IX-21 Southeast Australian Shelf: LME #42

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The Southeast Australian Shelf LME extends from Cape Howe, at the southern end of the State of New South Wales, to the estuary of the Murray-Darling river system in the State of South Australia. It borders the Southern Ocean and the western boundary currents flowing into the West Wind Drift, which circulates around the continent of Antarctica. The LME has a surface area of about 1.2 million km^2, of which 0.17% is protected (Sea Around Us 2007), and contains the island of Tasmania and the Bass Strait, which separates the island from the mainland state of Victoria. There are over 50 islands in Bass Strait, the largest and inhabited ones being Kings Island and Flinders Island. The Murray-Darling river system has a large catchment area, and it used to transport nutrients and sediments from the land into the coastal waters, but the river is heavily exploited and river flow is minimal. A book chapter on this LME has been published by Morgan (1989).

The region is characterised by sub-tropical species with southern Tasmania being Australia's main temperate region. The area has a large and variable marine flora and fauna including a large number of endemic species and is of high conservation value (Hoese et al. 2006).

The southeast region is the meeting place of two of Australia's main currents. The East Australian current (see Eastern Australian LME) brings low nutrient waters into south eastern Australia before heading offshore off eastern Tasmania. The Leeuwin Current (see Western Australian LME) brings low nutrient waters into southern Australia and down the western region of Tasmania. Off western Tasmania this current is often referred to as the Zeehan Current (Baines et al. 1983). Higher nutrient waters are brought to southern Tasmania from the sub-Antarctic waters. The Flinders Current is a westward flow along the 600 m isobath, from western Bass Strait to Kangaroo Island (Middleton and Bye 2007). An upwelling system off the Bonney Coast between southeastern South Australia and Victoria also brings nutrients to the surface.

I. Productivity

The Southeast Australian Shelf LME has a diversity of habitats such as seagrass beds, mud flats, intertidal and sub-tidal rocky reefs, kelp forests and pelagic systems. It is considered a Class III, low productive ecosystem (<150 $gCm^{-2}yr^{-1}$). Estimates of the mean annual primary productivity from 1998-2006 of the southeast Australian continental shelf vary between 68 and 251 $gCm^{-2}d^{-1}$ (www.science.oregonstate.edu/ocean.productivity/) depending whether the estimate is based on chlorophyll or particulate carbon concentration, and if a temperature correction is applied. The Sea Around Us project estimates mean primary productivity at 187 g C m^{-2} d^{-1}. The large range of values may result from the atypically low nutrient concentrations for a shelf system at this latitude - a result of low continental discharge and poleward flowing boundary currents.
It is a temperate marine environment inhabited by communities rich in species, many of which are endemic to Australia. Investigations in Bass Strait and the south-eastern slope have revealed soft-bottom benthic communities more diverse than anywhere else in the world. For example, of the 638 species of fish recorded for Tasmania, 38 (6%) are endemic to Tasmania and 273 (43%) are endemic to Australia (Hoese et al. 2006).

Near the island of Tasmania, seasonal storm events accelerate the mixing of nutrients onto the shelf. Runoff from the Murray-Darling river system was a regional contributor to shelf nutrient processes and fluxes. For a general understanding of oceanographic processes affecting the nutrient dynamics and productivity of Australian marine ecosystems, see Australia's State of the Environment (SOE) Report 2006 (www.deh.gov.au/soe/index.html). Reports by States and Territories and National environment audits are available from this index. For more information on productivity, nutrient dynamics and land-sea interactions, see Furnas (1995) and UNEP (2003).

In the southwest of this LME strong westerly winds drive colder nutrient rich sub-Antarctic waters up the east coast of Tasmania. These waters are characterised by high nitrate and dissolved organic nitrogen concentrations in surface waters. These cooler windy periods result in less oligotrophic conditions with the phytoplankton dominated by large diatoms and the zooplankton by larger species such as krill. In years of strong westerlies the phytoplankton biomass and productivity increase and the spring bloom lasts longer. In such years, the zooplankton biomass increased 10 fold in late spring. In contrast, the surface waters in the summer and autumn period (January to July) reflect the intrusion of sub-tropical water which can be detected by increased salinities and very low dissolved inorganic phosphorus. This period coincides with a reduction in the westerly wind stress. These calmer warmer periods result in more oligotrophic conditions when the phytoplankton is dominated by small dinoflagellates and the zooplankton by small copepods (Harris et al., 1988; Harris et al., 1991; Clementson et al., 1989).

Productivity in the northwest of the LME is dominated by summer upwelling events. The largest of these is the Bonney upwelling in southeastern South Australia adjacent to the Victorian border. During winter the Leeuwin Current moves eastwards along the south Australian coast to the southern tip of Tasmania (Cirano and Middleton 2004; Cresswell and Peterson 1993; Godfrey et al. 1986). In the summer, the coastal wind reverses and changes to induce upwelling producing a westward flow at the coastal boundary (Middleton and Platov 2005). Sub-surface upwelling extends in an almost continuous band from the Bonney Coast to western Tasmania. Extensive areas of krill have been observed along this shelf margin, Hunter group of islands and King Island and the region has high conservation values, including the pygmy blue whale (Butler et al. 2002). La Nina years are associated with a weaker influence of the East Australian Current in Eastern Bass Strait and the Leeuwin Current in western Bass Strait. During this time cooler waters enter Bass Strait from the Bonney upwelling and the Flinders Current.

Oceanic fronts: The East Australian Current (EAC) carries tropical waters from the East-Central Australian Shelf LME into the Southeast Australian Shelf LME to feed a southward EAC and mesoscale eddies off eastern Tasmania (Figure IX-21.1). The Zeehan Current is the final extension of the Leeuwen Current along western Tasmania. East of Kangaroo Island the Flinders Current is probably responsible for intermittent upwelling in the deep canyon systems off the western Victorian Shelf. The Kangaroo Island Front (KIF) develops seasonally southeast of Kangaroo Island caused by wind-driven coastal upwelling (Belkin & Cornillon 2003, Belkin *et al*. 2009).

Southeast Australian Shelf LME SST (after Belkin 2009)
Linear SST trend since 1957: 0.53°C.
Linear SST trend since 1982: 0.20°C.

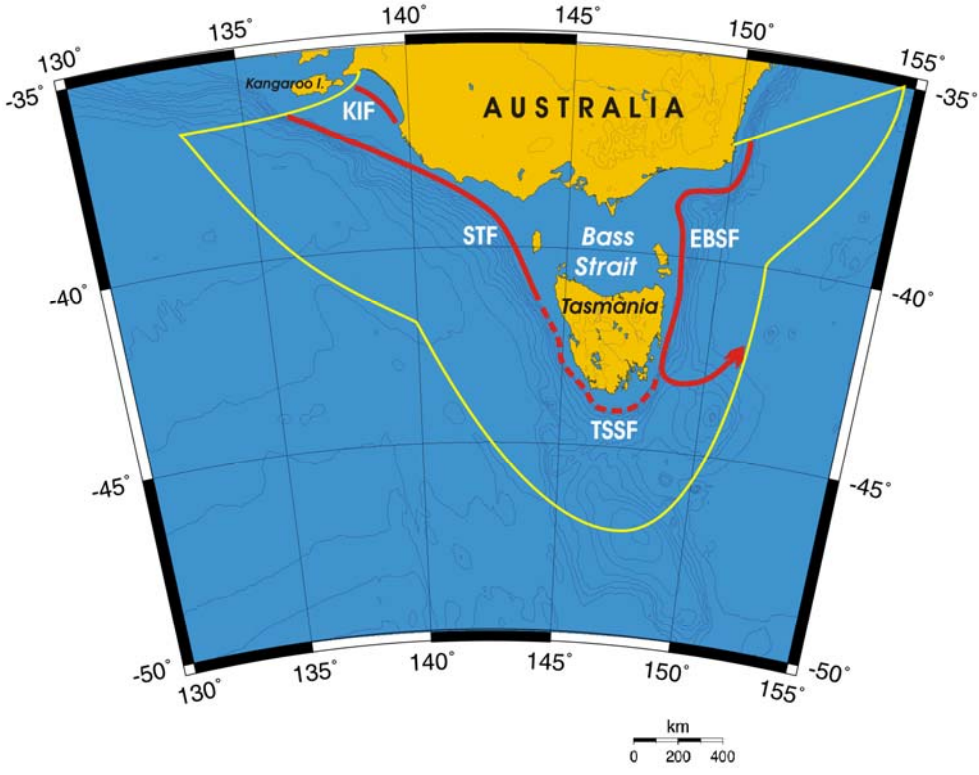

Figure IX-21.1. Fronts of the Southeast Australian Shelf LME. EBSF, East Bass Strait Front; STF, Subtropical Front; TSSF, Tasmania Shelf-Slope Front (most probable location). Yellow line, LME boundary. (after Belkin et al. 2009)

The thermal history of this LME features a long-term ascending trend, although this warming was quite erratic, including major reversals. Some peculiarities of this LME's thermal history are likely caused by its location as the southernmost Australian LME. Therefore this LME is affected by the Subantarctic and Antarctic (via atmospheric teleconnections) more strongly than are other Australian LMEs. The East Australian Current is a dominant warm current and its role increased over the last half-century as this current penetrated farther south by ~350 km over the 1944–2002 period, thus effectively warming up the East Tasmanian waters at a rate of 2.28°C/century (Ridgway, 2007).

The most striking difference between this LME and other Australian LMEs is the absence of a major peak in 1998 that could have been a manifestation of the 1997-98 El Niño, as observed elsewhere. Instead, SST peaked in 2001, possibly a delayed response to the El Niño 1997-98. A similar warm event peaked in 2000 in the adjacent Southwest Australian Shelf LME. The all-time maximum of 1989 can be tentatively correlated with the peak of 1988 in the Sulu-Celebes Sea LME, North Australian Shelf LME, West-Central Australian Shelf LME, and lesser peaks of 1989 in the Southwest Australian Shelf LME and of 1988 in the Northwest Australian Shelf LME. The peak of 1961 occurred simultaneously in the adjacent Southwest Australian Shelf LME. The cold events of 1964 and 1996 cannot be readily linked to similar events elsewhere. This asymmetry between

warm and cold events suggests a weaker correlation between cold events versus a stronger correlation between warm events.

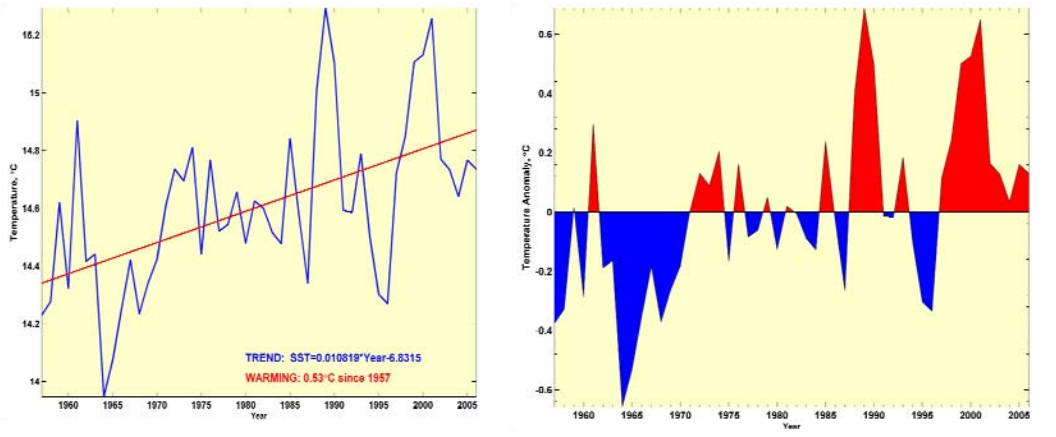

Figure IX-21.2. SE Australian Shelf LME annual mean SST (left) and SST anomalies (right), 1957-2006, based on Hadley climatology (after Belkin 2009).

Southeast Australian Shelf LME, Chlorophyll and Primary Productivity: The Southeast Australian Shelf is considered a Class III, low productive ecosystem (<150 $gCm^{-2}yr^{-1}$).

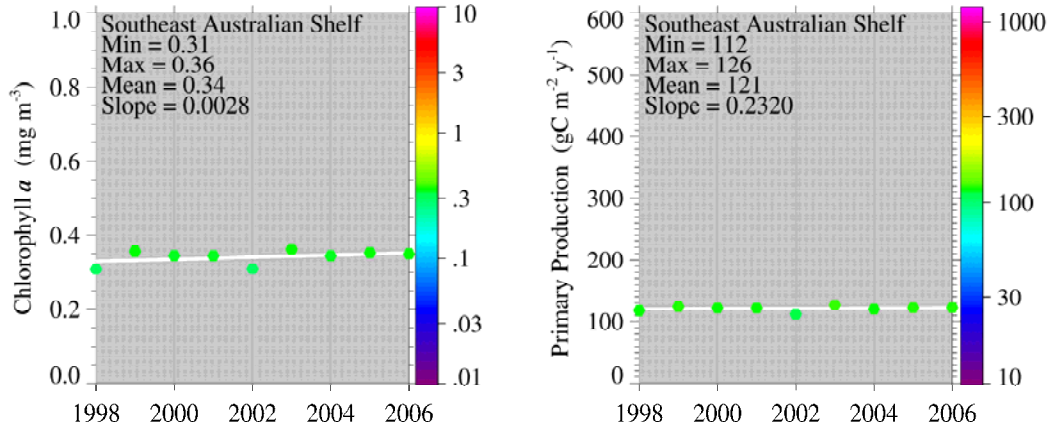

Figure IX-21.3. Southeast Australian Shelf LME trends in chlorophyll a and primary productivity, 1998-2006. Values are colour coded to the right hand ordinate. Figure courtesy of J. O'Reilly and K. Hyde. Sources discussed p. 15 this volume.

II. Fish and Fisheries

Fig. IX-21.4 and IX-21.5 present the estimates of the Sea Around Us Project for the capture fisheries landings in this LME, and their ex-vessel value. Australian sources suggest that the combined capture fisheries and aquaculture production in the southeastern Australian LME is 121.5 thousand tonnes, valued at $1.05 billion Australian dollars, with the wild fish sector accounts for 60% of the weight and 50% of the value of production in this region, suggesting that the Sea Around Us figures are underestimates. The main groups fished include lobster, abalone, scallops, crabs, prawns, snapper, sardines, blue grenadier and flathead. The aquaculture sector includes Atlantic salmon,

southern bluefin tuna, oysters and mussels. ABARE provides additional information on the characteristics of Australia's fishing industry (www.abare.gov.au).

The region is a mix of high valued export fisheries, which includes nearly 50% of the global wild caught abalone production, and the bulk of the domestic fish market in Sydney and Melbourne. The small pelagics fishery has undergone substantial fluctuations over the decades with large catches of jack mackerel (*Trachurus declivis)* dramatically declining in eastern and southern Tasmania. Recently there has been an increase in redbait (*Emmelichthys nitidus*) (Anon. 2008a) In addition to the small pelagics fishery, dramatic fluctuations in recruitment of scallops and striped trumpeter (*Latris lineata*) reflect the dynamics of the physical environment (Anon. 2008b).

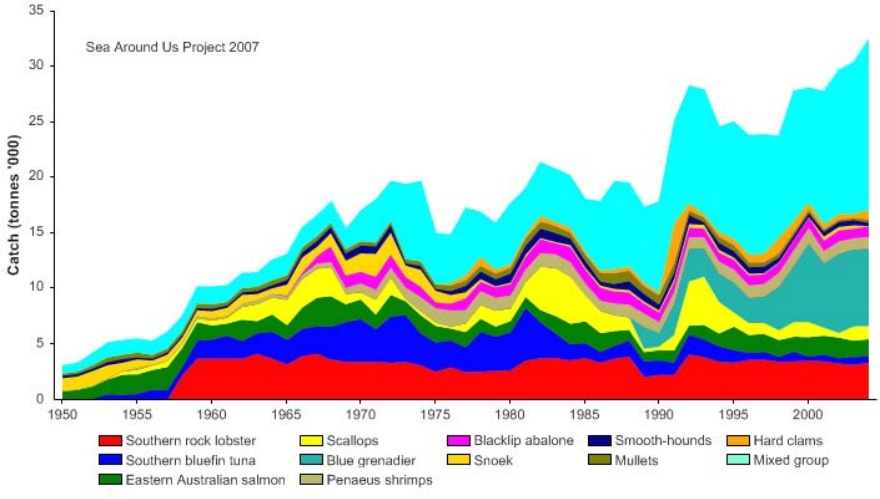

Figure IX-21.4. Total reported landings in the Southeast Australian Shelf LME by species (Sea Around Us 2007).

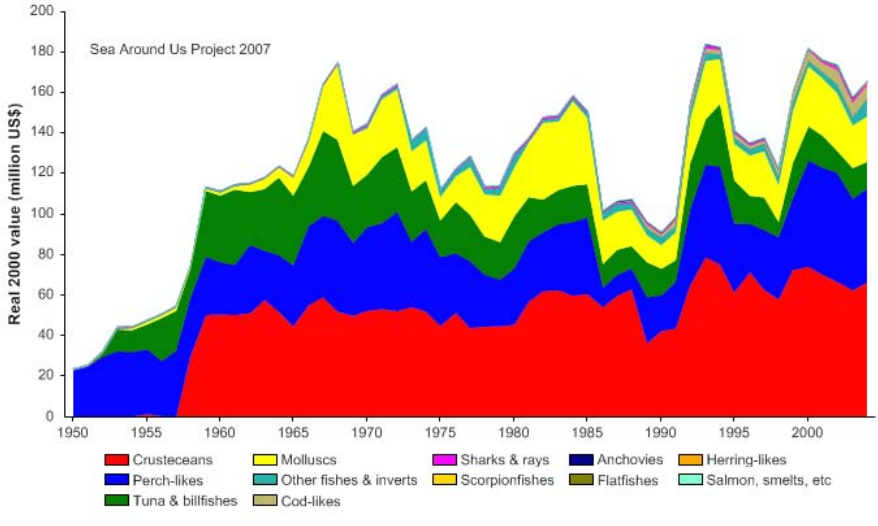

Figure IX-21.5. Value of reported landings in the Southeast Australian Shelf LME by commercial groups (Sea Around Us 2007).

ABARE estimates for 2006/2007 (including aquaculture) for fisheries production in Victoria was 8,243 t valued at $93.934 millions $AUD; South Australia production was 60,548 tonnes at a value in millions of $AUD of $426,499; Tasmania fisheries production in totalled 36,413 tonnes at a value in millions of $AUD $475,429 and Commonwealth managed fisheries harvested 16,328 tonnes at a value in millions of $AUD $54.539. (www.abare.gov.au). Quota management has been introduced into many of the more valuable fisheries over the last 20 years. This has resulted in substantial rebuilding of the biomass in several fisheries such as rock lobster (Haddon and Gardner 2008). The primary production required (PPR; Pauly & Christensen 1995) to sustain the reported landings in this LME is currently below 2.5% with Australia accounting for the largest share of the ecological footprint (Figure IX-21.6).

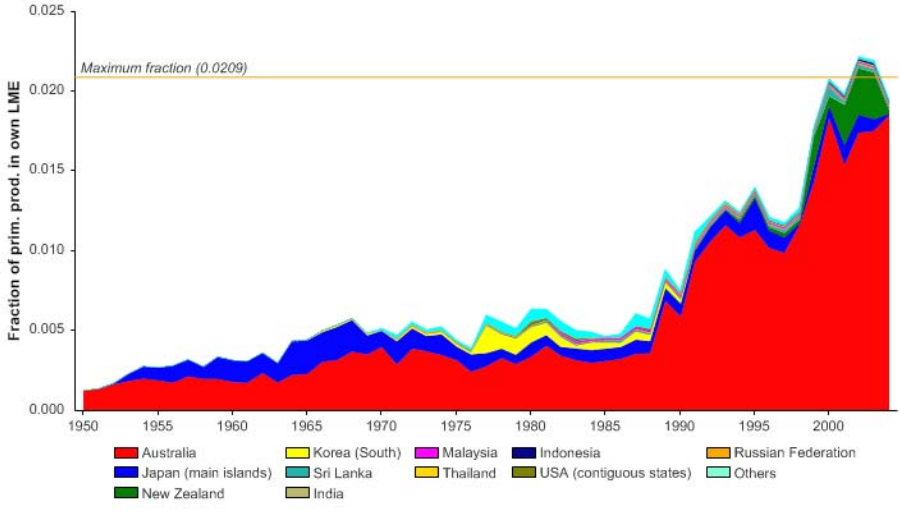

Figure IX-21.6. Primary production required to support reported landings (i.e., ecological footprint) as fraction of the observed primary production in the Southeast Australian Shelf LME (Sea Around Us 2007). The 'Maximum fraction' denotes the mean of the 5 highest values.

Over the past twenty years, both the mean trophic level of the reported landings (i.e., the MTI; Pauly & Watson 2005) and the FiB index have increased in the LME, indicating a development of new offshore fisheries from the late 1980s to the 1990s.

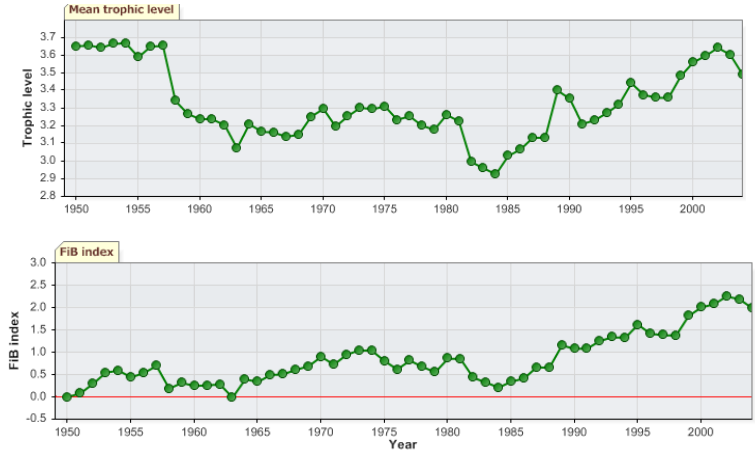

Figure IX-21.7. Mean trophic level (i.e., Marine Trophic Index) (top) and Fishing-in-Balance Index (bottom) in the Southeast Australian Shelf LME (Sea Around Us 2007).

The Stock-Catch Status Plots suggest that while a sizeable fraction of the stocks in this LME may have been overexploited (Figure IX-21.8, top), about half of the catch biomass originates from stocks that are fully exploited (Figure IX-21.8, bottom). Moreover, changes to gear, management, fleet dynamics/fisher behaviour, market forces, as well as discarding, unstandardised catch data and climate (e.g. the jack mackerel fishery) prevent further interpretation. There is limited or no fishery independent data for many species, and recruitment records are unknown. Recent changes to management have improved the stock status of many fisheries.

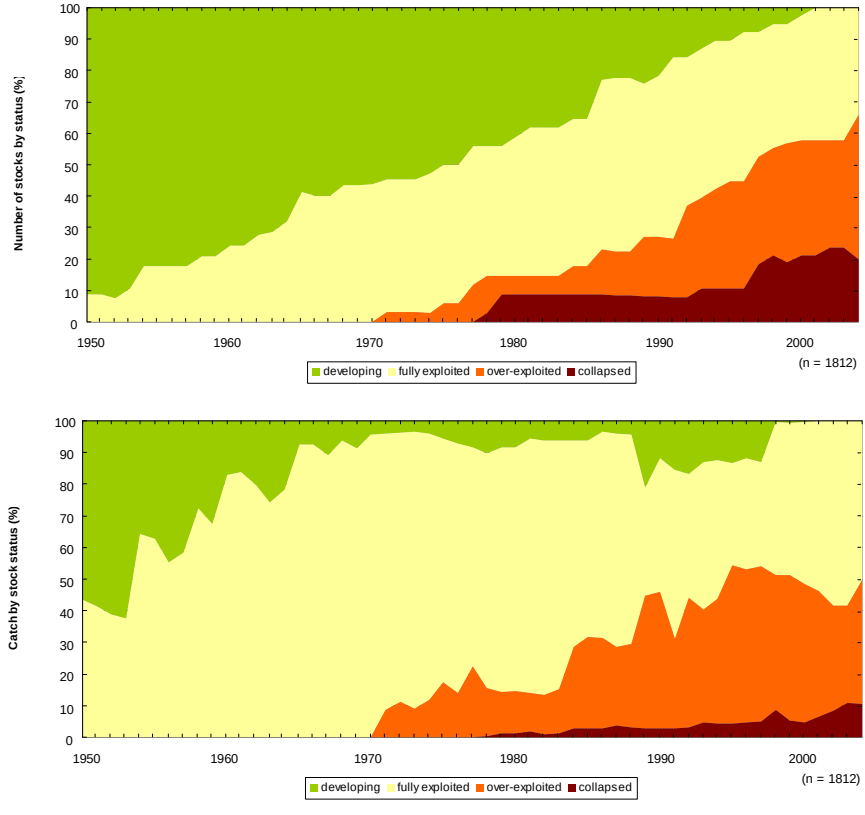

Figure IX-21.8. Stock-Catch Status Plots for the Southeast Australian Shelf LME, showing the proportion of developing (green), fully exploited (yellow), overexploited (orange) and collapsed (purple) fisheries by number of stocks (top) and by catch biomass (bottom) from 1950 to 2004. Note that (n), the number of 'stocks', i.e., individual landings time series, only include taxonomic entities at species, genus or family level, i.e., higher and pooled groups have been excluded (see Pauly *et al*, this vol. for definitions).

III. Pollution and Ecosystem Health

Land use impacts within the Murray Darling Basin, nutrient loading from diffuse and point sources, soil erosion, soil salinisation, and dry climate with intermittent flows and natural salt stores in the landscape have resulted in significant or major nitrogen exceedances in the Lower Murray, Myponga, Fleurieu Peninsula and Willochra Creek River basis. In several of these river basins, guidelines for salinity, phosphorus and for turbidity have also been exceeded (http://audit.ea.gov.au/ ANRA/water/quality/). A major problem in this LME is the introduction of exotic marine organisms from the hulls of ships or as a consequence of discharging ballast water. A recent inventory of introduced marine pests found 57 species in Victoria, 45 in Tasmania and 43 in South Australia (www.marine.csiro.au/crimp/nimpis). These introduced marine species threaten native marine flora and fauna and local marine diversity as well as fishing and aquaculture.

Introduced species in this LME include the North Pacific sea star (*Asterias amurensis*), Japanese kelp (*Undaria pinnatifida)*, the New Zealand screw shell (*Maoricolpus roseus*), European fan worm (*Sabella spallanzanii*) and the toxic dinoflagellate (*Gymnodinium catenatum*). The North Pacific sea star native to northern China, Korea, Russia and Japan, was first found in Tasmania in 1986, but was misidentified as a native species until 1992. The sea star has since spread to Victoria. At present, its distribution in Australia appears to be limited to these two States. However, suitable conditions exist for its survival and reproduction in the West-Central Australian Shelf LME. The sea star is a voracious predator of shellfish, thus posing a serious threat to mariculture and wild shellfish fisheries. While significant research is being undertaken on the potential impacts of the sea star in Australia, the available data are still not adequate to conclusively determine if it is having an impact on Australian fisheries. Japanese kelp has appeared in near-shore habitats along the east coast of Tasmania and is spreading fast with the potential to invade the entire southern coastline. For more information on pollution issues see www.deh.gov.au/coasts/pollution/index.html, the State of the Environment Reports at www.deh.gov.au/soe and CSIRO's Center for Introduced Marine Pests at www.marine.csiro.au/crimp/. Climate change is also impacting on the distribution of species in southeastern Australia. The magnitude and poleward distribution of the East Australian Current (EAC) has increased over the last 60 years (Ridgway, 2007) and is expected to increase due to climate change with predictions that southeastern Australian marine waters will be the fastest warming in the southern hemisphere. With the increased penetration of the East Australian Current there has been an increase in the number and southerly distribution of sub-tropical species into Tasmania. The most notable of these is the long-spined sea urchin, which forms extensive barrens habitat (Johnson et al., 2005). These barrens habitats lead to substantial changes in productivity and biodiversity (Ling, 2008) with flow on impacts on fisheries. Initially, range expansion was by way of larval transport from NSW via the EAC. With increasing warmer waters, the conditions for *C. rodgersii* to complete it larval cycle *in-situ* in eastern and southern Tasmanian become more favourable (Ling et al., 2008). The dinoflagellate *Noctiluca scintillans* has also dramatically increased with summer blooms impacting on coastal salmon farms (www.tafi.org.au/zooplankton).

In the northwestern region of the LME, climate change is expected to increase the strength and duration of upwelling winds (Bakun 1990). This is expected to result in a stronger Bonney upwelling and for increased sub-surface upwelling events that extend from western Victoria to western Tasmania. An increase in these upwelling events at the beginning of summer accelerates primary and secondary productivity.

Climate change simulations are currently being improved for the Australian region at CSIRO, particularly in modeling the Southern Ocean, developing a more realistic Antarctic Circumpolar Current, and modeling the transport of surface water into the deep ocean. The latter process is particularly important in the sequestering of heat and carbon into the deep ocean, which influences the rate and pattern of warming globally.

IV. Socioeconomic Conditions

In the Southeast Australian Shelf LME, the population is 1,465,200 persons and between 5% and 10% of the total employment is in the fish industry--fisheries, aquaculture and processing sectors. The region is socially diverse, with some small, isolated communities and some major metropolitan centres, with the population growth highest in coastal metropolitan areas and large coastal regional centres (especially Melbourne). The two main industries for the LME are marine tourism and oil and gas. Bass Strait accounts for about 20% of the nation's oil and gas (Love 2004). In the Atlas of Australian Marine Fishing and Coastal Communities, (http://adl.brs.gov.au/), the region is characterised by a lower proportion of Indigenous persons, by younger median ages in coastal

metropolitan areas and large coastal regional centres, by higher child dependency in many regional areas, and by higher socio-economic disadvantage in many non-metropolitan areas of coastal Tasmania with strong links to the fish industry. The southern rock lobster fishery is the most valuable in this region and was estimated in 2003 to provide 3,381 employment opportunities either directly or indirectly with a total economic impact of almost 0.5 billion dollars into regional economies. A record low catch rate in the South East coast is being reported for rock lobster in October, 2008 according to John Ashby, president of the Port MacDonnell Fishermen's Association (http://fis.com/fis/worldnews 16 October 2008). The South East Fishery, which includes both the trawl and gillnet, trap and line fisheries, is a major fish industry with landings in 2006/7 being 20,578 tonnes worth an estimated $AUD 78 million. Salmon aquaculture is carried out in Tasmania and its production was valued at $271 million in 2006/7 (www.abare.gov.au). Recreational fishing is an important pastime in this region with approximately 1 million people participating in the 12 months prior to May 2000. Participation rates were estimated at 29.3%, 24.1% and 12.7% in Tasmania, South Australia and Victoria respectively (Henry and Lyle 2003). The Southeast Australian Shelf LME contains a number of cities and ports, including Melbourne. Industry, shipping and tourism are major economic activities. There is offshore oil and gas off the Victoria coast. Marine and coastal-based tourism is important in this LME, both in terms of domestic and international tourism.

V. Governance

The Southeast Australian Shelf LME lies off the coast of four Australian States: New South Wales, Victoria, Tasmania and South Australia. The main governance issues of this LME pertain to industrial and agricultural degradation of the water quality, fisheries management and to the establishment of marine reserves. Fisheries are managed by either State or Commonwealth agencies. Most of the states manage the fisheries out to 5.5 km offshore and the Commonwealth manages fisheries beyond this zone. Several fisheries that are within the 5.5 km zone are managed by the Commonwealth (e.g. small pelagics) and other outside this limit by the State (eg. giant crab). Some fisheries have both Commonwealth and State zones (e.g. scallops). Most of the valuable fisheries in the region are managed under output controls and many have seen substantial rebuilding of legal sized biomass since the introduction of quota management systems. The less valuable fisheries tend to be managed through input controls that restrict effort. These include gear limits and seasonal and regional closures. Both State and Commonwealth fishers have established management advisory committees that usually involve industry, managers and research providers in the co-management of the resource. See the North Australian Shelf LME (Chapter VIII) for more information on fisheries management. Coastal marine reserves are managed by Conservation agencies in most States whereas offshore marine reserves are managed by the Australian Department of Environment, Water and Heritage.

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Atlas of Australian Marine Fishing and Coastal Communities at http://adl.brs.gov.au/mapserv/ fishcoast/south_ eastern_region html

Australia Land and Natural Resources Audit results for water quality in South Australia at www.epa.sa.gov.au/water_threatened.html

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