

# IX-18 East-Central Australian Shelf: LME #41

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The East-Central Australian Shelf LME extends from the southern edge of the Great Barrier Reef off Fraser Island, Queensland (24.5°S) to Cape Howe (37.5 °S), at the southern end of the state of New South Wales. It covers a surface area of 650,000 km<sup>2</sup>, of which 2.66% is protected, and contains 0.18% of the world's coral reefs and 0.20% of the world's sea mounts, as well as 15 major estuaries (Sea Around Us 2007). A narrow continental shelf (only 20-60 km wide) that is bordered by the Tasman abyssal plain and a temperate climate characterise the LME. The South Equatorial Current from the Pacific Ocean gyre flows westward towards the Australian coast, bifurcates with the southern branch bending south (left) under the influence of wind stress and topography to become the East Australian Current (EAC, Ridgeway and Dunn 2003). The EAC is Australia's largest current and is typically 30 km wide, 200 m deep and traveling at up to 4 knots (2 ms<sup>-1</sup>), with a variable annual transport variously estimated as 20-30 Sv (Ridgeway & Dunn 2003 and references therein). For comparison, the EAC has ~5 fold greater volume transport than the seasonally flowing Leeuwin Current on the west coast. The EAC intensifies in the northern part of this LME, before separating from the coast 31-33 °S, leaving behind a southward trending eddy field. The EAC's mesoscale variability is so large that a single continuous current can often not be identified, and this variability distinguishes it from other western boundary currents. After separation, the EAC retroflects northward and can feed back into the EAC, as an anticyclonic eddy. Further separations and retroreflections are evident along the NSW coast around 34 and 37°S (Ridgeway & Dunn 2003). The eddies are formed at 90 to 180 d intervals driven in part by intrinsic instabilities (Marchesiello and Middleton 2000; Bowen et al. 2005). The anticyclonic eddies may transport considerable amounts of heat into the Tasman Sea, or may turn northeast and coalesce back into the main current. The strengthening of the EAC is predicted to warm Australian waters by 1-2°C by 2030 and 2-3 °C by 2070s, particularly off Tasmania (Poloczanska et al. 2007). This has already affected growth rates of commercial fish (Thresher et al. 2007). Ridgeway (2007) and others have noted the remarkable impact of the EAC's southward penetration off Tasmania. Using the Maria Island long term quasi-monthly monitoring station (since 1944), they report the warming rate of 2.3 °C per century and increasing salinity of 0.34 per century. A book chapter and report pertaining to this LME are Morgan (1989) and UNEP (2003).

## **I. Productivity**

The East-Central Australian Shelf LME is considered a Class III, low productivity ecosystem, (<150gCm<sup>-2</sup>yr<sup>-1</sup>) (Sea Around Us 2007; [www.science.oregonstate.edu/ocean.productivity/](http://www.science.oregonstate.edu/ocean.productivity/)). At this latitude, water temperature, levels of wind mixing and light intensity go through seasonal cycles. During the winter, strong winds and cool surface water temperatures enhance vertical mixing processes, breaking down vertical density gradients and allowing nutrient-rich waters to mix into the surface layer. However, the overall productivity of this temperate Australian LME is restricted by the poleward transport of low-nutrient tropical waters along the continent's eastern margin by the EAC. There are no widespread seasonal blooms producing large surpluses of organic matter. Localised coastal blooms occur as a result of wind-driven and current-driven upwelling and occur throughout the year (Ajani, 2001; Baird et al., 2006). Localised blooms can produce ecosystem responses such as red-tides (Dela-Cruz et al., 2003), but are not sufficiently large to support a large demersal fishery such as those which characterise northern hemisphere continental shelf systems.

For a general understanding of oceanographic processes affecting the nutrient dynamics and productivity of Australian marine ecosystems, see the Australian State of the Environment Reports at [www.deh.gov.au/soe](http://www.deh.gov.au/soe) where the reports are listed by date. For more information on productivity, see Furnas (1995). For information on ocean surface environmental data (currents, temperatures, winds), see the website [www.marine.csiro.au](http://www.marine.csiro.au) for the Commonwealth Scientific and Industrial Research Organisation, CSIRO, and David Griffin's CSIRO site at [www.marine.csiro.au/%7Egriffin/](http://www.marine.csiro.au/%7Egriffin/). Regularly updated information on climate impact, fisheries and marine sciences, including an online Atlas of Australian Marine Fishing and Coastal Communities is available from the Australian Department of Agriculture, Fisheries and Forestry, Bureau of Rural Sciences at <http://adl.brs.gov.au> together with lists of publications on species, bycatch, the role of marine reserves and other important topics broken out by regions.

**Oceanic fronts:** The westward South Equatorial Current impinges on the east coast of Australia and bifurcates, with the two branches flowing north or south, along the coast (Belkin & Cornillon 2003, Belkin *et al.* 2009) (Figure IX-18.1). The southward branch is the East Australian Current (EAC), a strong poleward flowing western boundary current that carries tropical waters into the LME. A distinct front exists between tropical Coral Sea waters and the Tasman Sea waters at between 31-37°S, the Tasman Front. The EAC is a highly energetic current that shifts between a dominating poleward extension that flows past Tasmania, and a Tasman Front extension, which flows eastward towards Lord Howe Island, eventually forming the East Auckland Current. With currents more than  $1 \text{ ms}^{-1}$ , water flowing in from the north, surface waters can move through the LME in as little as a month. The poleward extension of the EAC has strengthened due to recent climatic changes, resulting in a significant warming of waters of southern NSW and Tasmania (Cai, 2006).

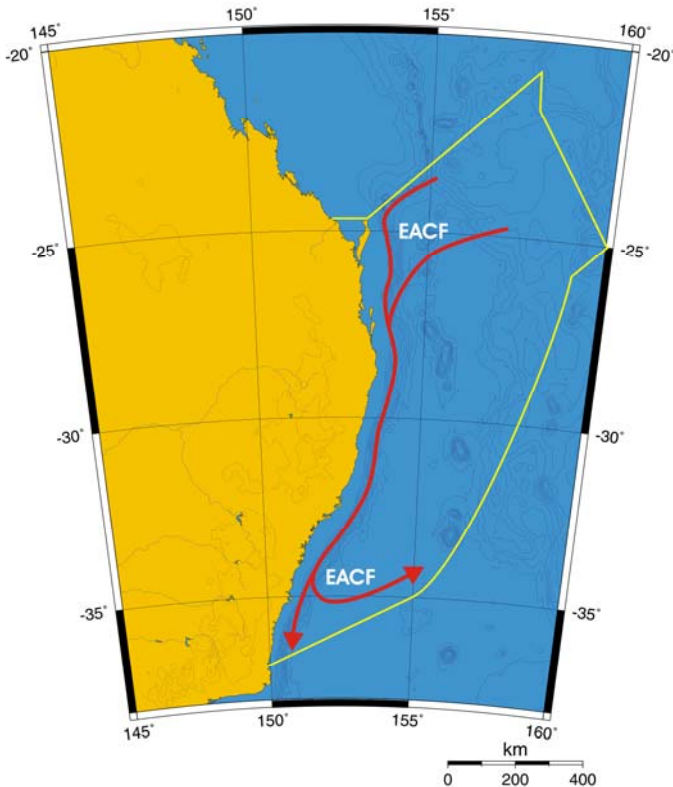


Figure IX-18.1. Fronts of the East-Central Australian Shelf LME. EAC, East Australian Current; TF, Tasman Front. Yellow line, LME boundary (after Belkin *et al.* 2009).

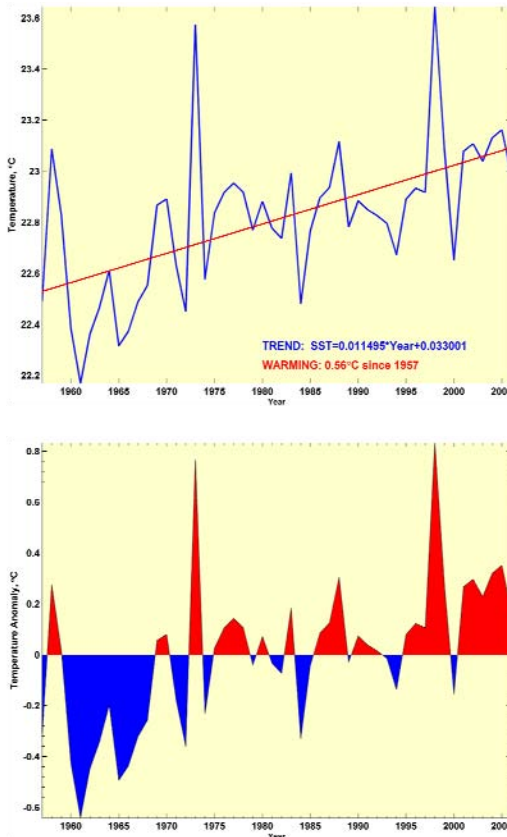
### **East-Central Australian Shelf SST**

Linear SST trend since 1957: 0.56°C.

Linear SST trend since 1982: 0.35°C.

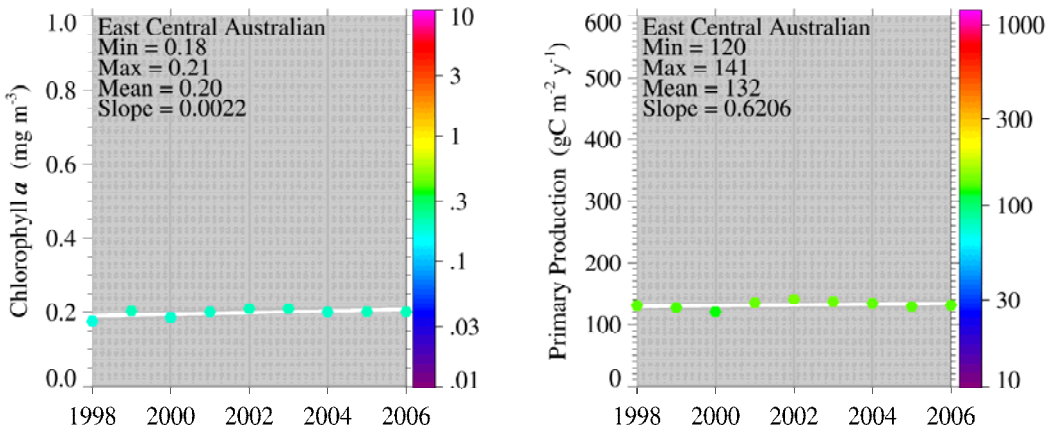
The steady warming of the East-Central Australian Shelf was punctuated by two warm events, in 1973 and 1998. The 1973 peak was a large-scale event that occurred simultaneously in the Indonesian Sea LME, North Australian Shelf LME, and Northwest Australian Shelf LME. The above-noted synchronism can only be explained by large-scale atmospheric forcing (teleconnections). Indeed, oceanic advection by currents must be ruled out because the entire Northeast and East Australian coastal and offshore region (basically, most of the Coral Sea and northern part of the Tasman Sea) is dominated by the South Equatorial Current and its extension, East Australian Current, whereas the Indian Ocean inflow via Torres Strait is negligible.

The 1998 all-time maximum was a manifestation of the 1997-98 El Niño. The summer of 1997-1998 was the hottest recorded on the Great Barrier Reef, causing bleaching of two thirds of inshore reefs (Berkelmans and Oliver 1999). Otherwise, the interannual variability of this ecosystem was rather small, with year-to-year variations less than 0.5°C (CSIRO 2007). Causes of the annual variation in the EAC eddies are still a puzzle, driven by intrinsic instabilities (Bowen et al. 2005).



**Figure IX-18.2. East Central Australian Shelf LME Mean Annual SST, 1957-2006 (top) and SST anomalies, 1957-2006 (bottom) based on Hadley climatology, after Belkin 2009.**

**East Central Australian Shelf LME, Chlorophyll and Primary Productivity:** The East-Central Australian Shelf LME is considered a Class III, low productivity ecosystem at  $<150 \text{ gCm}^{-2}\text{yr}^{-1}$  (Sea Around Us 2007; [www.science.oregonstate.edu/ocean.productivity/](http://www.science.oregonstate.edu/ocean.productivity/)).



**Figure IX-18.3.** East Central Australian Shelf 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

Australian waters are relatively nutrient-poor and unable to sustain large fish populations. Approximately 1 in 4 of the 4,482 species found in Australian waters are endemic (Hoese et al. 2006). Off the coast of New South Wales, 1,748 fish species are recorded of which 22% are Australian endemics. For information on South-East Fisheries, see the AFMA websites or DEWR reports. Federal, commercial fishing is not large in the Australian East Marine Planning region (approximates the East Central Australian LME) valued in 2002-2006 at around \$320 m and 1% of the national value of commercial fisheries. These AFMA managed fisheries <http://www.afma.gov.au/fisheries/default.htm> include the East Coast Deepwater trawl fisheries, (10 concessions, using demersal and midwater trawling); the Commonwealth Trawl Sector (formerly South East Trawl Fishery), with nearly 60 concessions, 54 vessels using otter trawl and danish seine methods, some midwater trawling; the Eastern Tuna and Billfish Fishery (ETBF) with over 100 permits, 72 vessels using pelagic longline, minor line (handline, troll, rod and reel). The vast bulk of the landings are restricted to the very narrow continental shelf (Moore et al. 2007). Three of the more significant commercial fisheries are the various estuarine and ocean prawn trawl fisheries to 3 nautical miles, and the federally managed South East Trawl and the East Coast tuna fishery. FAO provides information on Australia's fisheries and the characteristics of the industry ([www.fao.org](http://www.fao.org)). Reported landings in the LME include mullet, shrimps and prawns, butterfishes and tunas (skipjack, yellowfin and bluefin) and have fluctuated over the last 50 years with peaks in the mid 1970s, late 1980s and early 2000s with over 30,000 tonnes recorded in mid 1970s, late 1980s and again in 2002-2005 (Figure IX-18.4). The value of the reported landings reached nearly 300 million US\$ (in 2000 real US\$) in the mid 1970s and 100 million US\$ in recent years (Figure IX-18.5). For 2000/01, FAO reports landed catch in Queensland fisheries alone at 31,250 tonnes (excluding aquaculture), valued at 741 millions \$AUD. The ADL Bureau of Rural Science estimates that the Eastern Central Region's commercial fisheries caught 31,500 tonnes with Gross Value of Products (GVP) at 315 million \$AUD in 2002.

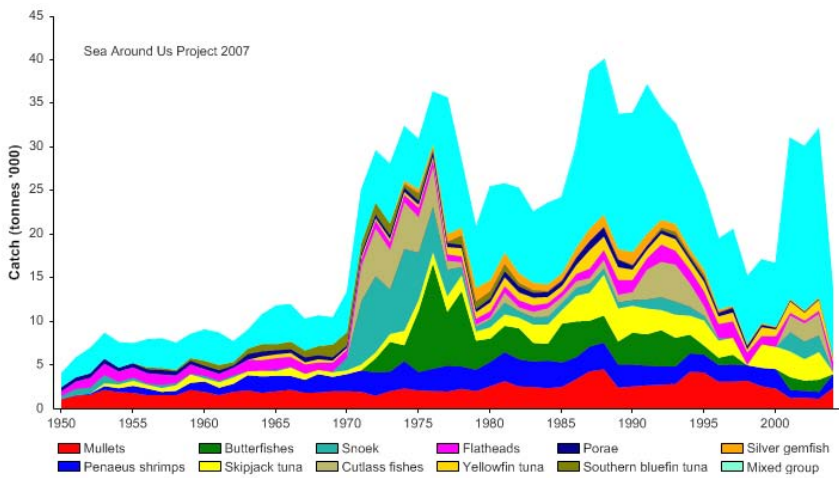


Figure IX-18.4. Total reported landings in the East-Central Australian Shelf LME by species (Sea Around Us 2007). Note that Porae = Blue Morwong.

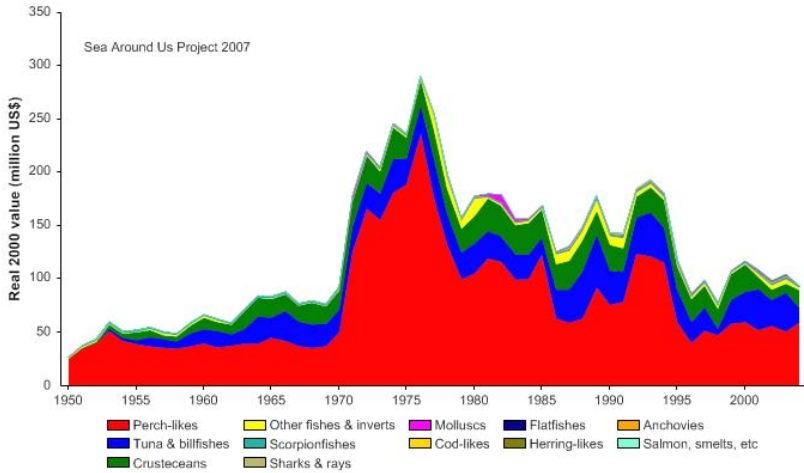
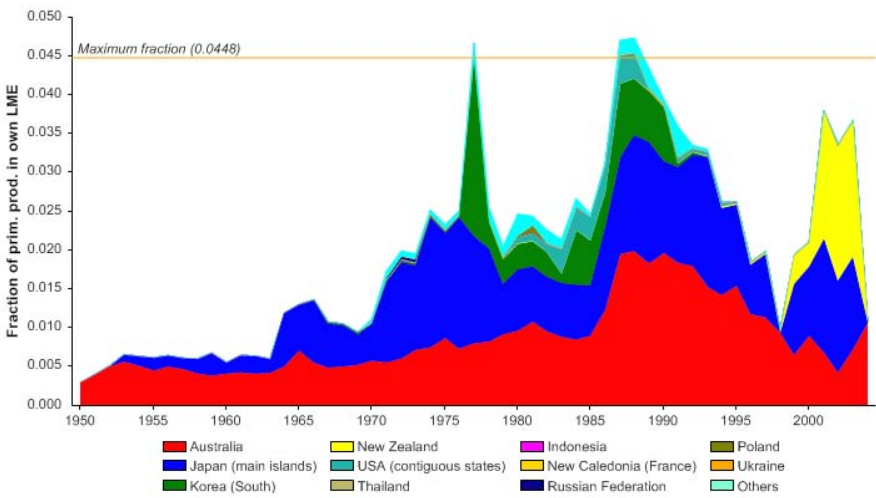


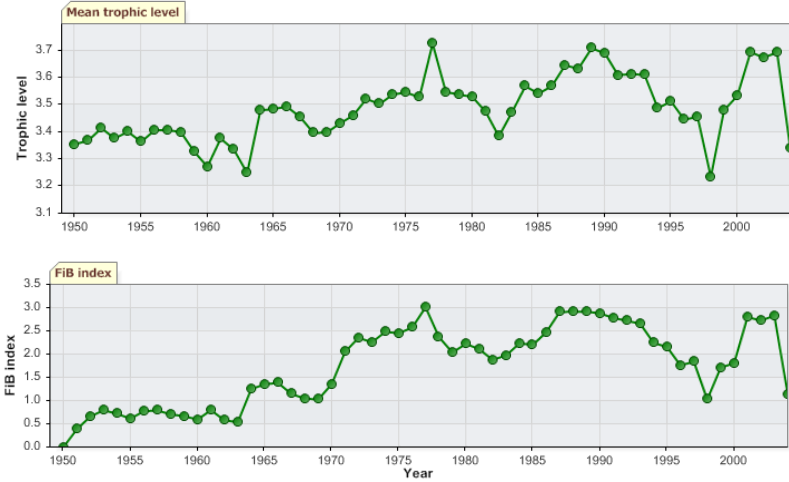
Figure IX-18.5. Value of reported landings in the East-Central Australian Shelf LME by commercial groups (Sea Around Us 2007).

The primary production required (PPR; Pauly & Christensen 1995) to sustain the reported landings in this LME is currently below 4% with Australia and New Zealand, as well as few distant water fishing countries, namely Japan and South Korea, historically accounting for the large share of the ecological footprint (Figure IX-18.6).



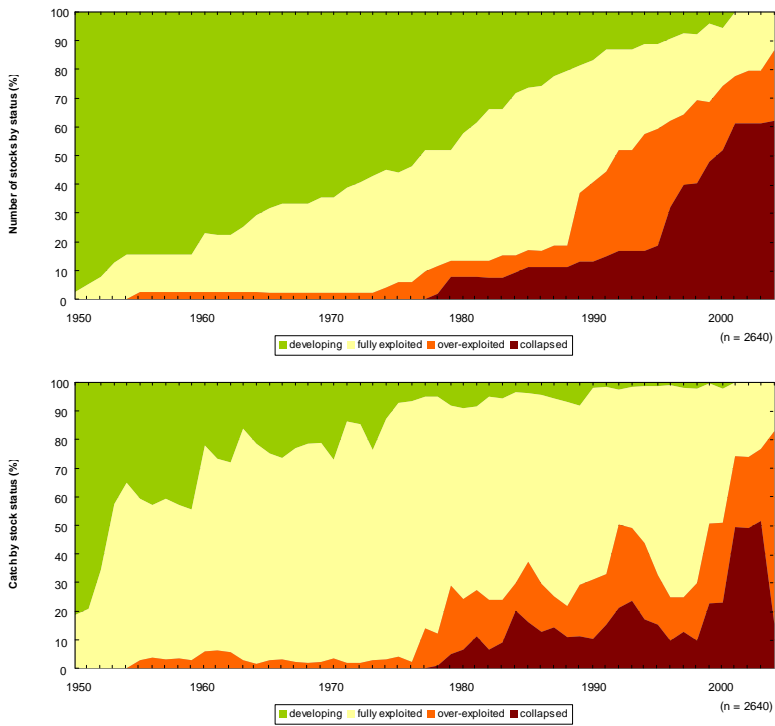
**Figure IX-18.6. Primary production required to support reported landings (i.e., ecological footprint) as fraction of the observed primary production in the East-Central Australian Shelf LME (Sea Around Us 2007). The 'Maximum fraction' denotes the mean of the 5 highest values.**

Both the mean trophic level (i.e., the MTI; Pauly & Watson 2005) and the FiB index vary widely and no clear interpretation on the state of the LME or its fisheries can be made based on these indices (Figure 18.7). It is likely that such variation in the two indices is due to the low level of exploitation in the region.



**Figure IX-18.7. Mean trophic level (i.e., Marine Trophic Index) (top) and Fishing-in-Balance Index (bottom) in the East-Central Australian Shelf LME (Sea Around Us 2007)**

The fluctuations in the reported landings are also making interpretation of the Stock-Catch Status Plots difficult (Figure IX-18.8). Whilst these plots imply approximately 20% and 40% of stocks being collapsed and overexploited, respectively (Figure IX-18.8 top), the causes are complex including changes to gear and management, price and especially multispecies effects (over 200 species are processed by the Sydney Fish Markets, Moore et al. 2007).



**Figure IX-18.8. Stock-Catch Status Plots for the East-Central 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). See also Moore *et al.* (2007) for a fisheries status overview.**

### III. Pollution and Ecosystem Health

The major problems for this coastline are real estate value, urbanization, water quality, freshwater, and beach erosion. The coastline of NSW alone has over 450 coastal discharge sites along the NSW coast, the largest three being off Sydney amounting to nearly 1000 ML.d<sup>-1</sup> or primary treated sewage. Desalination plants are planned or being constructed for the Gold Coast, Sydney (Kurnell) and Melbourne (at Wonthaggi on the South Gippsland coast). There are no mining activities in the LME but there is potential for sand mining, manganese nodule harvesting, or base/precious metals on the Lord Howe Rise. Sand mining has the greatest potential for NSW in light of beach erosion and construction needs. There is a pilot wave-energy generator at the breakwater of Port Kembla [www.oceanlinx.com/](http://www.oceanlinx.com/).

For 2005-2006, ports of the East Marine Planning region (mostly Newcastle, Sydney, Brisbane and Port Kembla) accounted for 42% of the nation's exports and 51% of national imports by tonnage (Anon. 2007). These ports accounted for 18% of freight loaded and 67% unloaded by all Australian ports. The busiest sea lanes are through the Coral Sea. The LME may be threatened by an increase in shipping. Ship ballast water has been shown to contain organisms including bacteria, viruses, algal cells, plankton and the larval forms of many invertebrates and fish. Two of Australia's largest three cities and four of the largest 10 ports are located in this LME, and it is the most urbanized coastline in Australia. Pressure is increasing on natural environments, productive agricultural land, water resources, sewage treatment and waste disposal systems. There

are environmental impacts caused by tourism and related infrastructure (airports, power generation facilities, accommodation, sewage treatment and disposal facilities, moorings and marine transport). For more information on coastal and marine pollution issues in this LME, see the Australia State of the Environment Reports indexed by date at [www.deh.gov.au/soe/index.html](http://www.deh.gov.au/soe/index.html).

#### **IV. Socioeconomic Conditions**

Australia's Bureau of Rural Sciences estimates that, on average, 5% of the population of the Eastern Central and Norfolk Regions is employed in the fishing industry (<http://adl.brs.gov.au/>). FAO provides information on the characteristics and socioeconomic benefits of Australia's fishing industry ([www.fao.org/](http://www.fao.org/)). The Eastern Central region contains 165 towns, and large cities and ports, including Sydney (Port Jackson and Botany Bay), Brisbane, Newcastle, and Port Kembla. Shipping and marine tourism are major economic activities and the cities absorb much of the country's population growth. The Australian Bureau of Statistics <http://www.abs.gov.au/> estimates the current coastal population in this LME at 8 million, mostly living in Sydney and Brisbane, with a quarter in the large coastal non-metropolitan centres like Newcastle, Wollongong, Gold and Sunshine Coasts, Coffs and Bundaberg (<http://adl.brs.gov.au/>).

The largest marine industry is marine tourism, contributing 22% of the national marine industry (\$27 billion in value added during 2002-03, The Allen Report 2004). The value of the marine industry (i.e. all recreational and light commercial vessels) in NSW is valued at over \$2 billion pa and employs over 11,000 – both figures are almost equivalent to all other states combined (mostly Victoria and Queensland, ([www.bia.org.au/data.html](http://www.bia.org.au/data.html))). Over a third of the national marine industry employment (36%) is in NSW – and mostly in marine tourism. These figures are more remarkable considering that our estuaries, while numerous (>130) are small and we have the nation's narrowest continental shelf. The Australian Bureau of Statistics estimates at [www.abs.gov.au/ausstats/](http://www.abs.gov.au/ausstats/) that, in the entire country, over 5 million Australians take part in recreational fishing in Australia as a leisure activity (i.e. 20% fish at least once a year), with some 120,000 people identified as members of fishing clubs in 1996-97, and that recreational fishing supports about 90,000 Australian jobs especially in industries supplying tackle and bait and recreational boating. The Bureau of Statistics estimates that international tourists spend over \$200m on fishing in Australia each year. A survey undertaken by the ABS in the early 1990s showed that recreational fishing accounted for 23,000 tonnes of fish, 2,800 tonnes of crabs and approximately 1,400 tonnes of freshwater crayfish. In NSW the recreational catch is about 30% of the commercial catch, but for 6 major species the recreational catch is actually greater than the commercial. In NSW the recreational fishing fee bought out commercial fishing licenses in 25 estuaries in 2001, now described as recreational fishing havens. Most of Australia's recreational fishing is undertaken along the coast and estuaries of New South Wales, Queensland and Victoria, reflecting both the excellent fishing areas and the geographic spread of Australia's population.

#### **V. Governance**

The East-Central Australian Shelf LME is bordered only by Australia and falls within the non-UNEP administered Pacific Regional Seas Programme. In 2003, Australia's Natural Resource Council endorsed a framework for a national cooperative approach to Integrated Coastal Zone Management. State jurisdiction is generally limited to the 3 nautical mile limit, but many state managed fisheries extend into federal waters to 200 nautical miles. Governance issues in this LME pertain to fisheries management and to the establishment of marine reserves. Lord Howe Island (33.5S, 159E) and the Solitary Islands (30.2S off northern NSW) were declared state marine parks in 1998/1999. Four



other NSW marine parks have been declared over the past 6 years, which extend out to the 3 nm mile limit of state waters: Cape Byron (22,000 ha), Batemans Bay (85,000 ha), Jervis Bay (21,000 ha) and the largest, Port Stephens-Great Lakes (98,000 ha). The Batemans Bay and Port Stephens parks have been the most controversial with the recreational fishing community that has challenged, in state parliament, the science on which they are based. The NSW Marine Parks Authority (MPA) through NSW Department of Environment and Climate Change aims to establish and manage a system of multiple-use marine parks designed to conserve marine biodiversity, maintain ecological processes and, provide for ecologically-sustainable use, public appreciation, education, understanding and enjoyment of the marine environment. Key issues remaining are larval connectivity amongst areas, and the degree of "spill-over". See the North Australian Shelf LME (Chapter VIII, this volume) for more information. NSW Department of Primary Industries is the principal agency responsible for conserving the aquatic environment and managing the fisheries resources of this LME. It is responsible for protecting and restoring fish habitats, promoting responsible and viable commercial fishing and supporting aquaculture industries.

The South Pacific Regional Environment Programme (SPREP), a regional intergovernmental organisation now based in Apia, Samoa, was initially established in 1982 as a programme of the South Pacific Commission. SPREP is the primary regional organisation concerned with environmental management in the Pacific, and serves as the Secretariat for three Conventions. The 1986 Convention for the Protection of the Natural Resources and Environment of the South Pacific region entered into force in 1990. The 1976 Convention on the Conservation of Nature in the South Pacific (Apia Convention), came into force in 1990. The Pacific Islands Forum is the key regional political organization in the Pacific representing the 14 Island countries as well as Australia and New Zealand. Australia ratified the United Nations Law of the Sea Convention (UNCLOS) in 1996. The 1995 Convention to Ban the Importation into Forum Island Countries of Hazardous and Radioactive Wastes and to Control the Transboundary Movement and Management of Hazardous Wastes within the South Pacific Region (Waigani Convention) entered into force in 2001. Australia's indigenous peoples are re-emerging in the environmental management process as a result of native title rights. The Pacific Islands Forum is the key regional political organization in the Pacific, representing the 14 island countries as well as Australia and New Zealand. The Action Plan has identified four broad priorities for the region: natural resources management, pollution prevention, climate change and variability, and sustainable economic development. The Australian Government's Department of the Environment and Heritage regularly updates a coasts and oceans website at: [www.deh.gov.au/coasts/](http://www.deh.gov.au/coasts/).

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