and De Deckker, 2004.](#)

### Data discovery tools

- The [National Offshore Petroleum Information Management System \(NOPIMS\)](#) provides access to wells and survey data acquired primarily in Commonwealth waters and submitted under legislation, currently the Offshore Petroleum and Greenhouse Gas Storage Act 2006. This data can be downloaded or packaged on request. NOPIMS has been upgraded to provide access to over 50 years of data submission of well and survey information. It represents more than 1 million records and includes an [interactive mapping tool](#) for data discovery.
- [Geoscience Australia's Data Discovery Portal](#) provides full access to Geoscience Australia data and other publically available data sources as well as a suite of analytical and multi-criteria assessment tools. This includes the [Acreage Release](#) and [Energy](#) personas that allow access to a wide range of geological and geospatial data. Themes include source rock geochemistry, petroleum wells, stratigraphic information, province and basin geology, geophysical survey data coverage and other fundamental geospatial and administrative datasets.



- The [National Petroleum Wells Database](#) application provides access to Geoscience Australia's Oracle petroleum wells databases. Data themes include header data, biostratigraphy, organic geochemistry, reservoir and facies, stratigraphy, velocity and directional surveys. Data is included for offshore and onshore regions, however scientific data entry is generally limited to offshore wells and is dependent on Geoscience Australia's project activities.

## Marine and environment information

The following section contains information about the marine protected areas, their management plans and the oceanographic, physiographic and ecological characteristics of the marine environments within the Sorell Basin (**Figure 12**). The information is provided in support of business decisions with respect to planned exploration and development activities. Potential hazards of note include storms and swell generated by the Southern Ocean, and the risk to seabed installations of undersea landslides in deeper areas of the continental slope.

### Marine Parks

Australian Marine Parks (Commonwealth reserves proclaimed under the EPBC Act in 2007 and 2013) are located in Commonwealth waters that start at the outer edge of state and territory waters, generally three nautical miles (nm) (5.6 km) from the shore, and extend to the outer boundary of Australia's Exclusive Economic Zone, 200 nm (370.4 km) from the shore. Marine parks have also been established by the state and territory governments in their respective waters. The marine parks operate under management plans that provide a balance between protection of the marine environment, and sustainable use of the area. Links to these management plans are provided for each marine park in the Sorell Basin region.

#### *Australian Marine Parks: South-east Marine Parks Network*

The South-east Network comprises fourteen Australian Marine Parks, together representing examples of the ecosystems of the South-east Marine Region, which incorporates Commonwealth waters extending from near the far south coast of New South Wales, around Tasmania and west to Kangaroo Island in South Australia. It also includes the Commonwealth waters of Bass Strait and those surrounding Macquarie Island in the Southern Ocean. The Commonwealth marine area starts at the outer edge of state waters, 3 nm (5.6 km) from the shore (territorial sea baseline), and extends to the outer boundary of Australia's exclusive economic zone, 200 nm (370.4 km) from the territorial sea baseline. State and territory jurisdictions extend from the shoreline to 3 nm (5.6 km) offshore.

The South-east Marine Region is recognised as a major marine biogeographic region within the temperate oceanic realm. When compared to most of the world's marine environments, those of temperate Australia display an enormous diversity of plant and animal species and are believed to have the most diverse marine floral assemblage in the world. High diversity in terms of the number of species is a feature common to many plant and animal communities in the region. In addition to high diversity, the region has large numbers of endemic species, that is, species found nowhere else in the world.

Significant variation in water depth and sea-floor features found throughout the South-east Marine Region are contributing factors to the high level of species diversity in the region. Sections of the continental shelf, including Bass Strait, have a mosaic of rocky reefs and soft sediments. These shelf habitats support a diverse range of species from a broad range of taxonomic groups. The shelf break, which includes the edges of the continental shelf and the upper continental slope, serves to intensify currents, eddies and upwelling, creating a rich and productive area for biodiversity, including species that are fished commercially and recreationally.

Submarine canyons along the continental margin are identified as important ecological features in the South-east region. Canyons can have steep or rugged topography that provide habitat for sessile invertebrates, such as corals and sponges, which in turn attract other organisms including higher order fish species. Depending on their size and shape, canyons can intensify local currents and the concentrate nutrients to enhance productivity and biodiversity.

Seven of the marine parks within the South-east Marine Parks Network intersect or are within proximity to the Sorell Basin (**Figure 15**). Tasman Fracture Marine Park, Franklin Marine Park and Zeehan Marine Park overlie Sorell Basin. Apollo Marine Park, Boags Marine Park and Beagle Marine Park are in Bass Strait to the northeast of Sorell Basin and Huon Marine Park is located to the east of the southern portion of the basin.

Management plans for the South-east Marine Parks Network are in place, and can be viewed at: <https://parksaustralia.gov.au/marine/pub/plans/se-network-management-plan2013-23.pdf>

### *Tasman Fracture Marine Park*

Tasman Fracture Marine Park extends south-west of Tasmania from the continental shelf to Australia's exclusive economic zone boundary, 200 nm from land. The marine park spans the continental shelf, continental slope and deeper water ecosystems south of Tasmania, and is scored by steep canyons. It also encloses other geological features, including steep escarpments and troughs, saddles, basins, and part of a plateau that is over 400 km long and rises up to 3 km above the sea floor. The marine park includes a number of undersea peaks rising to less than 1500 m below the sea surface that provide habitat to deep-water hard corals. These corals provide a structure and habitat for a rich diversity of marine invertebrate animals that live attached corals. Waters of the marine park are home to many species of seabirds, seals and cetaceans, such as dolphins and killer whales. Partly surrounded by the marine park is Mewstone Island, a Tasmanian nature reserve, which has the largest breeding population of the shy albatross. Due to its southerly location, extending south of the subtropical convergence zone and into the subantarctic front, the fauna of this marine park includes subantarctic fishes and seabed invertebrates on the continental shelf and slope. Biodiversity in this marine park is influenced by the most easterly extent of flow of the Zeehan Current.

#### **Statement of significance**

- Ecosystems, habitats and communities associated with the Tasmania Province, the Tasmanian Shelf Province and the West Tasmania Transition.
- Associated with the following sea-floor features: abyssal plain/deep ocean floor, basin, canyon, knoll/abyssal hill, pinnacle, plateau, ridge, saddle, shelf, slope, terrace, and trench/trough.
- Important migration area for humpback whale.
- Important foraging areas for New Zealand fur seal and sea birds, notably the wandering, black-browed and shy albatrosses, white-chinned petrel, common diving petrel, short-tailed shearwater, and fairy prion.

The park has three zones. In the Multiple Use Zone IUCN Category VI, mining operations including exploration are allowed in accordance with a permit or a class approval. In the Special Purpose Zone IUCN Category VI, limited mining operations and low level extractive activities are allowed in accordance with a permit or a class approval. In the Marine National Park Zone IUCN Category II, mining operations including exploration are not allowed.

### *Franklin Marine Park*

Franklin Marine Park is west of the north-western corner of Tasmania and south-east of King Island. The marine park represents an area of shallow continental shelf ecosystems and incorporates areas of two major bioregions: western Bass Strait and the Tasmanian shelf. These cool temperate waters are exposed to large swells driven by westerly gales. At its northern end, the waters are only 40 m deep, and in much of the marine park the sea floor slopes gently and is covered by fine and coarse sediments. At the southern end of the marine park there is a valley where the water is up to 150 m deep. The marine park provides a feeding ground for a variety of seabirds, such as the fairy prion, shy albatross, silver gull, short-tailed shearwater, black-faced cormorant and common diving petrel that have breeding colonies on the nearby Hunter group of islands. Black Pyramid Rock, 6 km north of the marine park supports the largest breeding colony of the Australasian gannet in Tasmania, and one of only eight breeding sites for this species in Australia. White shark also forage in the marine park.

#### **Statement of significance**

- Ecosystems, habitats and communities associated with the Tasmanian Shelf Province and the Western Bass Strait Shelf Transition.
- Associated with the following sea-floor features: shelf, deep/hole/valley, escarpment and plateau.
- Important foraging areas for sea birds, notably Shy Albatross, Short-tailed Shearwater, Australasian Gannet, Fairy Prion, Little Penguin, common diving Petrel, Black-faced Cormorant and Silver Gull.

The park is zoned Multiple Use Zone IUCN Category VI. Mining operations, including exploration, are allowed in accordance with a permit or a class approval.

### *Zeehan Marine Park*

Zeehan Marine Park is north-west of Tasmania. The marine park covers a broad depth range, from the shallow continental shelf at a depth of about 50 m to the abyssal plain, which is over 3000 m deep. A significant feature of this marine park is a series of four submarine canyons that incise the continental slope, extending from the shelf edge to the abyssal plain. Biodiversity and productivity on the outer shelf and upper slope in this marine park are influenced by the Zeehan Current and its interactions with the canyons. The reserve includes a variety of seabed habitats, including exposed limestone, that support rich animal communities of large sponges and other, permanently fixed, invertebrates on the continental shelf. There are also extensive 'thickets' of low invertebrate animals, such as lace corals and sponges, on the continental slope. These communities are exceptionally diverse and include species new to science. The rocky limestone provides important habitats for a variety of commercial fish species, including Australia's giant crab. Concentrations of larval blue warehou and ocean perch indicate the area is a nursery ground. It is also a foraging area for a variety of seabirds and white shark.

### **Statement of significance**

- Ecosystems, habitats and communities associated with the Tasmania Province, the West Tasmania Transition and the Western Bass Strait Shelf Transition.
- Associated with the following sea-floor features: abyssal plain/deep ocean floor, canyon, deep/hole/valley, knoll/abyssal hill, shelf and slope.
- Important migration areas for Blue and Humpback whales.
- Important foraging areas for sea birds, notably Black-browed, Wandering and Shy Albatrosses, and Great-winged and Cape Petrels.

The park has two zones. In the Multiple Use Zone IUCN Category VI, mining operations including exploration are allowed in accordance with a permit or a class approval. In the Special Purpose Zone IUCN Category VI, limited mining operations and low level extractive activities are allowed in accordance with a permit or a class approval.

### *Apollo Marine Park*

The Apollo Marine Park is in Bass Strait south of Cape Otway and Apollo Bay in western Victoria, and north-west of King Island. The marine park represents the continental shelf that extends from South Australia to the west of Tasmania. The cool waters of the marine park are less than 50 m deep near Cape Otway. The marine park includes the Otway Depression, a 100 m deep undersea valley joining the Bass Basin to the deeper ocean. This valley was an outlet channel for the ancient Bass Lake and mainland river systems, during the last ice age. The waters of the marine park are exposed to large swell waves generated from the southwest, as well as strong tidal flows. The sea floor has many rocky reef patches interspersed with areas of sediment and, in places, has rich, benthic fauna dominated by sponges.

### **Statement of significance**

- Seabirds, dolphins and seals forage in the reserve.

- Ecosystems, habitats and communities associated with the Western Bass Strait Shelf Transition and the Bass Strait Shelf Province.
- Associated with the following seafloor features: deep/hole/valley and shelf.
- Important migration area for Blue, Fin, Sei, and Humpback whales.
- Important foraging area for sea birds, notably Black-browed and Shy Albatrosses, Australasian Gannet, Short-Tailed Shearwater, Crested Tern. Also a foraging area for White Shark.

Cultural and Heritage site: Wreck of the MV City of Rayville

The park is zoned Multiple Use Zone IUCN Category VI. Mining operations, including exploration, are allowed in accordance with a permit or a class approval.

### *Beagle Marine Park*

Beagle Marine Park lies entirely within Bass Strait, with its northwestern edge abutting Victorian waters southeast of Wilson's Promontory. It is a shallow-water reserve surrounding a collection of Bass Strait islands.

The marine park represents an area of shallow continental shelf ecosystems in depths of about 50–70 m that extends around south-eastern Australia to the east of Tasmania. The sea floor that it covers formed a land bridge between Tasmania and Victoria during the last ice age 10,000 years ago. Its boundary encloses Tasmania's Kent Group Marine Reserve and the Hogan and Curtis Island groups. Nearby to the north-east is Victoria's Wilsons Promontory Marine National Park. The marine park encompasses the fauna of central Bass Strait, which is expected to be especially rich based on studies of several sea floor-dwelling animal groups. Its ecosystems are mainly based around habitats of rocky reefs supporting beds of encrusting, erect and branching sponges, and sediment composed of shell grit with patches of large sponges and sparse sponge habitats. Islands encompassed by the marine park and nearby islands support important breeding colonies for many seabirds and for the Australian fur seal. The waters of the marine park provide an important foraging area for those species breeding nearby. The rich marine life also attracts top predators, such as the great white shark and killer whales. The SS Cambridge, a British freighter, which lies in the marine park to the east of Wilson's Promontory, was sunk in 1940 by a WWII mine. The trading ketch Eliza Davies, which lies in the marine park to the east of Wilson's Promontory, sunk under tow in 1924.

### **Statement of significance**

- Ecosystems, habitats and communities associated with the Southeast Shelf Transition
- Associated with the following sea-floor features: basin, plateau, shelf and sill
- Important migration path for the Southern Right Whale.
- Important foraging area for Australian Fur Seal, Killer Whale, White Shark, Shy Albatross, Australasian Gannet, Short-tailed Shearwater, Pacific and Silver gulls, Crested Tern, Common Diving Petrel, Fairy Prion, Black-faced Cormorant, and Little Penguin.
- The park contains cultural and heritage sites including the wreck of the steamship SS Cambridge and the wreck of the ketch Eliza Davies.

The park is zoned Multiple Use Zone IUCN Category VI. Mining operations, including exploration, are allowed in accordance with a permit or a class approval.

### *Boags Marine Park*

The Boags Marine Park is off the north-west tip of Tasmania, north of Three Hummock Island. The marine park represents an area of shallow ecosystems that has a depth range mostly between 40 m and 80 m. It encompasses the fauna of central Bass Strait, which is expected to be especially rich based on studies of several sea floor–dwelling animal groups. The marine park contains a rich array of life, particularly bottom-dwelling animals and animals living in the sea-floor sediments and muds, such as crustaceans, polychaete worms and molluscs, as is common for the Bass Strait seabed. The marine park is adjacent to the important seabird breeding colonies of Tasmania's north-west, particularly the Hunter group of islands (Three Hummock Island, Hunter Island, Steep Island, Bird Island, Stack Island and Penguin Islet), and so is an important foraging area for a variety of seabirds. White shark also forage in the marine park.

#### **Statement of significance**

- Ecosystems, habitats and communities associated with the Bass Strait Shelf Province.
- Associated with the following sea-floor features: plateau and tidal sandwave/sandbank.
- Important foraging area for sea birds, notably shy albatross, Australasian Gannet, Short-tailed Shearwater, Fairy prion, Black-faced Cormorant, Common diving Petrel and Little Penguin.

The park is zoned Multiple Use Zone IUCN Category VI. Mining operations, including exploration, are allowed in accordance with a permit or a class approval.

### *Huon Marine Park*

Huon Marine Park is located south-east of Tasmania. The marine park covers a broad depth range from the inner continental shelf at about 70 m, to abyssal depths of more than 3000 m. The majority of the area is in deep water. The marine park contains a cluster of seamounts that appear as cone-shaped submerged mountains, which provide a range of depths for a diversity of plants and animals. The peaks of many of the park's seamounts are between 750 m and 1000 m below the sea surface and support endemic species, including large erect corals and sponges. Some of the flora and fauna are hundreds and possibly thousands of years old, making them some of the longest-lived animals on Earth. The marine park also provides an important connection between seamounts of the Indian Ocean and the Tasman Sea. Seamounts are regarded as areas of increased productivity in the otherwise nutrient-poor open ocean. Their topography accelerates water currents to provide a consistent and relatively rich food source for filter feeders, and which sweeps the seamounts clear of fine sediments, exposing rocks for animals, such as corals, to attach to. Seamounts are generally considered to be important stepping stones in the transoceanic dispersal of larvae of bottom-dwelling species. The habitat protection zone was established to protect the unique and vulnerable benthic communities of the park's seamounts. The zone includes seamounts rising 650–1000 m above the sea floor, which have been subject to commercial fishing. Deeper seamounts, peaking at 1150–1700 m above the sea floor, have not been fished, and are in pristine condition. Benthic communities include coral dominated communities found at depths less than 1400 m. The hard coral *Solenastrea variabilis* forms a dense matrix that provides a platform for hydroids and sponges; stone corals; and black, gold and bamboo corals. Benthic communities deeper than 1400 m are urchin dominated. The marine park is a foraging area for white shark and seabirds and a spawning or nursery area for important commercial fish, including ocean perch and blue warehou.

#### **Statement of significance**

- Ecosystems, habitats and communities associated with the Tasmanian Shelf Province and the Tasmania Province.
- Associated with the following sea-floor features: canyon, knoll/abyssal hill (seamount), pinnacle, saddle, shelf and terrace.
- Features with high biodiversity and productivity: seamounts south and east of Tasmania.
- Important migration area for: humpback whale.
- Important foraging area for sea birds, notably Black-browed, Buller's and Shy Albatrosses, Great-winged Petrel, Short-tailed Shearwater and Fairy prion. Also a foraging area for Australian fur seal and killer whale.

The park has two zones. In the Multiple Use Zone IUCN Category VI, mining operations including exploration are allowed in accordance with a permit or a class approval. In the Habitat Protection Zone IUCN Category IV, mining operations including exploration are not allowed.

### ***Victorian Marine Protected Areas***

#### ***Discovery Bay Marine National Park***

The [Discovery Bay Marine National Park](#) (2770 ha) is located 20 km west of Portland, and protects part of the largest coastal basalt formation in western Victoria. The park is adjacent to Cape Bridgewater along the coast from Blacks Beach to Whites Beach and offshore to 3 nm (5.6 km). Between Whites Beach and Cape Duquesne the park boundary commences 500 m from the coastline.

The park comprises several habitats—intertidal rocky shores, subtidal rocky reef, subtidal soft sediment, and the water column—that provide for a range of significant marine fauna including mammals, birds and invertebrates. The park encompasses a section of the Bonney Coast, which is a productive area because of a nutrient-rich cold water upwelling. This high productivity provides an important feeding ground for seabirds, fur seals and whales, and supports commercially important fishery species and significant recreational fishing in the area. The park provides feeding and roosting habitat for fifteen threatened bird species, and feeding area for ten internationally significant migratory bird species.

#### ***Point Addis Marine National Park***

The [Point Addis Marine National Park](#) (4600 ha) is located about 25 km southwest of Geelong. It extends offshore from the high water mark along 10 km of coastline east of Anglesea, around Point Addis to the eastern end of Bells Beach, and offshore approximately 3 nm (5.6 km) to the limit of Victorian waters. The park includes all waters within these boundaries and extends 200 m beneath the seabed.

The park protects representative examples of subtidal soft sediments, subtidal rocky reef, rhodolith (benthic marine red algae) beds, and intertidal rocky reef habitats. These substrates provide habitat for a range of invertebrates, fish, algae, birds and other wildlife. The park also has cultural importance based on evidence of a long history of Indigenous use, and contains surf breaks that are culturally important to many people associated with surfing. The park is zoned a National Park IUCN Category II. Category II areas are managed primarily for ecosystem protection and recreation.

#### ***Port Phillip Heads Marine National Park***

The [Port Phillip Heads Marine National Park](#) (3580 ha) is located at the southern end of Port Phillip, about 60 km southwest of Melbourne, and stretches along 40 km of coastline. The park comprises six sections: Swan Bay, Mud Islands, Point Lonsdale, Point Nepean, Popes Eye and Portsea Hole.

The park supports a great diversity of marine species, due to the presence of diverse habitats ranging from mudflats and seagrass to deep and shallow reefs, rocky shores, and pelagic waters. The area marks the end of range for some animals that prefer the cold waters of western Victoria, whilst also supporting warm-water species from eastern Australia. The waters of Port Phillip also provide shipping access to one of Australia's busiest seaports, and contain heritage-listed shipwrecks. The park is zoned a National Park IUCN Category II. Category II areas are managed primarily for ecosystem protection and recreation.

#### ***Twelve Apostles Marine National Park***

The [Twelve Apostles Marine National Park](#) (7500 ha) is southeast of Port Campbell between Broken Head and Pebble Point, and extends offshore 3 nm (5.6 km) to the limit of Victorian waters.

The park protects unique limestone rock formations—including the iconic cliffs and pillars of the Twelve Apostles—and a range of marine habitats representative of the Otway marine bioregion. The park also protects Indigenous culture based on a spiritual connection to sea country and a history of marine resource use, as well as the wreck of the clipper Loch Ard.

Arches, canyons, fissures, gutters and deep sloping reefs support kelp forests, sponge gardens, habitat for seabirds, seals, lobsters, reef fish and sea spiders. Marine mammals visit the area and Little Penguins nest in the caves below the Twelve Apostles. The park is zoned a National Park IUCN Category II. Category II areas are managed primarily for ecosystem protection and recreation. All forms of extraction are prohibited in the park (Parks Victoria, 2006).

### *The Arches Marine Sanctuary*

The [Arches Marine Sanctuary](#) (45 ha) is approximately 600 m offshore from Port Campbell. The sanctuary is in the vicinity of the Twelve Apostles Marine Park, and the two areas are covered by the same management plan.

The sanctuary protects important features including underwater limestone formations of arches and canyons, a diverse range of encrusting invertebrates, and Indigenous culture based on a spiritual connection to sea country, as well as spectacular scuba diving areas. Waters of the sanctuary are characterised by high-energy waves and cool waters. There is a diverse array of life including gorgonians, sponges, bryozoans and hydroids. The upper side of limestone structures are covered in the thick, brown kelp *Ecklonia radiata* with an understory of delicate red algae. These habitats support schools of reef fish, seals and a range of invertebrates such as lobster, abalone and sea urchin.

## **Biologically important areas**

The Sorell Basin overlaps or is close to the following biologically important areas:

- The Antipodean, Black-browed, Buller's, Campbell, Indian Yellow-Nosed, Shy, and Wandering albatross forage in the region.
- The Common Diving-Petrel forages in the region year-round, and breeds on islands in the region from July to January. The Sorell Basin also overlaps important foraging/breeding areas for the Black-faced cormorant, Little penguin, Short-tailed shearwater and White-faced storm-petrel.
- The basin overlaps the migratory corridor of the Pygmy Blue Whale, and the region is a known important foraging area, with seasonal high density. Southern Right Whales also occur in the region from May to November.
- The basin overlaps the White Shark distribution area, also used as a breeding nursery and opportunistic feeding area in autumn, winter, and spring. White Sharks generally occur in water depths between 120 m and 1000 m.

The [National Conservation Values Atlas](#) and the [Atlas of Living Australia](#) provide further information and visualisations concerning animals and plants recorded in the Sorell Basin region.

## **Heritage**

### *Maritime Heritage*

Australia protects its shipwrecks and associated relics that are older than 75 years through the [Historic Shipwrecks Act 1976](#). There are many shipwrecks along the west coast of Tasmania that lie close to or within the eastern limit of the Sorell Basin that are not associated with a defined protected zone. These can be identified using the [Australian National Shipwreck Database](#) map search tool.

## **Fisheries**

Fishing effort varies spatiotemporally in the region based on fishing restrictions, stock status and environmental conditions (Larcombe et al, 2001). The following [Commonwealth Fisheries](#) occur within the Sorell Basin area:



[The Bass Strait Central Zone Scallop Fishery](#) operates in the Bass Strait north of Tasmania and extends from the Victoria/New South Wales border around to the Victoria/South Australian border. The fishery is between the Victorian and Tasmanian scallop fisheries that lie within 20 nm (37.0 km) of their respective coasts. The fishing season is a period determined by AFMA, typically July to 31 December.

[The Eastern Tuna and Billfish Fishery](#) extends from Cape York in Queensland to the South Australian/Victoria border. Fishing occurs both in the Australian Fishing Zone (generally between 3 nm and 200 nm [5.6-370.4 km] from the coast) and adjacent high seas. The fishing season generally runs for 12 months, starting on 1 January.

[The Small Pelagic Fishery](#) extends from the Queensland/New South Wales border, typically outside 3 nm (5.6 km), around southern Australia to a line at latitude 31°S (near Lancelin, north of Perth). The Sorell Basin intersects the western sub-area of this fishery. The fishing season runs for 12 months, starting on 1 May.

[The Southern and Eastern Scalefish and Shark Fishery](#) stretches south from Fraser Island in southern Queensland, around Tasmania, to Cape Leeuwin in southern Western Australia. The fishery comprises major sectors, of which three overlap the Sorell Basin: the Commonwealth South East Trawl Sector, the Scalefish Hook Sector, and the Shark Hook and Shark Gillnet Sector. The fishing season runs for 12 months, starting on 1 May.

[The Southern Bluefin Tuna Fishery](#) covers the entire sea area around Australia, out to 200 nm (370.4 km) from the coast. The fishing season runs for 12 months, starting on 1 December.

[The Southern Squid Jig Fishery](#) is located off New South Wales, Victoria, Tasmania and South Australia, and in a small area of oceanic water off southern Queensland. The fishing season runs for 12 months, starting on 1 January.

Nine [State Fisheries](#) are managed under the jurisdiction of Tasmania, all of which can occur within the Sorell Basin: [The Giant Crab Fishery](#) overlaps with Commonwealth waters and occurs primarily along the shelf edge in waters ~ 200 m, including the eastern Sorell Basin. [The Rock Lobster Fishery](#) operates on rocky reefs in more shallow waters, while [The Scalefish Fishery](#) operates throughout Tasmanian waters. The other fisheries are active in very shallow waters, generally < 20 m, and are therefore only applicable to the north eastern-most edge of the Sorell Basin.

## Climate

The region is characterised by a cool temperate climate. Precipitation is delivered throughout the year, and there are few temperature extremes. At the closest onshore weather station (Cape Otway Lighthouse), mean minimum and maximum temperatures were 7.5°C and 21.5°C respectively for the period 1864–2019 (Bureau of Meteorology, 2019). Mean annual rainfall over a 151 year period at Cape Otway Lighthouse is 894.8 mm. The region is at the edge of a known climate change hotspot (Oliver et al, 2013; Hobday and Hartog, 2016).

## Oceanic regime

The mean sea surface temperature in the Sorell Basin ranges between 12° C and 15° C. The area is mainly influenced by the Zeehan Current (Baines et al, 1983), which is the eastern end of the 5500 km long boundary flow off southern Australia (Ridgway and Condie, 2004). The Zeehan Current is sourced from the South Australian Current, which is a continuation of the Leeuwin Current further west. The Zeehan Current flows south along the west coast of Tasmania and is strongest in winter with the maximum speed up to 0.5 m/s. The northern part of the basin may also be affected by the 'Bass Strait Cascade' which originates from the shallow waters of western Bass Strait and flows eastward down the continental slope to depths of several hundred meters in the Tasman Sea (Luick et al, 1994). The mean chlorophyll-a concentrations of surface waters in the area range from 0.5 mg/m<sup>3</sup> to 0.7 mg/m<sup>3</sup>, with higher values in autumn and are typical for these oligotrophic (low nutrient levels) clear temperate waters. Despite some conflicting evidence, there may exist a productive ecosystem on the western Tasmanian shelf due to wind-driven upwelling (Kampf, 2015; Huang and Wang, 2019). The tidal regime in this area is microtidal (range up to 1 m), with mainly diurnal mixed tide. The mean significant wave height can be up to 4 m due to the influence of Southern Ocean storms. The wind regime is dominated by the southerly and south-westerly airflow during summer and northerly during winter.



## Seabed environments

Water depths within the Sorell Basin range from 50 to 5300 m, but the basin is dominantly a deep water environment with areas deeper than 2000 m covering 75% (59 760 km<sup>2</sup>) of the basin area (Exon et al, 1994, 1996). Shallower areas with depths less than 200 m cover 15% (11 260 km<sup>2</sup>) of the basin area, with the shallowest (~50 m) on the King Island Plateau in the northeast. Across these depths, the basin underlies a narrow (15–30 km) continental shelf (11 430 km<sup>2</sup>) and continental slope (72 370 km<sup>2</sup>), with a small area (880 km<sup>2</sup>) of abyssal plain along its western boundary. The shelf break occurs at approximately 150–170 m water depth and the slope break at 4500–5000 m. The shelf is low gradient (< 2 degrees) and characterised by surface deposits of reworked relict siliciclastic sediments, with minor amounts of shell debris (Jones and Davies, 1983).

On the continental slope, the sea floor is mainly blanketed by a relatively smooth cover of sediment, broken in places by protruding bedrock blocks that rise as much as 2.5 km above the surrounding surface (Hill et al 1997). The slope is characterised by numerous canyons and large-scale mass movement features. Canyons up to 100 m deep and over 60 km long act as conduits conveying sediment from the shelf edge to the lower slope and abyssal plain at depths of 4000–5000 m (Hill et al 1997). The largest canyons, which include Strahan Canyon and Pieman Canyon incise onto the continental shelf. The southern portion of the continental slope within Sorell Basin is characterised by slumps and mass-flow deposits, with the largest of these defined by a 50 km wide scar that is several hundred metres deep on the upper slope in the southeastern part of the basin and above the Port Davey Sub-basin (Exon et al, 1996). To the south of this slump scar the continental slope incorporates the Toogee Ridge that rises almost 2 km with steep scarps along its western flank, and a large saddle feature connecting the basin with the South Tasman Rise (Exon et al 1997; **Figure 15**).

Seabed sediments within the Sorell Basin form part of the larger cool-water carbonate province that encompasses Tasmania and the south eastern Australian mainland. Sediments on the continental shelf are dominantly coarse with high concentrations of calcium carbonate, comprising mostly bryozoan fragments. Siliciclastic material forms a minor part of the sediment due to minimal inputs of sediments from rivers on the west coast of Tasmania, and is largely relict. On the continental slope sediment composition is more variable with two distinct sediment populations; gravelly sand and sandy mud. These sediment facies indicate the dominant sediment processes on the slope, i.e. winnowing by currents to form gravelly sand deposits, and gravity driven processes and pelagic sedimentation to form sandy mud. Manganese crusts and nodules are widespread throughout the South Tasman Rise in areas of steep topography and flat abyssal plains, where deposition of pelagic sediment is minimal (Exon, 1997). It is inferred that manganese crusts and nodules are common in the abyssal depths of the Sorell Basin, however, no sampling has been undertaken to confirm this.

## Ecology

Pelagic and benthic habitats within the Sorell Basin support a diverse range of temperate marine species, with some Sub-Antarctic species also present. The submarine canyons that characterise the continental slope enhance seabed complexity, providing a range of habitats for pelagic, demersal and benthic species. Cold nutrient-rich water is periodically drawn up the canyons where it mixes with warmer surface waters of the shelf. This enhances biological productivity and makes the area an important feeding ground for many species. The pelagic environment of the region therefore hosts a wide variety of marine fauna including endangered and migratory animals, such as the Pygmy Blue Whale (*Balaenoptera musculus brevicauda*), which may use the offshore waters of the Sorell Basin as a foraging area during their migration to and from northern breeding grounds. These offshore areas are also important feeding grounds for a wealth of ocean-foraging seabirds, including several species of Albatross, some of which breed on islands around Tasmania.

Most knowledge of benthic habitats and biota within the Sorell Basin is derived from the shelf break and upper continental slope (depths 100–1500 m), while little is known about the benthos in areas deeper than 2000 m. Detailed benthic studies of canyon heads along the shelf break in depths of 114–612 m, identified a variety of benthic habitats, including rocky outcrops, fragile bryozoan thickets (that support high biodiversity), sponge and invertebrate gardens, and soft-sediments (Schlacher et al, 2007; Williams et al, 2009). In these studies, epifaunal diversity systematically decreased with depth (Schlacher et al, 2007; Williams et al, 2009). However, this pattern may be confounded by habitat type, as more complex habitats (e.g. bryozoans thickets and rocky outcrops) were recorded in shallower depths ( $\pm$  200 m) along the shelf break, while bare sediments characterised deeper habitats ( $\pm$  400 m) along the upper continental slope. Sponge cover and diversity increased as a function of bryozoan cover, with the former providing a valuable index for predicting the overall diversity of benthic epifaunal assemblages (Schlacher et al, 2007; Williams et al, 2009). Bryozoan thickets may also provide a feeding resource for the commercially important Tasmanian giant crab, *Pseudocarcinus gigas*. Giant Crabs were recorded in high abundance on soft-sediment upper slope habitats within canyon heads of the Sorell Basin, adjacent to extensive bryozoan thickets (Williams et al, 2009). Williams et al (2009) noted that the soft-sediments provide malleable habitats that allow Giant crabs to dig and burrow into for refuge, while the adjacent bryozoan thickets support numerous species of epi-benthic invertebrates, many of which are prey for giant crabs.

The continental shelf and slope off the west coast of Tasmania are important fishing grounds for demersal fishes and sharks (e.g. blue grenadier and gummy sharks), the Tasmanian giant crab (*Pseudocarcinus gigas*), scallops and squid (e.g. southern calamari). Fishery surveys targeting the shelf break and upper slopes of the continental margin along the west coast of Tasmania have identified high fish diversity, dominated by commercially important demersal and benthic-pelagic sharks and fishes. Benthic trawl fisheries and infrastructure activities, however, may have a major impact on fragile habitats, such as bryozoan-thickets and sponge gardens, which may support many of these fishery species.

## National seabed mapping data and information

Geoscience Australia provides bathymetry and acoustic backscatter data to assist in understanding the shape and composition of the sea floor. Geoscience Australia also maintains the Marine Sediment database ([MARS](#)), comprising information (e.g. percentage mud/sand/gravel, mean grain size, sediment texture) from seabed sediment samples collected during marine surveys between 1905 and 2017.

These data are discoverable and accessible through the AusSeabed [Marine Data Discovery Portal](#). AusSeabed is an innovative national seabed mapping initiative designed to coordinate data collection efforts in Australian waters and provide open access to quality-controlled seabed data.

## Other online information resources

Please follow these links for more detailed information pertaining to the marine and environmental summaries provided in this section.

- [Bureau of Meteorology: climate statistics](#)
- [National Conservation Values Atlas](#)
- Australian Marine Parks: [South-east Marine Parks Network](#)
- [Parks Victoria Marine protected areas](#)
- [Commonwealth Fisheries](#)
- [Victorian Fisheries Authority—Commercial Fisheries](#)
- [Historic shipwrecks](#)

- [Protected Matters Search Tool](#)

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## Figure Captions

- Figure 1** Map of the Sorell Basin showing bathymetry and distribution of petroleum exploration wells.
- Figure 2** Tectonic elements map of the Sorell Basin showing major faults, bathymetry, wells and location of seismic cross sections (Figures 5, 6 and 7).
- Figure 3** Structural elements of the Sorell Basin with major faults and mapped sediment thickness from Stacey et al (2013).
- Figure 4** Stratigraphic chart for the Sorell Basin including basin phases, lithostratigraphy, Otway Basin supersequences and horizons from Krassay et al. (2004), and hydrocarbon occurrences (after Stacey et al 2013; Geologic Time Scale after Gradstein et al, 2020).
- Figure 5** Seismic section DS01-126 through Whelk 1 across the southern Otway Basin and northern Sandy Cape Sub-basin, Sorell Basin (from Stacey et al., 2013). Location of the line shown on Figure 2. Seismic sequences are shown in Figure 4. For modelled present day maturity see Figure 11.
- Figure 6** Seismic line SS04-001 through Cape Sorell 1, Strahan Sub-basin (from Stacey et al, 2013). Location shown on Figure 2. Seismic sequences are shown in Figure 4. For modelled present day maturity see Figure 10.
- Figure 7** Seismic line s159-01 across the southern Sorell Basin identifying depocentres and tectonic features (after Totterdell et al., 2014). Location shown on Figure 2.
- Figure 8** Map showing the Sorell Basin and surrounding basins with their petroleum exploration permits, gas fields and petroleum production facilities.
- Figure 9** Map showing the Sorell Basin and surrounding basins with current operators, active exploration permits, retention leases, production licences, gas fields and pipelines.
- Figure 10** a) Geological model across the Strahan Sub-basin (seismic SS04-001) through Cape Sorell 1; and b) and modelled present-day maturity for same section (after Stacey et al, 2013). Location shown on Figure 2
- Figure 11** a) Geological model across the southern Otway basin and northern Sandy Cape Sub-basin (seismic line DS01-126) through Whelk 1; and b) and modelled present-day maturity for same section (after Stacey et al, 2013). Location shown on Figure 2
- Figure 12** Map showing marine reserves, marine parks, multiple use zones and ecological features in the Sorell Basin and surrounding areas.