IX-20 Northeast Australian Shelf: LME #40

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The Northeast Australian Shelf/Great Barrier Reef LME lies in the Pacific Ocean off the coast of the State of Queensland, Australia. It is bounded by the Coral Sea to the east and by the Torres Strait, which separates Australia from Papua New Guinea, to the north, covering an area of 1.3 million km^2 of which 28.06% is protected (Sea Around Us 2007). The LME is characterised by a tropical climate, with tropical cyclones being common seasonal events. The South Equatorial Current, a part of the Pacific Ocean counterclockwise gyre, and the Great Barrier Reef (GBR), a system of coral reefs that stretches 2,000 km along Australia's northeast coast, are notable features of the LME (Brinkman et al., 2002). It has the largest system of corals and related life forms in the world, with 13.51% of the world's coral reefs, in addition to 0.26% of the world's sea mounts (Sea Around Us 2007). Nutrient enrichment is due to land-based sources as well as small upwelling areas and advection while mixing in this LME is due to tidal effects and the wind regime in inshore areas. Intensive fishing is an important force driving the LME but the combined stresses of climate change, terrestrial pollution and over-harvesting are degrading the system, as similar stresses degrade other coral reef systems globally (Pandolfi et al., 2003; Bruno and Selig, 2007). Book chapters and articles pertaining to this LME include Bradbury & Mundy (1989), Morgan (1989), Kelleher (1993), Brodie (1999, 2003), Furnas (2003), Hopley et al. (2007), Johnson and Marshall (2007), and UNEP (2003).

I. Productivity

The Northeast Australian Shelf LME is considered a Category III, low productivity (<150 gCm^{-2}yr^{-1}) ecosystem. Ocean currents and wind systems along this coast inhibit the development of highly productive upwelling systems. On this continental shelf, sources of nutrients are Coral Sea surface water, Coral Sea local upwellings of deep sea water, terrestrial runoff and atmospheric inputs. Tidally-induced mixing in the GBR is a major contributor to the nutrient dynamics of this ecosystem. For more information on oceanographic processes in this LME, see Wolanski, 1994, Wolanski et al., 2001 and Brinkman et al., 2002. For large-scale shifts in biomass of the GBR, see Bradbury & Mundy (1989).

There has been a steady accumulation of knowledge and understanding of the structure and dynamics of this system. There is high biological diversity in this LME, with high numbers of rare species. On the GBR are found 350 species of hard corals, along with 1,500 species of fish, 240 species of seabirds, and at least 4,000 species of molluscs (see Brodie 1999). The physical and biological structure of the GBR is complex. For a map of the GBR region, see Kelleher (1993). The abundance of hard corals has been reduced by at least 50% in areas where there is intense crown-of-thorns starfish activity. For more information about the large-scale effects of crown-of-thorns starfish outbreaks on the benthic community, and for the propagation of effects into the fish and plankton communities, see Bradbury & Mundy (1989) and Brodie et al. (2005).

Oceanic fronts: From satellite data (Belkin & Cornillon 2003, Belkin et al. 2009), the GBR is marked by a seasonal thermal front (GBRF) that peaks during the austral winter (Figure IX-20.1). This front is better defined off southern Queensland, whereas the fronts' extension off northern Queensland is less robust. Satellite data analysis revealed another, inner shelf front that runs off the Queensland coast (QISF). This front appears to consist of three segments, northern, central and southern, whose possible connectivity is not yet established. In addition, a coastal region affected by terrestrial material is evident (Brodie et al., 2007) separated from the oceanic regions off the shelf in deeper waters.

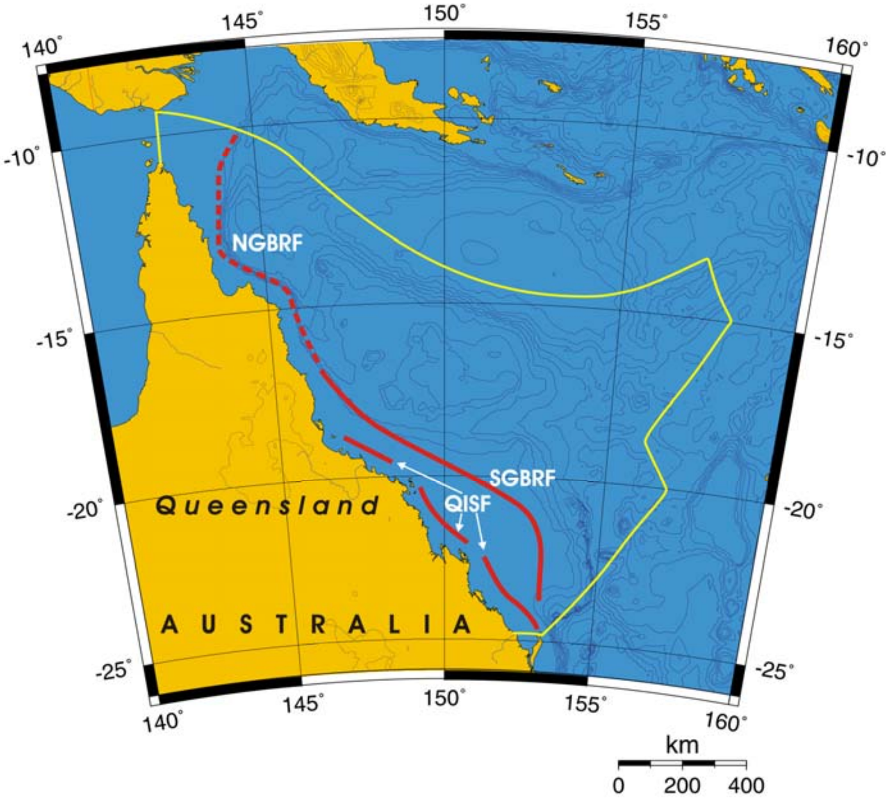


Figure IX-20.1. Fronts of Northeast Australian Shelf/Great Barrier Reef LME. NGBRF, North Great Barrier Reef Front (most probable location); QISF, Queensland Inner Shelf Front; SGBRF, South Great Barrier Reef Front. Yellow line, LME boundary, after Belkin et al. (2009).

Northeast Australian Shelf SST (after Belkin 2009)
Linear SST trend since 1957: 0.46°C.
Linear SST trend since 1982: 0.37°C.

Interannual and long-term variability of SST in this LME (Figure IX-20.2) are correlated with a few neighboring LMEs. For example, the twin peaks of 1970-1973 occurred simultaneously in the North Australian Shelf LME. The local minimum of 1982 occurred at the same time in the Indonesian Sea LME and in the Australian Shelf LME. The all-time maximum of 1998 was a local manifestation of the global warming effect of the El Niño 1997-98. The absolute minimum of 1965-66 occurred concurrently with the Southeast Australian Shelf LME. This cold anomaly probably originated upstream, in the South Equatorial Current.

High SST exceeding the coral colony' tolerance threshold is the primary cause of coral bleaching (Hoegh-Guldberg, 1999; Liu et al., 2003). In 2002, the Great Barrier Reef suffered from the worst coral bleaching event ever, which affected up to 60% and severely damaged 5%, of reefs surveyed (Berkelmans et al., 2004). Further severe bleaching and damage is predicted under the current climate change predictions and in association with ocean acidification (Lough, 2008, Hoegh-Guldberg et al., 2007).

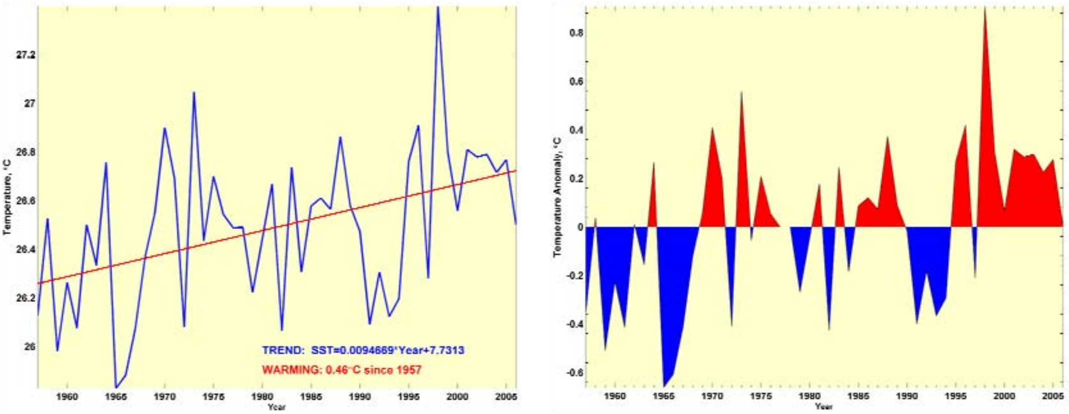


Figure IX-20.2. NE Australian Shelf mean annual SST (left) and SST anomalies (right), 1957-2006, based on Hadley climatology. After Belkin (2009).

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

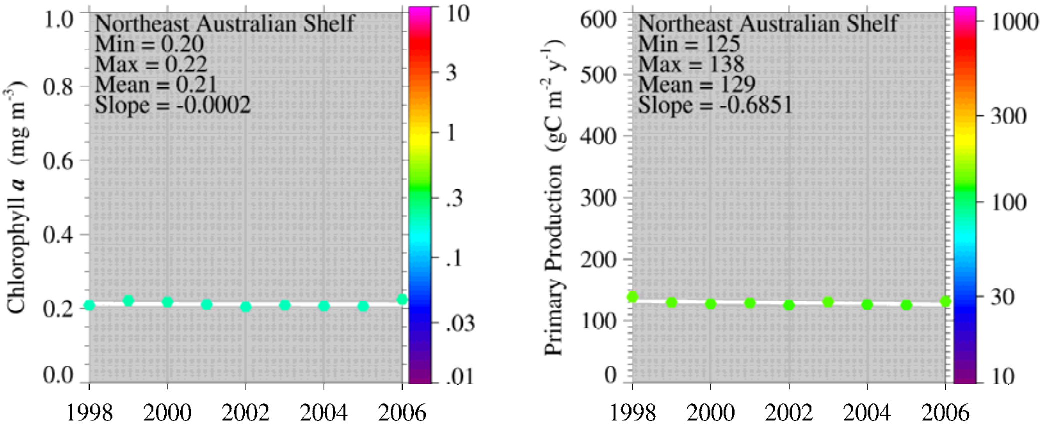


Figure IX-20.3. Northeast Australian Shelf Trends in chlorophyll-*a* and primary productivity, 1998-2006. Values are colour coded to the right hand ordinate. Figure courtesy of J. O'Reilly and K. Hyde. Sources discussed p. 15 this volume.

II. Fish and Fisheries

The relatively nutrient-poor waters of the Northeast Australian Shelf are unable to sustain large fish populations. The trawl fishery (Brodie 1999) targets tiger prawns, banana prawns and king prawns. Commercial and recreational fishing remain important industries in the Northeast Australian Shelf/Great Barrier Reef LME. The commercial sector in the state of Queensland annually harvests about 24,000 tonnes of seafood while the 800,000 recreational fishers in Queensland annually catch between 3,500 and 4,300 tonnes (www.oceanatlas.org). The Bureau of Rural Sciences estimates a total commercial fisheries production in national waters in 2002 at 15,600 tonnes with a value of AU$165 million (http://adl.brs.gov.au/). The annual catch of scallops and prawns is about 8,000 tonnes. Scallops are caught in the southern section of the GBR Marine Park. The Torres Strait prawn fishery is fully-exploited while the Torres Strait lobster is still underexploited. Information on Australia's fisheries is also available on the FAO website (www.fao.org/). Total reported landings of the LME comprised mainly of tunas (mostly of skipjacks but also yellowfin, bigeye and albacore), shrimps and prawns, and squids (from the late 1980s to early 1990s) and recorded 62,000 tonnes in 1990 (Figure IX-20.4). The landings have since declined to about half of the peak landings. The trend in the value reflected that of the landings, rising to about US$250 million (in 2000 US dollars) in 1989 (Figure IX-20.5).

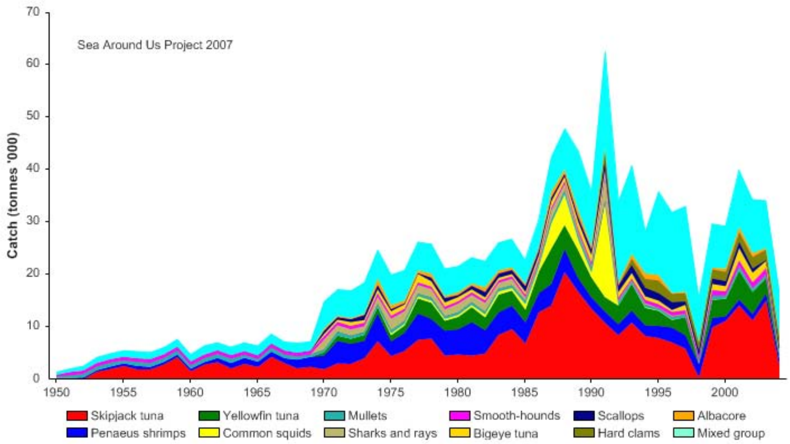


Figure IX-20.4. Total reported landings in the Northeast Australian Shelf LME by species (Sea Around Us 2007)

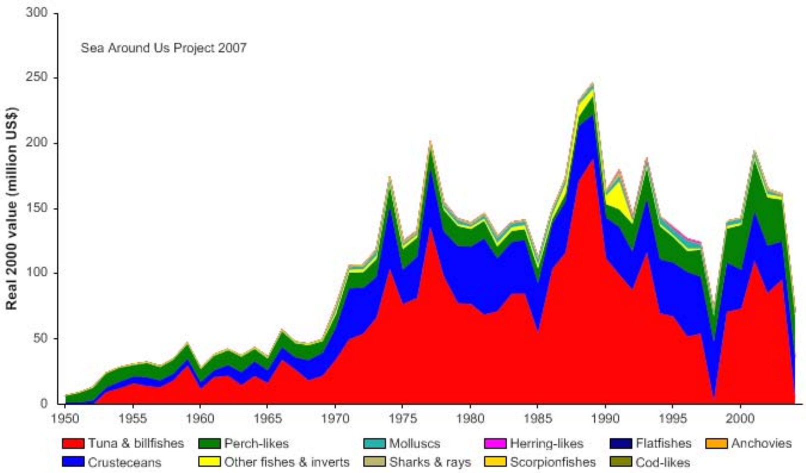


Figure IX-20.5. Value of reported landings in Northeast Australian Shelf LME by commercial groups (Sea Around Us 2007).

The primary production required (PPR; Pauly & Christensen 1995) to sustain the reported landings in this LME reached 5% of the observed primary production in the late1980s, but still is relatively low, considering the high proportion of high trophic pelagic species in the landings (Figure IX-20.6). Japan, with its distant water tuna fleets, accounts for the largest footprint in the region.

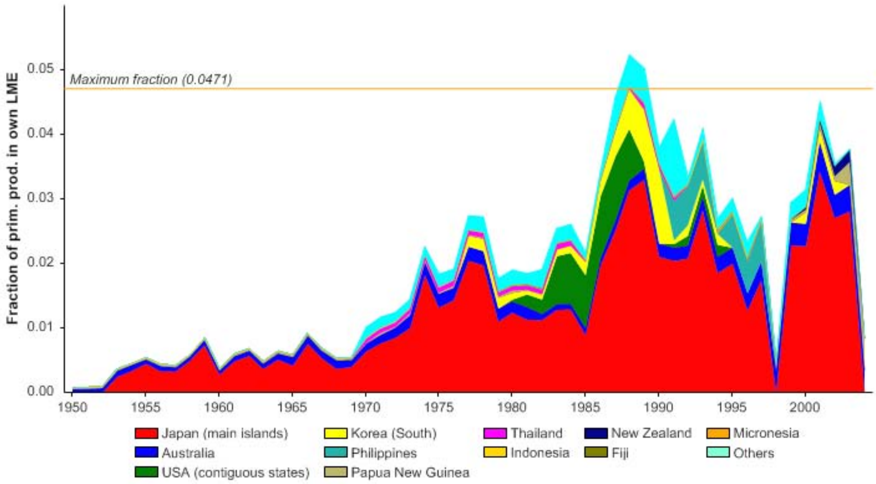


Figure IX-20.6. Primary production required to support reported landings (i.e., ecological footprint) as fraction of the observed primary production in the Northeast Australian Shelf LME (Sea Around Us 2007). The 'Maximum fraction' denotes the mean of the 5 highest values.

The mean trophic level of the reported landings (i.e., the MTI; Pauly & Watson 2005; Figure) in the LME is still high, except for 1998 and 2004 when the landings of tuna were unusually low (Figure IX-20.7, top), while the FiB index has been stable following an increase from 1950 to the mid-1970s (Figure IX-20.7, bottom). These trends imply a growth of fisheries in the region with no clear signs of a 'fishing down' (Pauly *et al*. 1998)..

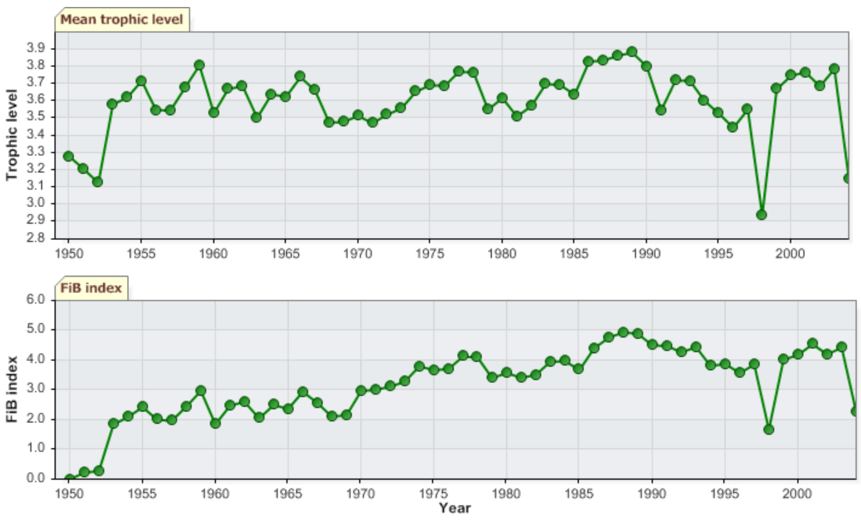
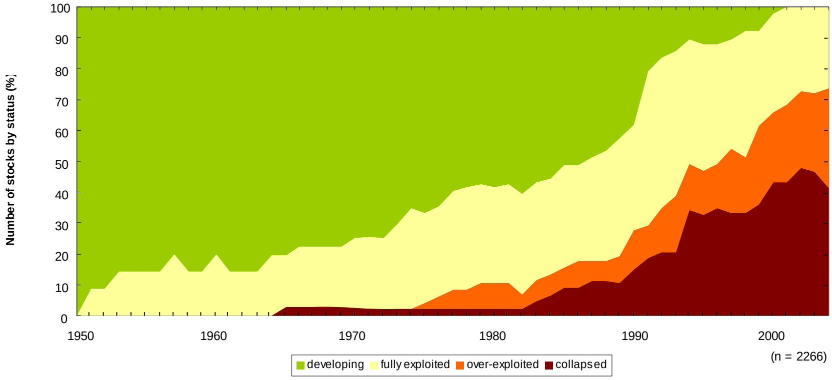


Figure IX-20.7. Mean trophic level (i.e., Marine Trophic Index) (top) and Fishing-in-Balance Index (bottom) in the Northeast Australian Shelf LME (Sea Around Us 2007).

The Stock-Catch Status Plots indicate that more than half of the stocks in the region are currently either overexploited or have collapsed (Figure IX-20.8, top) and that half of the reported landings is supplied by such stocks (Figure IX-20.8, bottom).



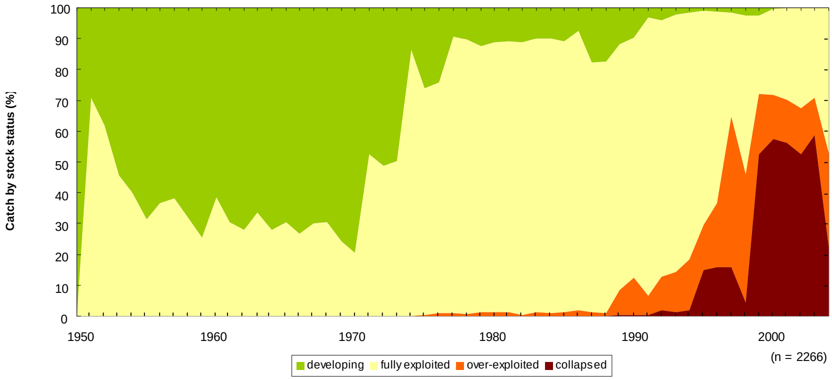


Figure IX-20.8. Stock-Catch Status Plot for the Northeast Australian Shelf LME, showing the proportion of developing (green), fully exploited (yellow), overexploited (orange) and collapsed (purple) fisheries by number of stocks (top) and by catch biomass (bottom) from 1950 to 2004. Note that (n), the 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

The Northeast Australia LME has been perturbed by the crown-of-thorns starfish (*Acanthaster planci*) that has devastated reefs (Kelleher 1993). There is uncertainty as to whether the outbreaks are human-induced or a natural part of the ecological variability of the GBR (Brodie 1999). Possible anthropogenic causes are the overfishing of crown-of-thorns predators such as fish or the triton shell, and enhanced nutrient runoff from coastal development (Brodie et al., 2005). The large-scale effects of crown-of-thorns starfish outbreaks on the benthic community have been discussed in Bradbury & Mundy (1989) and in the State of the Environment Report (www.deh.gov.au/soe/index).

The GBR is also threatened by increased shipping. A number of ports line the GBR coastline (Brodie 1999), and navigation in the Torres Strait is intense. Ballast water introductions of toxic dinoflagellates have caused serious ecological problems in other parts of Australia but so far no undesirable introduction has been detected in the GBR region. One significant anthropogenic impact on the GBR region is the change in the water quality of terrestrial runoff (Brodie 1999). Excess nutrients affect coral and coral reef systems (Kinsey 1991). There is considerable evidence that reefs, particularly inshore fringing reefs, are now muddier and have less coral cover and more algal cover (Fabricius et al., 2005). Reef ecosystem damage is evident in a large area of the north-central GBR (Devantier et al., 2006) coinciding with the area known to be exposed to polluted terrestrial runoff (Devlin and Brodie, 2005). Recreational fishermen tend to target reef ecosystems and remove larger predatory species. The effects of this selective removal of fish are largely unknown. Shore-based recreational fishing can affect shore populations of invertebrates that are collected for bait in intensively visited areas.

Environmental impacts on the Great Barrier Reef also stem from tourism. Large numbers of people are engaged in recreational fishing, SCUBA diving and boating. The expanding marine tourism industry is a major contributor to the Australian economy and now supports more than 820 operators, generates $4.2 billion annually, and accommodates 1.8 million visitors each year (www.oceansatlas.org). Activities associated with this level of recreational use can affect the environment through the pollution of water by boats and the disturbance of species and habitats (including mangroves). A major source of environmental impacts is the provision of infrastructure to support tourism (airports, power generation facilities, accommodation, sewage treatment and disposal facilities, moorings, and marine transport, including high-speed ferries). Often, this infrastructure is located in fragile or pristine environments that are susceptible to disturbance and fragmentation. For more information on pollution control in the GBR, see Kelleher (1993).

IV. Socioeconomic Conditions

According to the Bureau of Rural Statistics, the North Eastern Region of Australia has a population of 441,300 of whom 90% reside in 66 medium-to-large coastal towns. (http://adl.brs.gov.au). Employment within the fishing sector is heavily concentrated in the commercial sector, and involves from 1% to 5% of total employment. Total commercial fisheries production for the region in 2002 was estimated at 15,600 t with a GVP of AU$165 million (http://adl.brs.gov.au/). FAO provides information on Australia's fisheries and the socioeconomic benefits of the industry (www.fao.org/fi). Marine and coastal-based tourism is the main industry of the GBR, an internationally recognised tourist site and one of Australia's six World Heritage Sites (see Brodie 1999). In the 1980s, tourism in the GBR was evaluated at 150,000 visitor-days. In the late 1990s, tourism was worth US$1 billion, with 1.5 million visitor-days. Whale-watching takes place off the coast of Queensland. Tourism clearly depends on sustaining environmental and heritage values. Tourism can affect the lifestyle of community residents in ways they perceive as intrusive. In terms of fisheries, for instance, there can be tensions between recreation, commercial and indigenous interests. Traditional fishing by Aborigines and Torres Strait islanders is confined to areas close to Aboriginal communities (Brodie 1999). Shipping is a major activity. Mining including extraction of petroleum is not permitted within the Marine Park boundary. For more information about human uses of the GBR, see Kelleher (1993) and Brodie (2003).

V. Governance

This LME falls within the Pacific Regional Seas Programme (see the East-Central Australian Shelf LME). The main governance issues in this LME pertain to fisheries management and to the Great Barrier Reef Marine Park and Great Barrier Reef World Heritage Area. See the North Australian Shelf LME (Chapter VIII) for more information. For sustainable fishing issues in the GBR, see Kelleher (1993). Under the offshore constitutional settlement between the Australian states and the federal government, the management of most fisheries within the GBR is the responsibility of the Queensland government (Brodie 1999). Fishery Management methods covering recreational and commercial fishing are: input controls (gear restrictions, limited entry licenses, area and seasonal closures); output controls (TAC, ITQs, bag limits and size limits), measures for species and habitat protection. There is often a 'user pays' approach in which users (usually fishers) pay the full cost of supporting management and compliance for their fisheries, including substantial license or access fees (www.fao.org/). In 2003 the Australian Government Representative Areas Program for the GBR was introduced where the area of highly protected status (no take) was increased from 6 to 30 % of the total (Fernandes et al. 2004). More information on the governance of Australia's fisheries is available at the FAO website.

The GBR Marine Park Act was one of the first pieces of legislation in the world to apply the concept of sustainable development to the management of a large natural area. The GBR Marine Park Authority was established in 1975 to manage the multi-use park. The Authority aims to protect the natural ecosystems of the GBR, and ensures that fishing does not have unacceptable ecological impacts on the fished areas and the reefs. For more information on the history and zoning system of the GBR Marine Park, see Brodie (1999) and Kelleher (1993). Compulsory pilotage in the area reduces the risk of collision with reefs.

On the national level, the Commonwealth Government developed a National Action Plan for Tourism in 1998. The Plan, which identifies conservation and careful management of the environment as essential to the long-term viability of the tourism industry, makes a commitment to ecologically sustainable tourism development and recognises that environmental considerations should be an integral part of economic decisions.

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